Edible Insects: Rearing Methods And Incorporation Into Commercial Food Products-A Critical Review

Victor. N Enwemiwe, Kehinde. O.K Popoola

Delta State University, Department of Animal and Environmental Biology,
Abraka, Delta State, Nigeria. PH-2347031882676
enwemiwevictor@gmail.com

University of Ibadan, Department of Zoology,
Ibadan, Oyo State, Nigeria. PH-2347034742824
kokpopular@gmail.com

Abstract: Insects are appealing assemblage of organisms classified under the phylum Arthropoda and considered the most diversified in nature. A sum of 2-3 million are estimated on earth constituting as much as 80% - more than 90% of all species in the animal kingdom. Varied nutritional aspects range from high quality protein, natural fat, vitamins, fibre contents and diverse minerals. That they are of great taste, confirmed delicacy and reduce to minimal the climatic change impacts from increasing world growing population and increased agro-ecosystem output are positive reports. Inclusion criteria of potentially suitable edible insect species is a function of defined benefits, stereotyped conditions of breeding, detailed intensive care of insect nutritional structure and profile, and risk assessments to combat threat in hygienic and toxicology aspects. These aforesaid factors would pull edible insects into been fully implemented as food into the world legislation brochures. Entomophagy: human insectivory is actualized from mass producing edible insects either as mini-livestock treatments or mechanized breeding facilities and not the stressful harvesting from the wild. Cultural, social, psychological and western bias are key note barriers to be fully redressed to realize the high prevalence in entomophagy and production of insect-based food products. Notwithstanding, a few insect-based products including fresh pasta from mealworm flour, jungle bars, protein bars, cricket flours, snack packs from various edible insects, insect candies and biscuits, amongst others are available in European markets but records of these insect-based food products in Africa and Nigeria are lacking, only feed production from larva and adult insects are available in South Africa. Instead, roasting, frying, cooking, toasting among other processing strategies and hawking whole processed insects within different regions in Africa and Nigeria are the order of the day. Since edible insects have varied advantage over livestock production and are promising as food prospects, it is imperative to promote insect-based food entrepreneur and enlighten the general public to have a bite.

Keywords: Edible insects, rearing methods, incorporation, commercial food products

1.0.Background

Insects are most diversified assemblage of organisms classified under the phylum Arthropoda in nature. An aggregate sum of 2-3 million insect species constituting as much as 80% - more than 90% of all species in the animal kingdom are estimated to dominate the Earth (Premalatha, 2011; Speight et al., 2008; FAO, 2013). Most astonishing is their capability of rapid reproduction producing large numbers of offspring although depending on the suitability of environment with which they are predisposed. Insect are however classified as either holometabolous or hemimetabolous in nature with subject to life cycle exploration; both adept in shedding their skin as grow to maturity occurs (Speight et al., 2008). The release of noxious, greenhouse and related gases is negligible but discharge of methane gas from the hindgut of some insects such as cockroaches, termites and scarab beetles is reported which have the potentials of contributing to global warming (FAO, 2013). Entomophagy: human insectivory referred to as the use of insects as food (Evans et al. 2015), is often not promoted in various parts of the world by National, International, local governments and the general public. Yet, westernizing dietaries are the focus of standards to be emulated (DeFoliart G.R. 1999; Yen. 2009). Today, over 1,600 to more than 2000 insect species are consumed deliberately by 80% of world population, are a normal and important part of the diet especially in Asian, African and some Latin American countries but capricious cultures, varying religion and erratic traditions are, straddling the continuum from vigorous aversion to occasional and substantial consumption (Raubenheimer and Rothman, 2013; Jongema, 2012). The checklist of insects consumed around the world are common within Coleopterans (beetles and their larvae) being the most eaten, Lepidoptera (moths, butterflies and their caterpillars), Hymenoptera (bees, wasps and ants), Orthoptera (migratory and desert locusts, crickets and grasshoppers) and the order Diptera (flies and their larvae). The nutritional value of edible insects, their role in preserving biodiversity and the use as frequent diets in particular part of the world such as sub-Saharan Africa, Australia aborigines, Latin America: Mexico, and Southeast Asia: Laos PDR, Myanmar, Thailand, and Vietnam are focal points for studies on entomophagy (Ramos-Elorduy et al., 1998; van Huis A. 2003; Cherry, 1991; Yhoung-Aree and Viwatpanich, 2005). Notwithstanding, insects cannot be overlooked as they played an important role in human nutrition as a source of protein since time immemorial and are good alternative other food supplement all over the world (Melo et al., 2011). The trails of entomophagy is often considered a peculiar habit practiced by “primitive man” and have often provoked curiosity due to their major importance in the nutrition, especially in tropical countries of the world. In the tropics, insects as human food often fill gaps in the one-sided vegetarian diets of food gatherers, and they even do so in the regions of highly developed monsoon agriculture (Bodenheimer, 1951). Also, Australian aborigines have been recorded from the point of view of entomophagy to be primitive food-gatherers. Many Insects are cold-blooded depending on thermo-environmental conditions for their metabolism, natural occurrence in high densities relating to effective reproduction, development in successful rearing systems and also from animal welfare perspective in general. This review wishes to enlighten the general public on the nutritional quotient embedded in the species they long consider pest, rearing standards with general to note requirements and lastly on the incorporated food products to be imported.

