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Research Paper

PRELIMINARY CONSUMPTION SURVEY ON EDIBLE CATERPILLARS: CASE OF IMBRASIA OYEMENSIS CONSUMED IN CÔTE D'IVOIRE

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Abstract

Description of the subject
The article deals with information about the consumption and the importance of caterpillar *Imbrasia oyemensis* in Ivorian people nutrition.
Objective: The aim of this study was to get information about the acknowledgment, the reason of consumption and the importance of caterpillar *Imbrasia oyemensis* in Ivorian people nutrition.
Methods: This consumer survey of caterpillars *Imbrasia oyemensis* concerned 300 persons of the two sexes (51.34% men and 48.66% women) who had answered questions about the reasons of consumption and the picking of these insects.
Results: This study has noted that these insects are known of the Ivorian population. Over 83.3% of 300 respondents know, consume and have their own and locally appellation. They provided per pick up drills (19.9%) but above the market (80.1%). First, 40.5% of people are attracted by the taste of those insects flesh, then by eating habit (31%), 16.6% of them eat these insects by curiosity and finally a few about nutritional qualities (11.9%). In good times, 33.3% of respondents consume 200 g of these animals on smoke form (80%). But, 75.02% of these persons eat caterpillars *Imbrasia oyemensis* in different soaps. During a week, 55% of respondents consume them as many times as possible. However, 31.9% of people think that the caterpillars are very expensive; when 27.5% mention their high cost; for 22.6%, the caterpillars are forbidden in their culture and for10.8%, they still disgusting them.

Conclusion: Caterpillars *Imbrasia oyemensis* are known by Ivorian people through their name, shop, preservation, and preparations. But their nutritional values are unknown and must be published for the Ivorian populations.
Key words: Caterpillars, *Imbrasia oyemensis,* Consumer Survey, Côte d'Ivoire.

INTRODUCTION

Rapid global population growth (9 billion people) in the early 2050s (FAO, **2009**), rapid urbanization, and recent high demands for animal nutrition have reduced food resources, including in protein of animal origin (AAIA, **2011**). The high prices of these common proteins (meat and fish) that make them inaccessible to the poorest and can rapidly worsen the problem of food security in developing countries (Belluco **et al**., **2013**). According to FAO (**2004**), the diet of the world's population is in stark contrast. On the one hand, more than 798 million people suffer from malnutrition in developing countries, while on the other hand, more than one billion people are overweight in the countries of the North. The concerns of these poor or industrialized countries are food safety and the sustainable production of food (FAO, **2009**). As a result, intensive animal production and overgrazing lead to forest degradation and contribute to climate change and other adverse environmental effects (FAO, **2013**). How then to consider global nutrition with resources increasingly limited, without negatively impacting our planet (Anonymous, **2009**)? New methods of producing novel foods or research on the development of animal proteins are needed and must be developed while preserving the quality of food, natural habitat and biodiversity of animal and plant species consumed (Nzevelo, **2016**).

Thus, there is an urgent need to find alternatives to conventional livestock and other animal feed sources (Verbeke, **2015**). Among these unconventional food resources, there are non-timber forest products namely mushrooms, snails, termites, and especially insects (Veldkamp, **2012**) These are increasingly emerging as a serious alternative and a future solution for humans, aquaculture and poultry farming (Hanboonsong **2012**, Van Itterbeeck **2013**). They represent a good opportunity to combine old traditional knowledge with modern science in these southern countries (Oonincx, **2010**, Vantomme, **2013**). They are indeed very rich in proteins (45 to 80% of MS) and their profile contains 6 to 9 essential amino acids and 7 non-essential (DeFoliart **2005**, Foua bi *et al*, **2016**). Their lipid content (20 to 40%) contains

saturated and unsaturated fatty acids (Ramos-Elorduy **2011**). The ashes of these insects are composed of minerals such as potassium, calcium, magnesium, phosphorus and trace elements such as iron, zinc, copper, manganese, molybdenum and selenium (Arnold van Huis, **2014**, Caparros et al, 2016). In addition, their energy value would be even higher than that of beef and dried fish. (Fao / Wur, **2012**). These caterpillars also contain vitamins such as niacin, riboflavin, thiamine and traces of folic acid, pyridoxine, B-carotene etc ... (Fao / Wur, **2012**).

