Chapter 2
African Edible Insect Consumption Market

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Abstract Consumption is the utilization of economic goods to satisfy needs. Africa is home to the rich diversity of insects with over 1500 species of insects. Several reports highlighted the nutritional, medicinal values and industrial uses of some edible insects. The global edible insects market is mainly segmented by insect type, product type, application, and geography. Insects can be grown on organic waste. The potential of edible insects in curbing the menace of malnutrition and ensuring food security has necessitated so much interest in the production, marketing, and utilization of edible insects.

Keywords Edible insect · Consumption · Commercialization · Market

2.1 Introduction

Consumption is often defined as the utilization of economic goods to satisfy needs. The dictionary of marketing terms defined consumption as the process of using consumer products in order to satisfy desires, real or imaginable needs so that the products are used up, transformed or deteriorated in such a manner as not to be either reusable or recognizable in their original form (https://www.allbusiness.com/

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barrons_dictionary/dictionary-consumption-4965423-1.html). African edible insect consumption market therefore refers to the business of promoting production, buying, and selling of edible insects and products derived from insects as well as other beneficial services from insects including entotherapy/zootherapy. Promotion of edible insect production requires preservation of forests where the insects thrive or provision of simulated environment or other devices for mass production of insects. In the wild, the volume of edible insects and by-products from it correlates with the wealth of forest resources. The African continent is endowed with rich forest resources, especially tropical rain forests (Bernard and Womeni 2017).

According to FAO (2005), forests and woodlands in Africa occupy an estimated 650 million hectares (21.8%) of the land area of this continent and account for 16.8% of the global forest cover. On average, forests account for 6% of gross domestic product (GDP) in Africa, which is the highest in the world. In Uganda, for example, forests and woodlands are now recognized as an important component of the nation's stock of economic assets and they contribute in excess of US$546.6 million to the economy. Leal et al. (2016) highlighted the relationship between the forest ecosystem and insect biodiversity. Insects according to Alaloiun (2014) play an essential role in forest ecosystems by affecting the primary production and evolution of plants. They form a critical link between plants and higher trophic levels (Crawley 1997, cited in Alaloiun 2014). There are over 1500 species of edible insects across Africa, this is closely related to its tropical climate and magnitude of tropical rainforest that is majorly home for an enormous species of insects. Today, these vast species of insects have become a singular resource in sustaining food security and curbing the menace of malnutrition in the continent.

Sidiki Sow (2016) in his report on "Insect Protein for Food Security in West Africa" stated that by 2050 the world population will be 9.4 billion, with 2.4 billion people in Africa. This teeming population will demand double amount of food and animal feed production to meet nutritional needs of man and animal. Van Huis (2015) and Alexandratos and Bruinsma (2012) reported that meat consumption in sub-Saharan Africa is expected to double from 202% from 2010 to 2050. It will therefore be a herculean task to feed such a huge population especially in Africa where the World Food Program (2016) already reported that one out of every four Africans is undernourished, 1.2 M people are in urgent need of food assistance in Mali, Niger, and Burkina Faso, and USS 11.5 M is needed to offset food deficit challenges in Mali and Niger. In Kenya USAID in 2014 reported that 1.5 million people needed food assistance, while cases of kwashiorkor is presently reported in northern part of Nigeria (Hamidu et al. 2003). If the extrapolation on population growth for 2050 becomes real, feeding of such a massive population will mean increase in agricultural activities and its concomitant environmental degradation. Of all food nutrients, animal protein deficiency is more pronounced, with records as low as 7–10 g/person/day in many African countries against the 35 g/person/day recommended by FAO (1991) for normal growth and development.

Besides, massive production of livestock to increase animal protein supply and consumption will lead to environmental issues especially higher levels of greenhouse gases (GHG), pollution of water resources and making land unavailable for other uses. According to Food and Agricultural Organization (FAO), livestock is the world's largest user of land resources, with grazing land and cropland dedicated to the production of feed representing almost 80% of all agricultural land. Judging by the hunger rate in Africa, if 50% of this land is used in producing food for human consumption, hunger rate would have drastically reduced. Livestock also requires large amount of water, grains used in feed formulation required about 1000–5000 kg of water to grow depending on the region (Chapagain and Hoekstra 2003). Livestock itself contains between 5 and 20 times more water per kg product (Chapagain and Hoekstra 2003). In most African countries, there is little or no factual record on the level of environmental degradation associated with livestock activities.