1.1. History and culture precedents for entomophagy

Insect eating has in many centuries been known as delicacies in various parts of the world. Reports have come down from archaeological findings of insects, especially locusts, being eaten by primitive peoples. Harvesting of honey as by-products has been known as a prized resource from time immemorial. Yet entomophagy, apart from honey consumption, has always been regarded as a curiosity or as ferociousness. Although, a number of recent authors have addressed the necessity of deriving stored nutrients in form of vitamin content, over and above the mere calorific value of food, as clamoured in present times. From antiquity, the earliest contact of man with insects was practical through the use of crude tools for insect harvest and the hypothetical nature of insect as food which arose with little uncertainty. Diving into knowledge on how entomophagy began is scanty and largely stemmed from analogies and circumstantial proofs. Furthermore, the consumption of various insects and their products mainly locusts and honey were common in the oldest civilizations (Bodenheimer, 1951). In prehistoric times, developmental stages (eggs, larva, nymph and pupae) and adult insects were used as food ingredients and this trend has survived into modern times. Man in early development before tools for farming and hunting evolved ate plants along with insect quite extensively which were a welcomed source of protein with the absence of meat from vertebrates (Sponheimer et al., 2005). Termites were also included in the plio-pleistocene hominin diet (Lesnik, 2014). Biblical passages had it that John the Baptiste fed on locust and honey in the wild forest during adventure in the wild. To date, human insectivory is reportedly practised traditionally in 113 countries around the world with 1600 to over 2000 insect species known to be edible. Globally, the beetles, caterpillars, bees, wasps, and ants followed by the grasshoppers, locust and crickets, cicadas, leaf hoppers and bugs, termites, dragonflies, flies and other species are largely and most frequently consumed species in Africa, Asia, Latin America and many parts of the world (Jongema, 2015). But human consumption of insects in European countries is considerably very low and often culturally inappropriate or even a taboo. Treated or infusing into convenience as novelty may encourage a bite from Europeans. Entomophagy exists in both proto-cultures and formal cultures as acceptable and most practiced around the world constituting a major source of nutritious ingredient for many people (DeFoliart, 1995; Nonaka, 2009; Ramos-Elorduy, 2009). (Ramos-Elorduy, 2009). Utilization of insect as essential elements of diet is seen in as much as 3071 ethnic groups in 130 countries (Ramos-Elorduy, 2009; FAO, 2008; Srivastava et al., 2009; Yen, 2009a, b). Insect eating in many part of the world is likely triggered by poverty especially populations particularly from Africa, Asia, the Neo-tropics, and the Palearctic (Gahukar, 2011; Manary and Sandige, 2008; Nonaka, 2009; Ramos-Elorduy, 2009). This is exemplified in African country such as Kenya where malnutrition is prevalent and studies have reported that wheat buns enriched with insects were actually preferred by the locals over ordinary breads (Gahukar, 2011). Recently, increasing interest in entomophagy as novelty in the United States and Europe is observed (FAO, 2008; Gahukar, 2011; Polis, 2011). Entomologists have made multiple efforts to promote insects and insect eating more broadly than appealing. Amongst these efforts are production of local cookbooks such as a popular cook book by Ronald Taylor's (1975) tagged Butterflies in My Stomach, and the accompanying recipe guide, Entertaining with Insects (1976) (Taylor, 1975; Taylor and Carter, 1976). Several subsequent entomophagy cookbooks have been published, including Insectes à croquer (Insects to Munch), produced by the Montreal Insectarium; and Cuisine des insectes: À la découverte de l'entomophagie, by Gabriel Martinez, a French culinary guide offering professional cooking advice. Others, such as the humorous The Eat-a-Bug Cookbook, offer readers familiar American recipes such as pancakes, pizza, and alphabet soup altered with the addition of edible invertebrates (Gordon, 1998). Due to recent popularity and interest in entomophagy in the United States, a second edition of The Eat-a-Bug Cookbook was released in 2013 (Gordon, 2013). Entomophagy is influenced by culture and religion. With trends in cultural acceptance of edible insect-based food, people are accustomed, implicated and are willing to eat edible insects as whole snack packs or infused food items that they perceive as to be with no risk and are inherently void of neophobic traits of any sort from product. The act of eating insects as food would not be justified for most inhabitants of the United States and Western Europe, where many food options exists unlike undeveloped or developing country sides. However with recent advancements in edible insect research in Europe and Netherlands, the industrial extraction of insect protein to be incorporated into a range of food products to slowly increase its prevalence for cultural acceptance by human is rising.