Insects are thought to be traditional meals for at least 2 billion people. More than 1,900 species are mentioned in the literature as human foods (Fao / Wur, **2012**). Insects also provide many basic ecological services for the survival of humanity. They play an important role in plant breeding through pollination, improve soil fertility by bioconversion of waste, control pests through natural biological control and provide a wide variety of valuable products, such as honey, silk, or medicinal as maggot therapy. (Vantomme, **2013**). Globally, the most commonly consumed insects are beetles (Coleoptera, 31%), caterpillars (Lepidoptera, 18%), bees, wasps and ants (Hymenoptera, 14%) etc ... (FAO, **2004**). The consumption of caterpillars, called campeophagy, is a very old practice in many human communities and has evolved differently depending on food choices and practices (Malaisse, **2016**). It has been maintained for millennia in societies that found a source of abundant and very cheap protein (Barre *et al.,* **2014**). For the past fifteen years, FAO has been working on topics related to the promotion of campeophagy and the enhancement of the food potential of edible insects in many countries around the world. First in 2003, it organized in the Central African Republic a study on the contribution of edible insects to the diet of populations in Central Africa. Then, the Chiang Mai Conference in Thailand is held in February 2008. Then, from 23 to 25 January 2012 at FAO Headquarters in Rome, Italy, an International Expert Consultation on "Assessing the Potential of Insects as food for humans and animals to contribute to food security. Finally, in 2013, the Laos Technical Cooperation Program 2010-2013 is established.

All these conferences have recognized that the promotion of these insects is one of the main ways to meet protein needs for this African population and thus help to fight against malnutrition that persists despite the substantial efforts made by governments. (Malaisse, **2016**). Although part of the advanced countries of West Africa, Côte d'Ivoire

remains a poor country and is not immune to protein-energy malnutrition (Tchibindat, **2004**). Recent surveys show that the malnutrition rate is relatively high and that micronutrient deficiencies persist. This is the case of the SMART transversal nutritional survey (PNN, UNICEF, WFP) of July **2008**, which made it possible to obtain recent data on malnutrition in the northern part of Côte d'Ivoire and in Abidjan.

In fact, it revealed alarming figures in the north of the country and in the displaced populations of war in Abidjan: a global acute malnutrition rate of 17.5%, a severe severe disease rate of 4% and a global anemia rate of 80.8% for children from 6 to 59 months. Yet the vast majority of wild caterpillars that make up this crucible of nutrients essential for food are harvested from the agricultural lands or forests of these malnourished populations (FAO, 2013). These caterpillars can validly help to secure and nutritionally rehabilitate these populations weakened by natural disasters (droughts, floods) and fratricidal wars. ndeed, insect consumption is particularly abundant in sub-Saharan Africa, where more than 30% of all edible insect species are caterpillars (Van Huis, **2013**). Despite their diversity, their economic and food importance and the potentialities they conceal, very few valuations have been granted to these unconventional animal resources in Côte d'Ivoire (Malaisse, 2016). This lack of interest can be justified by a poor knowledge of the latter, which is very popular with rural consumers (DeFoliart, **2005**). The main families of caterpillars consumed are (in decreasing number of the number of species): Saturniidae: 105, Hepialidae: 47, Sphingidae: 38, Notodontidae: 18, Lasiocampidae: 15, Noctuidae: 15 etc ... (Malaisse, **2005**). Among these caterpillars, four main species of the family Saturniidae are particularly consumed: Cirina Forda, Imbrasia epimethea, Imbrasia ertli, and especially Imbrasia oyemensis or Nudaurelia oyemensis, the most important species of caterpillars consumed in Côte d'Ivoire (Latham, **2003**).

In order to boost its consumption, a consumer survey on Imbrasia oyemensis caterpillars was conducted among the Ivorian population to collect information on its knowledge, the reasons for its consumption, its method of support and supply, and the reasons for rejection.

MATERIAL AND METHODS

1. Harvesting and morphological identification of caterpillars

Two samples of caterpillars (fresh and dried) were sent to Abidjan for analysis. The fresh caterpillars were harvested in Vouebouflа, a sub-prefecture of the town of Zuénoula, and the dried caterpillars were bought in the markets of the said cities. The collected caterpillars were identified by comparison with reference specimens kept at the Animal Biology Laboratory of the Félix Houphouët-Boigny University (Abidjan, Côte d'Ivoire).

2.Survey of campeophagy

This cross-sectional survey of the consumption of Imbrasia oyemensis caterpillars was carried out among randomly selected households in households in the cities of Zuénoula and Bouaflé, located in the interior of the country, and in Abidjan. It took place from February to July 2013 and covered a sample of 300 people at the rate of 100 per city. In practice, a survey questionnaire was developed and submitted to these 300 people selected randomly through these 3 communes of the country. All social classes were subjected to questionnaires (officials, salesmen, pupils, housewives, farmers, breeders, unemployed, etc.)