However, given the triad doom-spelling factors in Africa (fast growing population, natural resource degradation by slash-and-burn agriculture, and high level of malnutrition), edible insect cultivation and utilization as food and feed appear very promising in ensuring food security in the continent. FAO (2008) (cited in Van Huis 2013 recommended insects as alternative source of food, capable of meeting the animal protein demands of a growing population while preserving the environment. As a follow-up to the FAO workshop in Chiang Mai in 2008, the Non-Wood Forest Products Programme of the FAO Forestry Department and the Wageningen University and Research Centre (WUR) (Laboratory of Entomology) initiated a collaborative effort to promote entomophagy; thus FAO (2013) outlined common insects consumed globally, including beetle, grasshoppers, locusts, and crickets. Consumption of larva of many insects has also been documented. In an earlier work FAO (2013) reported consumption of mopane caterpillar (*Imbrasia belina*) in Angola, Botswana, Mozambique, Namibia, South Africa, Zambia, and Zimbabwe. Malaise (1997) identified 38 different species of caterpillar consumed across the Democratic Republic of Congo, Zambia, and Zimbabwe. Evidently, rearing insects requires remarkably less land than farming other categories of livestock (Oonincx and de Boer 2012).

Several reports in literature highlighted the nutritional, medicinal values and industrial uses of some edible insects (Ekpo and Onigbinde 2004, 2005; Banjo et al. 2006; Edijala et al. 2009; Alamu 2014; Mbah and Elekima 2007; Ebenebe and Okpoko 2014; Schabel 2010). According to Braide et al. (2010) protein content of edible insects ranged from 21 to 65% and therefore compares favorably with meat and fish proteins. Igwe et al. (2011) also reported that insect larvae are rich in essential amino acids like lysine and threonine which are deficient in grain and cereals. Similarly, Ekpo and Onigbinde (2004) had earlier reported that edible insect larvae are rich in essential fatty acids like linoleic and linolenic acids while Igwe et al. (2011) reported on vitamin content of edible insects. Apart from the nutritional and medicinal benefits, there are other ecological, magical, and spiritual benefits of insects; therefore edible insect consumption market in Africa will address all of these aspects of insect benefits and the level of commercialization in Africa. According to FAO (2012), edible insects contain high-quality protein, vitamins, and amino acids for humans. Insects have a high food conversion rate; for example, crickets need six times less feed than cattle, four times less than sheep, and twice less than pigs and broiler chickens to produce the same amount of protein. Besides, they emit less greenhouse gases and ammonia than conventional livestock (Oonincx et al. 2010). Insects can be grown on organic waste. The potential of edible insects in curbing the menace of malnutrition and ensuring food security has necessitated so much interest in the production, marketing, and utilization of edible insects.

The global edible insects market is mainly segmented by insect type (crickets, mealworms, black soldier flies, buffalos, grasshoppers, ants, silkworms, cicadas, and others), product type (whole insects, insect meal, insect powder, insect protein bars and protein shakes, insect baked product and snacks, insect confectionaries, insect beverages, insect oil, and others), application (human consumption, animal nutrition, and cosmetics and pharmaceutical), and geography.

2.2 Edible Insects as Food in Africa

Edible insect consumption in Africa is as old as the continent. The continent is home to the richest diversity of insects with over 1500 species of insects (Raheem et al. 2019) ranging from caterpillars (Lepidoptera) to termites (Isoptera), locust, grasshoppers, cricket (Orthoptera), ants and bees (Hymenoptera), bugs (Heteroptera and Homoptera), and beetles (Coleoptera) (Saliou and Ekesi 2017). Although almost all African countries practice entomophagy, there is considerable variation in the most consumed insect order in the continent.