1.2. Why take a bite from insects?

Globally, food insecurity is one ever pressing task, how a growing population would be sustain by using the conserved available water resource, limited agricultural land comprising of arid lands and forests, limited fish stock and biodiversity management, along with rise in nutrient hunts and non-renewable energy at the peak. Therefore, the Food and Agricultural organization has proposed innovative solutions including insects to be promising in reducing to minimal stress of food insecurity on the future. Insects are predicted as a result of the hyper-quality embedded proteins and healthful fats as well as diverse minerals, fibre content amongst other nutrient of importance yet unsourced (van Huis et al., 2013; FAO. 2013; Mlcek et al., 2014; FAO, 2015). As the world rise in population as estimated to be 9 billion by 2050, climate change impacts (CCI) would be on the upsurge leading to severe emphasis on increased industrial and agro-ecology from available land systems (FAO. 2015). This upturn can lead to intense global warming and many other environmental fluctuations. Why you and many population of the world should eat insects is that the nutritional aspects are widely varied containing hyper-quality protein, diversity in fat, vitamins and minerals and that are appetizing and even delicious (Rumpold and Schlüter, 2013; Makkar et al., 2014; De Foliart, 1999; FAO, 2013). Although, nutritional score may vary between different orders and families of insects or within a genus and species respectively depending on developmental stages and dietary requirements fed upon as high levels of different minerals including potassium, sodium, calcium, zinc and iron and are also a good source of vitamins, especially B-vitamins are contained (Mlcek et al. 2014).Some justification to pointing insects as a key to reducing stress on food biosecurity includes that they have a high feed conversion ratio converting feed to fleshy tissues when farmed in a controlled rearing system, this dependent on the fact that they are cold-blooded and no energy and feed are required in body temperature maintenance (Oonincx et al. 2010). Also, the requirements of land to breed them are limited, less greenhouse and ammonia gases are emitted (Oonincx et al., 2010). Comparing all of these benefits to conventional livestock production, insect rearing as replacement to livestock production is proposed in Western societies (van Huis, 2013). Insect have with time been used in herbal medicine to production local drug combinations due to the perceived healthiness. One most fascinating aspect of using insect as food is the drastic reduction in insecticide use in the future, as insect species that bite crops of humans are in turn bitten by human. This is exemplified in Mexico where pesticide use is reduced and Chapulines (grasshoppers of the genus Sphenarium) are frequently harvested from the wild to reduce financial burdens (Cerritos and Cano-Santana. 2008; Cerritos. 2009).