The questions were administered orally and then the answers were recorded on the questionnaire form by the interviewer. The statistical analysis of the collected data was done using the STATISTICA 6.0 software.

The chi-square test (X2) at an acceptance threshold of 5%, made it possible to compare the data for caterpillar consumption according to sex, age categories, shape consumed, accompaniments, and the amount of caterpillars consumed per day.

RESULTS

1. Distribution of the sample by ethnic group

The sample surveyed consisted of the following ethnic groups: 24.6% of the individuals are South Mandé, 12.6% are Mandé du Nord, 29% are Krou, 7.4% are Voltaic, 4.9% Akans and 21.4% belong to other ethnic groups (Ebrié, Adioukrou, Aladian, Avikam, Awlan).

2. Distribution of the sample by age

The study population is made up of 300 people, 25% children, 41% adolescents and 34% adults. It comprised 51.3% men and 48.6% women.

3. Local name of the caterpillars

The study revealed that respondents have perfect local language skills in the names of caterpillars. In GOURO (Mandé du Sud), caterpillars are called "Zeglé". The Krou group's BETEs call them "Zèglè". The MAHOU (Mandés du Nord) refer to them as "Zoorooh". In the Voltaic group, the LOBIs call them "Badoh". The BAOULE of the Akan group use the term "N'droloh".

Table I: Local name of the caterpillars

Ethnic	Local names
MAHOU (Mandé du Nord)	Zoorooh
BETE (Krou)	Zèglè
LOBI (Voltaïque)	Badoh
BAOULE (Akan)	N'droloh
GOURO (Mandé du Sud)	Zèglè

4. Mode of supply

The supply of dried caterpillars is essentially made up of the purchase on the markets (80.1%), ie four times the number of individuals who obtain it by collecting or catching in forests (19.9%).

5.Consumption Reasons

Several reasons seem to motivate the consumption of caterpillars. The organoleptic reasons come in first place with 40.5% of those surveyed. Then, 31% of respondents consume it by food habit and 16.6% eat it out of curiosity. Finally, 11.9% of those interviewed mentioned the nutritional properties of caterpillars.

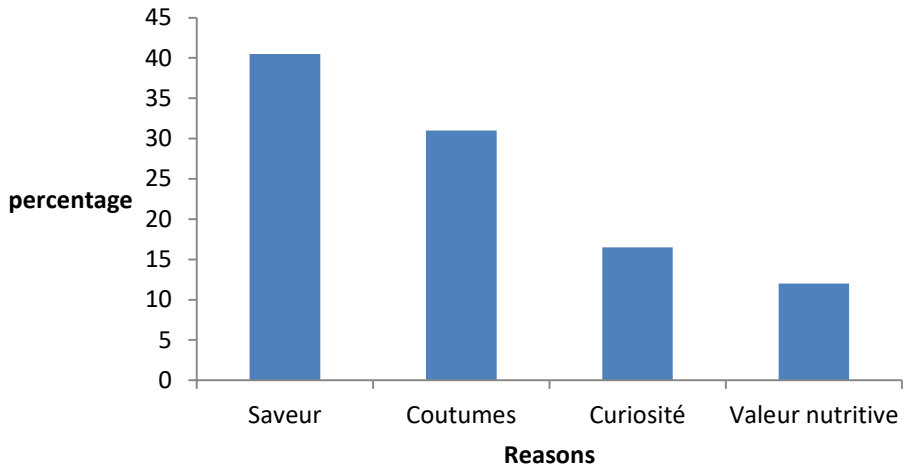

Figure I: Different reasons for caterpillar consumption

6. Consumptions modes

The principal modes of consumption of the caterpillars selected during the investigation are the smoked and / or dried caterpillar, the braised form and the grilled meats. The overwhelming majority of respondents (80%) prefer smoked caterpillars, while 13.3% eat braised caterpillars and 6.7% like them grilled.

7. Accompanying modes

Respondents claim to eat caterpillars either with pasta (24.7%) or with sauces (75.2%). Of these, the caterpillars are preferably prepared in peanut sauce (48.7%). Then, in descending order of choice, are seed sauce (26.5%), pistachio (14.1%), dry okra (8.4%) and aubergine (2.2%) (Table II).