Saliou and Ekesi (2017) listed the most dominant insect eating countries to include Democratic Republic of Congo, Congo, The Central African Republic, Cameroun, Uganda, Zambia, Zimbabwe, Nigeria, and South Africa. Kelemu et al. (2015) and Kelemu (Kelemu 2016) gave a country-by-country run down of common species/orders of insects consumed in each of the African countries (Fig. 2.1 and Table 2.1), while Adeoye et al. (2014) showed diversity of edible insects in the African subregion.

In the Central African Republic, 96 species of insects are consumed. Of these 96 species, Roulon-Doko (1998) cited in Raheem et al. (2019) stated that insects of the order Orthoptera (locust and grasshopper) were the most consumed (40% consumption level), followed by Lepidoptera (36%), Isoptera (termites 10%), Coleoptera (beetles 6%), and others such as cicadas and crickets (8%) (Table 2.2).

In Kenya, Kinyuru et al. (2012, 2013) showed that six species of edible insects are consumed in the western part of Kenya. Of the six species four are termites of four different subspecies (*Pseudocanthotermes militaris* H., *Macrotermes bellicosus* S., *Macrotermes subhyalinus* R., and *Pseudocanthotermes spiniger* S.), the rest are black ant and long-horned grasshopper. Ayieko et al. (2012) posited that insect species like “agoro” termites, black ants, crickets, and grasshoppers form part of traditional menu in the western part of Kenya (Table 2.3).

In Ghana, the report of Anankware et al. (2016) showed that nine edible insects are consumed in Ghana, with scarab beetle (2%), field cricket (5%), shea butter tree