Table 1.1 *Source efficiency comparison between edible insect species and conventional livestocks*

Animal species	Protein per kg edible weight	Edible portion	Feed conversion ratio – kg feed: kg live weight	Feed use – kg feed: kg edible weight	Virtual water use	Land use *
Mealworms	N.d	100%	N.d	N.d	Considerably lower	1ha
Crickets (adults)	205 g	80%	1.7	2.1	N.d	N.d
Chicken	200 g	55%	2.5	4.5	2.300 l	2 – 3.5 ha
Pork	150 g	55%	5	9.1	3.500 l	2 – 3.5 ha
Beef	190 g	40%	10	25	22.000 l	10 ha

Sources: *van Huis 2013; * van Huis et al. 2013, N.d= not determined*

1.3. Nutritional value of Edible Insects

As reiterated above, the nutritional score of edible insects are varied due to their diversity, richness and patchiness. Variability in nutritional aspects could be within groups of insect depending on the stage of metamorphosis, insect origin and diet fed upon (Finke and Oonincx. 2014). Similarly, changes in nutritional score could be a function of the preparation and processing strategies before consumption including drying, cooking, frying, amongst other local techniques (van Huis et al. 2013). Quantifying nutrient score of insects with other livestock display a significant variation to the advantage of insects. The nutritional value of edible insects is hinged on the following under listed:

a. Energy value
b. Proteins
c. Lipids
d. Fibres
e. Minerals
f. Vitamins

1.3.1. Macronutrients: This includes energy or calories and protein contents embedded in edible insects. Energy content is dependent on fat and protein on fleshy biomass quotient converted from quality diets. Adult species are calories lower compared to immature stages which are calories richer. On the contrary, high protein contained insects have lower energy content as examined in seven insect species which was relatively constant within the species ranging from 50.7% for yellow mealworm beetle (T. molitor) to 62.2% for the African migratory locust (L. migratoria) except for the wax moth (G. mellonella) where protein content was reported to be 38.4% based on dry matter only (Bednavora. 2013). Ramos-Elorduy et al. (1997) identified and calculated calorific value ranges of 293 to 762 per 100g of dry matter in 78 insect kinds and also for another eighty-seven (87) edible insect species investigated in Mexico, an average range of 15% to 81% protein content and 76% to 96% digestible insect protein ranges were reported. Edible insect have average embedded fat range of 10 – 60% in dry matter higher in immature stages compared to adults (Xiaoming et al. 2010). A peaked ranges in fat content is often related to mostly caterpillars of insects. Caterpillars of Lepidoptera have total fat content ranges of 8.6g to 15.2g per 100g of insects (Tzompa-Sosa et al., 2014). On the contrary, ranges of 3.8g to 5.3g fat content per 100g of insect were reported in grasshoppers and related Orthopterans. Several forms of fat including the triacylglycerol is the major fat constituent, phospholipids, oleic, linoleic, and linoleic acid are present in insects which serve as physiological reserves for high energy dissipations during longer flights (Tzompa-Sosa et al. 2014).

1.3.2. Micronutrients: includes fibres, minerals, vitamins and water content which are all a function of the species. Fibres are insoluble chitin material most predominant in the exoskeleton of insect with the content ranging from 2.7 - 49.8 mg per kg of fresh weight and 11.6 - 137.2 mg per kg of dry matter (Finke. 2007; van Hius et al. 2013). Although, chitin is considered an indigestible fibre, but the enzyme chitinase is present in human gastric juice to digest a considerable amount of it (Paoletti et al. 2007). Of the 7 different species of edible insects analysed, the African migratory locust had the highest fibre content while the least fibre was reported in Jamaican field cricket (Bednářová et al., 2013). Minerals such as iron, zinc, potassium, sodium, calcium, phosphorus, magnesium, manganese and copper are common to edible insects (van Hius et al. 2013). For instance, the large caterpillar of the moth Gonimbrasia belina called mopani or mopane has a high iron content (31–77 mg per 100 g of dry matter) and so does the grasshopper L. migratoria (8–20 mg per 100 g of dry matter) (Oonincx et al. 2010). Caterpillars of mopane could be a good source of zinc (14mg per 100 g of dry matter) together with palm weevil larvae Rhynchophorus phoenicis (26.5 mg per 100 g of dry matter) (Bukkens. 2005). On the other hand, the heavy metal content of an edible grasshopper Oxya chinensis formosana determined by Hyun et al. (2012) was low and safe for human consumption. A variety of insects have been reported to contain thiamine and its content ranges from 0.1 to 4 mg per 100 g of dry matter Bukkens (2005). Riboflavin, pantothenic acid, biotin, Vitamin B12, Retinol and β-carotene, α- tocopherol and 9 mg of tocopherols β + γ per 100 g of dry matter (Bukkens. 2005).