Table II: Principal modes of accompaniment of caterpillars

Accompagnements		Pourcentage (%)	
Pâtes		24, 7	
Sauces	Arachide	48,7	75,3
	Graine	26,5	
	Pistache	14,1	
	Gombo sec	8,4	
	Aubergine	2,2	

8. Distribution of the sample according to the quantity consumed per day

In season of abundance of caterpillars that is to say during the rainy season (from July to October), 33.3% of the individuals estimate to consume a quantity of 200g (1 pot) of caterpillars a day. Others cons (28.3%), think consume double (2 pots) while 30% consume triple while 8.3% go beyond 3 pots is more than 600g/d/per.

9. Frequency of consumption

When caterpillars are available (July to October), 55% of respondents consume caterpillars as many times as they can in a week. Then 28.7% consume them at least once a week when 12.3% say they consume them twice in the same period. Finally, 3.9% consume them occasionally, often during traditional ceremonies.

10. Factors limiting the consumption of caterpillars

The reasons for disinterestedness are diverse. In fact, 39.1% of respondents believe that caterpillars are too expensive. For 27.5% of people who are asked questions, it is difficult to get them. And for 22.6% of respondents, they are banned for consumption (totem) while 10.8% of people find them disgusting.

Table III: Factors limiting the consumption of larvae Imbrasia oyemensis

Limiting factors	Percentage (%)
Cost	39,1
Scarcity	27,5
Totem	22,6
Disgust	10,8

A significant difference in the amounts of caterpillars consumed daily was observed according to ethnic groups ($\chi 2 = 26.32$, $\alpha = 0.05$, DL = 5).

In addition, no significant difference in caterpillar consumption was observed according to the consumer's gender ($\chi 2 = 2.1$, $\alpha = 0.05$, DL = 1). In fact, insects are globally as consumed by men (78.5%) as by women (85.6%). Regarding the age categories, no significant difference in caterpillar consumption as a function of age was observed ($\chi 2 = 2.76$, $\alpha = 0.05$, DL = 2). As for the caterpillar supply modes, a significant difference in the quantities of caterpillars harvested as a function of the place was observed ($\chi 2 = 66.12$, $\alpha = 0.05$ DL = 1). With regard to caterpillar consumption patterns, a significant difference in the quantities of caterpillars consumed was observed. ($\chi 2 = 61.7$, $\alpha = 0.05$, DL = 2). In descending order, the caterpillar smoked (80%) followed by braised (13.3%), and grilled (6.7%).

DISCUSSION

The surveys were conducted in three Ivorian cities. It focused on the following major Ivorian ethnic groups: South Mande, Mande of the North, Krou in the West, Voltaic in the Northeast, Akan in the Center of the country. This survey, by its size, could constitute a solid database of statistics at the national level concerning the consumption of caterpillars. However, it is not exhaustive because this survey only concerned 300 people in an Ivorian population of more than 21 million individuals. This preliminary consumption survey is similar to that obtained by Balinga (**2003**) who surveyed a

Cameroonian population in 180 households in Central Province, 20 in East, 130 in Western, 90 in North Vietnam. West, 174 Southwest and 96 in the Littoral Province. However, it is far removed from sectoral surveys conducted in 251 schools in the Democratic Republic of Congo by Moussa (**2002**), and in Brazzaville markets and in 600 households in Kinshasa by Monzambe-Mapunzu (**2002**) and in 100 households. in the Ngotto forest by N'gasse (**2003**). This good integration of campeophagia (Imbrasia oyemensis) in the food practices would date millennia because in some cultures Chinese, African or Latin-American.