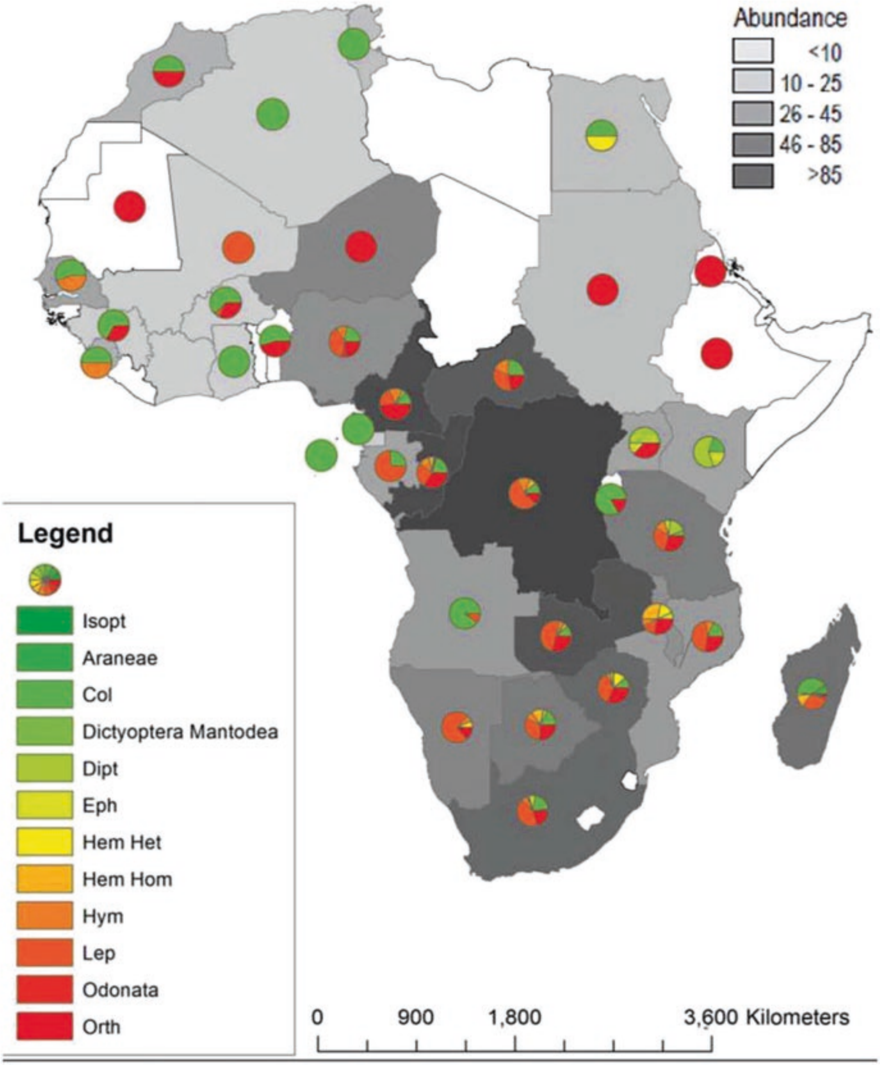


Fig. 2.1 Diversity and abundance of main groups of edible insects in Africa. (Source: Kelemu 2016 in Raheem et al. 2019)

caterpillar (8.7%), house cricket (9.5%), and locust (10%), African palm weevil larvae (47.2%), termites (45.9%), ground cricket (*Scapteriscus vianus*, 33.3%), and grasshoppers (30.5%). His report showed that Northern Ghana dominates in entomophagy as eight out of the nine edible insects consumed are mostly eaten in that region (Table 2.4). In Uganda, Raheem et al. (2019) reported that termites (*Macrotermes* spp.) and grasshopper (*Ruspolia nitidula*) are the most consumed edible insects.

Table 2.1 The most consumed insect species in Africa. Countries and regions of Africa where species are mostly consumed

Order	Scientific and common names	Countries
Coleoptera	*Oryctes owariensis* (Palisot de Beauvois) (Rhinoceros beetle)	DRC, South Africa, Ivory Coast, Sierra Leone Guinea, Ghana, Equatorial Guinea, Guinea Bissau
	Rhynchophorus phoenicis (Fabricius) (African palm weevil)	DRC, Cameroon, Congo, CA Republic, Nigeria, Angola, Ivory Coast, Niger, *São Tomé and Príncipe*, Guinea, Togo
	Oryctes boas (Fabricius) (Boas rhinoceros beetle)	Nigeria, Ivory Coast, Sierra Leone, Guinea, Liberia, Guinea Bissau DRC, Congo, South Africa, Botswana, Namibia
Hemiptera	*Encosternum delegorguei* (Spinola) (Stinkbug)	South Africa, Swaziland, Mozambique, Malawi, Zimbabwe, Botswana, Namibia
Hymenoptera	*Apis mellifera mellifera* Linnaeus (European dark bee)	DRC, Zambia, Botswana, Nigeria, Tanzania, Senegal, Sierra Leone, Ghana, South Sudan, Togo, Lesotho, Benin
	Apis mellifera adansoni (Latreille) (Africanized honey bee)	DRC, Zambia, CA Republic, Nigeria, Tanzania, Sierra Leone, Ghana, Benin
	Carebara vidua (Smith)	DRC, Zambia, South Africa, Zimbabwe, Botswana, Malawi, Sudan, Kenya, South Sudan
	Carebara lignata (Westwood)	Zambia, South Africa, Zimbabwe, Botswana, Sudan, Mozambique, Namibia, South Sudan
	Macrotermes spp. (African mound-building termites)	DRC, Zambia, Zimbabwe, Nigeria, Tanzania, Malawi, Senegal, Uganda, Cote d'Ivoire, Guinea, Ghana, Togo, Burundi
	Macrotermes bellicosus (Smeathman) (Termites)	DRC, Cameroon, Congo, CA Republic Nigeria, Cote d'Ivoire, Kenya, *São Tomé and Príncipe*, Guinea, Togo Liberia, Guinea Bissau, Burundi
	Macrotermes subhyalinus (Rambur) (Mendi Termite)	Zambia, Angola, Kenya, Togo, Burundi
	*Macrotermes falcige*r (Gerstäcker)	Zambia, Zimbabwe, Burkina Faso, Burundi, Benin
	Macrotermes natalensis (Haviland)	DRC, Cameroon, Congo, CA Republic, Nigeria, Burundi, South Africa, Zimbabwe, Nigeria, Malawi
Lepidoptera	*Bunaea alcinoe* (Stoll) (African moth)	DRC, Zambia, South Africa, Cameroon, Congo, Central African Republic, Zimbabwe, Nigeria, Tanzania
	Anaphe panda (Boisduval) (Silk moth)	DRC, Zambia, Cameroon, Congo, CA, Republic, Zimbabwe, Nigeria, Tanzania
	Cirinaforda (Westwood) (Emperor moth)	DRC, Zambia, South Africa, Botswana, Burkina Faso, Nigeria, Mozambique, Namibia, Ghana, Togo, Chad
	Dactyloceraslucina (Drury) (Drury's Owl Moth)	DRC, Zambia, South Africa, Cameroon, Congo, Angola, Gabon, Sierra Leone, São Tomé and Príncipe, Equatorial Guinea