1.4. Risks of insect consumption

Eating insects could pose certain risks and these risk profile related to consumption of insects has been recently published by the EFSA (2015). Therefore, recommendations exist that persons should consume only reared insects at farms in controlled and defined conditions. The healthiness and safety of edible insects is thus ensured by high quality feeds with no traces of heavy metal contaminants. An analysis of results reported from 2003–2010 show possible risks of eating insects fed by bran containing a higher concentration of heavy metals (Bednářová et al. 2010). Some insects can also contain toxic substances naturally such as cyanogenic glycosides (Zagrobelny et al. 2009). Vijver et al. (2003) reiterated that the total heavy metal pool of the soil in which insects live could influence to a high degree correlated body concentrations of Cadmium and lead in larva T. molitor. Other possible risks of consuming edible insects may arise from eating inappropriate developmental stages of insects, poor control and gastronomic treatment.

2.0. Rearing methods

Edible insects can be treated as minilivestocks or reared in mechanized facilities. Thus, a notable scholar Rich (2006) have revised the feasibility of establishing insects in closed production facilities under controlled conditions for commercial purposes. The proposed method involved includes:

(1) Obtaining a generic pool from the wild
(2) Breeding larvae to metamorphose into adults
(3) Getting adults to mate
(4) Female insects to oviposit and eggs transferred to nursery prepared crevices in containers (where each female may carry up to 20 000 eggs)
(5) Egg hatching and
(6) Larva or caterpillars of insects are fed with high-quality feed till they grow to up to 15 centimetres in length. This method is positive for breeding various insects including witjuti grubs, hepialid moth larvae, Bardistus cibarius (bardi grub), honey ants, and the Bogong moth (Agrotis infusa) and some beetle larvae. General to note before erecting a breeding facility is the life cycle history, dietaries to feed insect species, favourable abiotic factors and nutritional aspects along with consumers' preference of species. The balance of all the mentioned will encourage survival, fecundity amongst many others.

2.0.1. Treatment of insects as minilivestocks: Treating insects as minilivestock involves small scale rearing in cement tanks, wooden containers or any other defined facilities covered with a nylon nets filled with nutrient filled loam soil, desirable grasses and weeds e.g. cricket farming in Thailand. The most preferred species eaten by the people could be farmed in small scale. However, special care are taken to secure whatever species reared and avoid any escape into crops where they could invade crops and become serious pests.

Fig. *A typical Asian minilivestock system for crickets. (Photo: Anna Jansson).*

2.0.2. Mass producing insects in mechanized facilities: Rearing insects in mechanized facilities involves high designed equipment, mechanization, industrial intensive, varieties of production elements, computerizations and cost effectiveness while feeding, watering, handling, harvesting, cleaning systems, processing, packaging and storage are the processes involved with production (Cortes-Ortiz et al., 2016). Employing personnel to oversee the process may not be needed since the process of rearing is automated. Rearing in large quantity is often not justified since a lot are present in market which are of varied worth. Although, incorporating these insect mass produced ingredient into easy-made ready to eat food products with designated price tags could improve the level of mechanization in production processes to a considerable percentage and encouraging edible-insect farming to a high extent with costs per kilo sufficiently low compared to when treated as whole packed. History of each insect life cycle and performance are needed for effective mass production. For instance, the below pictograph is designated to farm the yellow mealworm, T. molitor in the south of Spain and this design could be applied to other variable insects reported to be edible with no risk. The feed stocks are stored up in silos where raw feed stuff can stay for maximum of 3 days and dry feedstock for a week or two. They are mixed and fed upon insects stacked in cabinet in the rearing area. When insects attain a desirable size, they are harvested, cleaned and sorted larva from adults and eggs while separating debris and faecal casts of insects. Faecal sediments are deposited in the composite area while rearing troughs are cleaned for repeated rearing process. The harvested are processed for snack pack production or fractionalization of nutrients for incorporation into convenient food products as offices and management is set at control room (Fig 2.2.).