Men traditionally consume insects that would play important roles in traditional medicines, decoration, entertainment, witchcraft, and are present in myths, legends and dances (Chen & Feng, 2009; Yen *et al*, **2013**). The practice of consuming insects and therefore caterpillars is even mentioned in Christian, Jewish (Amar **2003**), Islamic (El-Mallakh *et al*, **1994**) and Hindu religious literature (Yen *et al*, **2013**). This knowledge of caterpillars has been highlighted by the work of N'gasse (**2003**), for which nearly 85% of the populations of the Central African Republic know and consume these caterpillars. It is also the case of Mapunzu-Monzambe (**2002**) for which 70% of the people questioned in the Democratic Republic of Congo eat caterpillars. Indeed, it is names received or learned from their parents or their respective communities that identify, recognize, identify and manipulate these insects (Mela, 1999). These local names of caterpillars are given by Mabossy-Mobouna (**2014**) in the Central African Republic, Niaba *et al.,* (**2013**) in Côte d'Ivoire and by Malaisse *et a l.*, (**2016**) who named Imbrasia oyemensis in Lingala and Ngando, two local languages. in the DRC. Most insect crops occur in the wild, mainly in forests and fields (Kinyuru, **2010**). Entomophagy was traditionally practiced by rural populations, who found in insects harvested in the wild an abundant and very cheap source of protein (Barre, **2014**). It has spread to the frequently overpopulated cities destined for urban populations (DeFoliart, **2005**) because of the exodus of populations to the big cities linked to rampant deforestation and general impoverishment. Also, conditions for harvesting, storage by smoking, transport and sale of caterpillars remain to be improved (Caparros, **2016**). This is unfortunately the case in the Democratic Republic of Congo where it is easy to find unprotected insects on the markets of villages and cities. (Nzevelo, **2016**). Indeed, in the different markets, these dried caterpillars are exposed on the stalls without any

protection or enclosed in jute bags which could cause the rancidity of caterpillars. In fact, free fatty acids under the effect of atmospheric oxygen cause rancidity of the fat of these insects making them dangerous and unclean for consumption (Klunder, **2012**). In fact, in most cases where they are a staple in local diets, caterpillars are eaten for their taste and not because there is no other source of food available (DeFoliart, **2005**). Men generally have a strong sense of loyalty and attachment to their traditional diet (Bacckman **2002**, Tan **2016**). For Lisingo, (**2010**) the caterpillars are consumed at 37, 98% because of the taste, 35,65% by eating habit and 25,35% only for their nutritional value. 11.92% of respondents consume them for their nutritional values, under the terms of energy intake, protein, fatty acids, fiber, minerals and vitamins. They satisfy the human needs in amino acids, are rich in mono and polyunsaturated fatty acids, in minerals such as copper, iron, magnesium, manganese, phosphorus, selenium and zinc, as well as in vitamins like riboflavin (B2), pantothenic acid (B5), biotin (B8) and, in some cases, folic acid (B9) Rumpold (**2013**). The digestibility of the proteins of these caterpillars varies from 76 to 98% according to Ramos Elorduy *et al*. **2011**). Their use in the Ivorian diet can therefore improve the nutritional quality as a source of animal protein (Headings *et al*, **2002**). The diets of Africans in general, are mostly carbohydrates, based on cereals including rice, corn, millet ..., often deficient in tryptophan, threonine and lysine. their enrichment by combining them with caterpillar-based sauces could be recommended because they are rich in these amino acids (Michaelsen *et al*, **2009**). These caterpillars contain vitamins, essential to stimulate the metabolic processes and strengthen the functions of the immune system. These are vitamins B1 (0.11 to 8.9 mg per 100 g of dry matter), B12 and E (traces), retinol and β-carotene (respectively for 32 µg to 48 µg per 100 g and 6, 8 µg at 8.2 µg per 100 g of dry matter) (Finke, **2002**). The nutritional value of these two essential fatty acids is well known, mainly for the healthy development of infants and young children, particularly for Ivorians (Michaelsen *et al*., **2009**). However, this campeophagy must be framed because according to Foua Bi *et al*, (**2016**), the ratio Ω6 / Ω3 which is 8.02 is outside the range [1; 4] recommended by EFSA (**2015**).

These excesses can be corrected in a moderate and controlled diet to prevent the development of various diseases such as cardiovascular diseases, cancers and various inflammatory and autoimmune diseases (Artémis, **2002**). In addition, most edible

insects have iron levels that are equivalent to or better than beef (Oonincx *et al*., **2010**) and their inclusion in the daily menu could be effective in controlling iron and zinc deficiencies to prevent iron deficiency. anemia by improving infant and maternal health in developing countries (FAO, **2013**). The shape of the dried and smoked form allows a long and good physical preservation and organoleptic and taste qualities of the caterpillars. Smoking processes that keep caterpillars for at least three months, slightly different in different regions and collectors (Kankonde, **2001**). In all cases, heat from wood fires is used to facilitate depilation and elimination of droppings (Bukkens, **2005**). As a result, caterpillars can be stored for months in bags, baskets protected from moisture, other insects and rodents (Mapunzu, 2002). These results corroborate the observation made by FAO (**2004**) for which caterpillars are generally consumed in dried form. Clawson et al (**1993**) have shown that the reduction in protein content could be attributed to the partial loss of nitrogen compounds by heating certain amino acids. In addition, smoking may be carcinogenic (Malaisse, **2005**) because the wood fumes used may contain phenolic compounds, antinutrients, disgusting and toxic. In effect, to better reduce these adverse effects and feel their taste, caterpillars are 75% prepared in various sauces such as peanuts and seeds.These sauces which are the combination of ingredients from various vegetable sources and containing proteins, fiber, lipids and minerals, enhance the nutritional value of caterpillars. In addition, cooking processing improves food digestibility and consumer appeal (Ndong *et al*., **2007**). Also in its plan to eradicate food problems in the Kwango District, Bandundu Province in the Democratic Republic of Congo, did the NGO Action Against Hunger (ACF, **2014**) organize nutrition education and training courses. Culinary demonstrations based on caterpillars.