(continued)

Table 2.1 (continued)

Order	Scientific and common names	Countries
	Platysphinx stigmatica (Mabille) (Red spot moth)	DRC, Zambia, Congo, CA Republic, Sierra Leone, São Tomé and Príncipe, Equatorial Guinea, Rwanda, Burundi
	Cirina butyrospermi (Vuillot) (Shea tree caterpillar)	DRC, Zambia, South Africa, Zimbabwe, Burkina Faso, Nigeria, Mali, Ghana
	Epanaphe carteri (Walsingham)	DRC, Zambia, Angola, Gabon, Sierra Leone, São Tomé and Príncipe, Equatorial Guinea
	Imbrasiabelina (Westwood) (Mopane caterpillar, mopane worm, emperor moth)	DRC, Zambia, South Africa, Zimbabwe, Botswana, Malawi
	Gynanisaata (Strand) (African moth)	DRC, Zambia, Malawi, South Sudan
	Eumeta cervina (Druce) (Bagworm)	DRC, Cameroon, Congo, CA Republic, Angola, Gabon, Sierra Leone, Sao Tome
	Imbrasia ertli (Rebel) (Confused Emperor)	Zambia, South Africa, Cameroon, Congo
	Anaphe venata (Butler) (African silkworm)	Zambia, South Africa, Cameroon, Congo, CA Republic, Zimbabwe, Botswana, Angola
	Imbrasia epimethea (Drury) (African moth)	DRC, Zambia, South Africa, Cameroon, Congo, CA Republic, Zimbabwe
	Urota sinope (Westwood) (Tailed Emperor)	DRC, South Africa, Zimbabwe, Botswana, Gabon, Mozambique, Namibia
Orthoptera	*Schistocerca gregaria* (Forskål) (Desert locust)	Zambia, South Africa, Cameroon, Congo, Botswana, Tanzania, Sudan, Uganda, Ethiopia, Kenya, Sierra Leone, Morocco, Guinea, Lesotho, Mauritania, Somalia, Eritrea, Guinea Bissau
	Acanthacris ruficornis (Fabricius) (Garden locust)	DRC, Zambia, South Africa, Cameroon, Congo, CA Republic, Zimbabwe, Burkina
	Brachytrupes membranaceus (Drury) (Tobacco cricket)	Zambia, Cameroon, Congo, CA Republic, Zimbabwe, Burkina Faso, Nigeria, Tanzania, Angola, Togo, Benin
	Nomadacris septemfasciata (Serville) (Red locust)	Zambia, South Africa, Congo, Zimbabwe, Uganda, Mozambique
	Ruspolia differens (Serville) (Longhorn grasshopper)	DRC, Zambia, South Africa, Cameroon, Zimbabwe, Kenya, Uganda, Tanzania
	Zonocerus variegatus (Linnaeus) (Variegated grasshopper)	DRC, Cameroon, Congo, CA Republic, Nigeria, Côte d'Ivoire, São Tomé and Príncipe, Guinea, Ghana, Liberia, Guinea Bissau
	Locusta migratoria migratorioides (Reich & Fairmaire) (Migratory locust)	Zambia, Cameroon, Congo, Zimbabwe, Sudan, South Sudan
	Locusta napardalina (Walker) (Brown locust)	Zambia, South Africa, Zimbabwe, Botswana, Malawi, Libya