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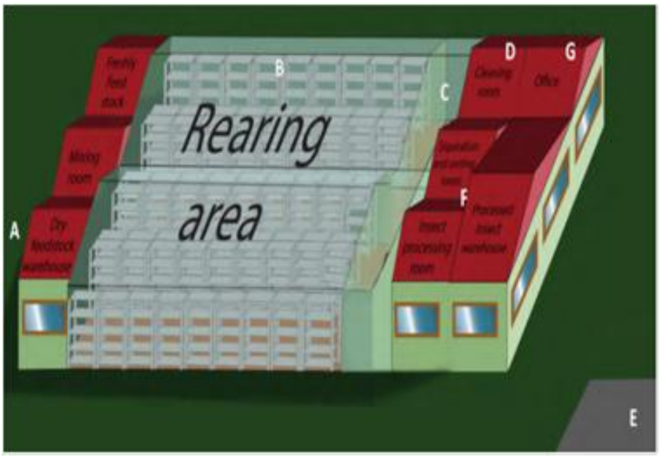

Fig. 2.2. *Pictograph of a designed structure of modern insect farm showing distribution of the operations. Source: Cortes-Ortiz et al., 2016*

How the mechanized facility functions:

- **A.** Feedstock warehouse
- **B.** Rearing area
- **C.** Harvesting room
- **D.** Cleaning room
- **E.** Composite area
- **F.** Insect processing room
- **G.** Control room

3.0 Preparation and processing strategies:

Steinberg et al. (2016) described the stepwise method to realization of insect based products. The preparation, processing and incorporation of edible insects involves:

- ✓ Selection of the desirable developmental stages or adult species is necessary as foremost process
- ✓ Preparation: cleaning the ectoderm of the selected species, inactivating through degutting by removal of alimentary canal which could house symbiotic bacteria and various parasites and classifying the insect larvae, pupae or adults as presented above. It is reported already that immature stages are richer in calories compared to adults which are hyper-protein embedded. Classification is necessary for front-of-pack label exhibition to trigger consumers informed choice.
- ✓ Processing: involves the decontamination of ectodermal and endodermal parts of insects and afterwards processed and preserved for whole snack pack production. Where further production other than snack pack production is required,
- ✓ Fractionalization of insect component nutrients are carried out and the extracts are
- ✓ Incorporated into different forms of insect-based products either as biscuits, appetizers, breads, juice, flavours, tomato pastes to mention just a few. Also where the extracted insect ingredient are in large quantity, they are
- ✓ Purified and stored up for future use either as protein, lipid, chitin etc.

Haven successfully followed this method as reiterated. Many insect-based products are made. They include examples as presented in the next sub-section below.