Energy needs must therefore be assessed according to parameters such as age, sex, height, weight and socio-professional and / or sports activity. This quantity of 200g of caterpillars could be sufficient for the equilibrium of the body because according to Malaisse (**2005**), the daily consumption of one quarter (50g) of this mass of dried caterpillars covers the human needs in essential elements including niacin and riboflavin. This value is higher than that of N'gasse (**2003**) which has established a consumption of about 137 g (fresh insects) per person per day. But this mass of 200g represents twice the consumption of dried insects per person found by Ndoye (2009)

(100g) and five times that of Katia Kitsa (1989) (40g) in Kasaï in the Democratic Republic of Congo. In general, culture, influenced by the environment, history, community structure, human activities, mobility and politico-economic systems, defines the rules of what is edible and what is not (Mela, **1999**). In fact, acceptance or rejection of entomophagy is a question of culture (Mignon, **2002**). he knowledge of indigenous peoples, who often included the sustainable management of edible insects and their habitat, is gradually disappearing (Kenis *et al*., **2006**), to the benefit of inexperienced harvesters who resort to unsustainable harvesting methods such as bushfires. Stability and regeneration of edible insect populations is threatened if harvesting techniques become less selective (Choo, **2008**).

Over exploitation is another major challenge, both for current and future campeophagy, particularly if the number of individuals (immature or adult) collected exceeds regeneration capacity (Cerritos, **2009**). Finally, as with many other natural resources and non-timber forest products, habitat degradation, such as deforestation, agricultural activities, forest destruction and pollution (by insecticides), have increased the stress edible insect populations (Vantomme, **2010**).

These effects on the habitat of the insects invariably influence their abundance and their distribution and induce their rarefaction on the one hand and their price on the other hand. The future of caterpillars is all the more worrying as increasing temperatures could induce population growth, although periods of extreme heat or drought may also lead to their decline (FAO, **2013**). 94.8% people interviewed by Mabossy-Mobouna *et al.* (**2014**) in Brazzaville mentioned the seasonality of insects as the main factor limiting the consumption of the larvae Imbrasia truncata. On the other hand, according to 15.01% of respondents, a large number of customs-related prohibitions reduce and prevent the consumption of insects. These dietary practices are influenced by culture, which is also influenced by religious beliefs (Verbeke, **2015**). For Pagezy (**2006**), these prohibitions persist even if they are no longer rigorously respected. Disgust forms the basis of moral judgment and plays a key role in rejecting populations for food, although this is an innate reaction (Fessler *et al.* **2003**). The feelings of disgust are mostly triggered by questions about the origin and nature of the food. Apart from basic human emotions, the origins of disgust or taste are rooted in culture, which undoubtedly has a major effect on eating habits. (Herz, **2012**). The slow westernization of populations in

major African cities unfortunately contributes to the rejection of insects, thus undermining FAO's efforts to combat food insecurity in developing countries.

CONCLUSION

the information on the knowledge of the Imbrasia oyemensis caterpillars has shown their importance and interest in the diet of the Ivorian population. The results obtained reflect the good and empirical knowledge of the caterpillars through its mode of supply and its culinary methods. It would be interesting then that an extension of the nutritional potentialities of these insects be conducted to better promote their consumption among local populations whose diet is largely deficient in ordinary animal protein. Problems faced by edible insect populations that are directly related to their harvest, conservation, and survival are deeply rooted in the unsustainable use of nature by humans. It is also important to inform, promote and share sustainable best practices and harvesting techniques so that sufficient attention is given to the sustainable management of these edible insect populations. The bioavailability of micronutrients (especially iron and zinc) in edible insects requires further research, given the massive deficiencies in these elements of our different dishes.

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