3.0.1. Examples of insect-based food product in world market: Insect-based foods and ingredients in the supermarkets are novelty incorporated products while in local markets are locally prepared. This products are hyper-prevalent in the United States and Europe, unlike in Africa where locally processed are highly recurring. Entomophagy started in Africa where local inhabitants eat insect to ward off hunger and starvation but today it is high-jacked by the Europeans, Asians, United States to convert these products into what and what consumers perceives as new in order to kill neophobic attitudes for processed whole insects. Although, only about 10-30% concentrates of whole insects extracts are infused. Novelty products can be sold at relatively high prices in comparison to whole processed and level of mechanization would rise for sustainability. Consumer acceptance of insect-based food has been addressed. So barriers to eating including perceived risk and every other related factors have been scholarly addressed from the individual, consumer organization perceptive and the governmental organization regulation acts. Thus, it is proposed (Shockley and Dossey, 2014) that an increased focus on developing more standard processed insect-containing foods, similar to those that people are already familiar with and enjoy is essential to truly realizing all of the benefits of humans eating insects. Some foody insect products available in the market includes fresh pasta from mealworm flour made in Belgium, Anty Gin made from extracted ant components by both Nordic Food Lab and The Cambridge Distillery, jungle bars made from dates, chocolates and cricket flours by Crowbar Protein, savoury and Sweet mealworm spreads also made in Belgium, various cricket-based products including chips, snack packs, biscuits and lots more, cricket bars made from cricket flour by Chapul, cricket Flour Based Protein Bars and granola bars, Pastas from bugs, insect burgers of different conformations For instance the first insect burger is made of water, ground buffalo worms (14%), vegetable oil (sunflower oil), wheat gluten (13%), wheat flour (13%), salt, white pepper, chicken egg protein powder, insulin, wheat starch, potato fiber, starch (corn, wheat) (Guar gum), yeast, paprika powder, turmeric, the second is made of made of Water, flour (13%), wheat gluten, vegetable oil (sunflower), paprika, jalapeno pepper, wheat flour, salt, white pepper, acid regulator (potassium chloride), antioxidant (vitamin E), chicken protein powder, nutrient fiber (inulin), wheat starch , Potato fibers, and the third is made up of Water, ground buffalo worms (14%), TARWEGLUTEN (14%), vegetable oil (sunflower oil), paprika, carrot, corn, salt, white pepper, chicken egg protein powder, inulin, TARWE starch, potato fibers. It is so painful that Africans who first started entomophagy are left behind due to neglect in innovation. While tourist that visit the areas quickly make do of the neglected resource. This neglect is what I tagged unprocessed income lying waste in an ignorant continent. There are no edible insect products in Africa. Available are only traditionally processed whole insects which are sold in local markets within the countries in Africa and these whole insects are either steamed, boiled, or fried. Potential entrepreneurs to promote insect incorporation are lacking in Africa. Where they are available, income to establish is often not available. The hunt of insect is seen as a game, a way to perpetuate ancestral traditions and maintaining the cultural heritage in Africa. Eating whole insects in Northern Benin is considered as snarky than a diet to be frequented. The reverse is the case in other African regions, such as areas of Southern Nigeria where edible insects are conceived as a proper meal and source of nutrients, or among the Pedi of South Africa who prefer certain of their traditional insects to meat (Banjo et al., 2006). As such insect eating and preparation is mostly localised, with only a few known species being commercialised and sold to both within rural communities and urban centres. The saturniid caterpillar, C. forda**,** palm grubs (R. phoenicis), termites, and Anaphe larvae are main ventured insect species as food. Most Nigerians have had direct or indirect experience with entomophagy, although it is more prevalent in rural than in urbanized areas. Directly by purchasing locally processed or indirect by food contaminations.

Cricket Flour Based protein Bars
Cricket Flour Based Granola Bars
Nutribug Pro Pasta
Insect burger 1
Insect burger 2
Insect burger 3
At table in France

Fig 3.1 *Show some selected insect products in the United States, Asian and European countries.*

Source: *4ento 2015 a & b.*

The fig 3.2 pictograph below is the only process found in African countries where insects are harvested from the wild, or from minilivestock and roasting in hot charcoals among other local processing strategies are common. Whole insects processed by local inhabitants are hawked in various regions of Nigeria especially South-western region of the country. Nigerians have failed to acknowledge that insects alone cannot solve the problems linked food biosecurity and that it is by insect incorporation that sustainability is realized as food to be known by its masses. According to the 2013 report by the UN Food and Agriculture Organization, it is estimated that at least 2 billion people worldwide already eat insects as part of their diet in fulfilment to promoting edible insects as a way to improve nutrition, reduce greenhouse-gas emissions and creating jobs in insect food production. Although, several reports from scholars in different parts of the world have reviewed insects to be an important alternative source of proteins and nutrients that can contribute to improvement of food and nutritional safety for the poorer and disadvantaged areas of the planet. The foci of interest is the involvement of governmental (if there is any) and non-governmental organizations spread throughout the world to contribute to filling the gaps that exist in shortage of food products to combat food insecurity. Promoting insect breeding or micro-breeding can help to increase the available of edible insects in time of incorporation into different forms either as flours, confectioneries, snack packs, and other flavoured products. These checklist of insect in fig 3.3 below are used for incorporation of various foods in fig 3.1.

Bamboo worms Cicadas Crickets Dragonflies

Conclusively, the state of the art of edible insects to decreasing the environmental burden of food consumption are available and proceedings of incorporated insect-based food product as triggered by the 2014 first interdisciplinary meeting of Insects to Feed the World (IFW) and the 2015 World Edible Insect Day (WEID)clarified. Sensorial attractiveness, perceived healthiness, Visibility, sweetness, tolerance and convenience are all accountable attributes reported (Materia and Linnemann, 2016) and benefits to this valued proposition of insect-based foods. Since edible insects are promising and have varied advantages over livestock production as food prospects, it is imperative to promote insect-based food production, entrepreneur and enlighten the general public to have a bite.

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