(continued)

Table 2.1 (continued)

Order	Scientific and common names	Countries
	Gastrimargus africanus (Saussure) (African grasshopper)	Cameroon, Congo, Niger, Lesotho, Liberia
	Phymateus viridipes brunneri (Bolivar) (Gaudy grasshopper)	Zambia, South Africa, Congo, Zimbabwe, Botswana, Mozambique, Namibia
	Gryllus bimaculatus (De Geer)	Guinea Bissau, Sierra Leone, Guinea, Liberia, Benin, Togo, Nigeria, DRC, Kenya, South Sudan, Zambia
	Anacridium melanorhodon melanorhodon (Walker) (Sahelian tree locust)	Cameroon, Sudan, Niger
	Paracinema tricolor (Thunberg)	Cameroon, Malawi, Lesotho
	Acheta spp. (Crickets)	Zambia, Zimbabwe, Kenya

Source: Kelemu et al. (2015) cited in Raheem et al. (2019)

According to Silow (1976) cited in Kelemu et al. (2015), a single community in Africa consume different kinds of insect species. In the report of Kelemu et al. (2015) communities like Mbunda people in Angola, Zambia, and Namibia 31 species of edible insects, 21 species are consumed by Ngandu people in Democratic Republic of Congo (DRC), 96 species by Gbaya people (Takeda 1990), 30 species consumed among the Bemba people in northern Zambia, southern DRC, and north-eastern Zimbabwe (Malaisse 2005) and 27 species in Botswana (Obopile and Seeletso 2013). Van Huis (2003) earlier stated that 246 species of edible insects are consumed in 27 African countries.

Nigeria appear to be taking the lead in edible insect consumption in Africa, probably due to her very large population (over 180 million) even though the number of species is not as much compared to other African countries but the quantity consumed is by far more appreciable. Alamu et al. (2013) listed 22 insect species commonly consumed in Nigeria: 27.3% Lepidoptera (moths), 27.3% Coleoptera (beetles), 22.7% Orthoptera (grasshoppers and crickets), 13.6% Isoptera (termites), and 9.0% Hemiptera and Hymenoptera (bees). Besides, there are numbers of regional report on edible insect consumption. Ebenebe and Okpoko (2016) reported that even though the cricket (*Brachytrupes* spp.) is the most preferred edible insect in the south east Nigeria, termite is the most consumed, due to unavailability of cricket in the local markets. However, termites are seasonal, while African palm weevil larvae, the third most preferred edible insect, have the advantage of year round availability. Insect consumption in the six geopolitical zones in Nigeria is summarized in Amobi and Ebenebe (2018) (Table 2.5). Ebenebe et al. (2017a) also reported on the survey of edible insects consumed in the south eastern Nigeria and the local dishes cooked with edible insects (Table 2.6).

Table 2.2 Diversity of edible insects in Nigeria and their geographical distribution

Scientific name	English name	Local name	Order	Family	Location	Consumption stage
Cirina forda Westwood	Pallid Emperor moth	Yoruba: Kanni, Munimuni	Lepidoptera	Saturniidae	North Central, North East, South-West	Larvae
Bunaea alcinoe Cram	Emperor moth	–	Lepidoptera	Saturniidae	North Central, North-East, North-West	Larvae
Rhynchophorus Phoenics	Palm weevil	Yoruba: Ipe, Itun	Coleoptera	Curculionidae	South-South, South-West	Larvae
Oryctes boas Otyctes monocerus Oliver	Snout beetle	Yoruba: Ogongo	Coleoptera	Scarabaeidae	South-South, South-West	Larvae
Analeptes trifasciata	Rhinocerus beetle	Ibo: Ebe	Coleoptera	Scarabaeidae	South-South, South-West	Larvae
Anaphe venata	Caterpillar	Yoruba: Ekuku	Lepidoptera	Notodontidae	South-West	Larvae
Heteroligus meles Billberger	Yam beetle	–	Coleoptera	Scarabaeidae	South-West South-South South-East	Adults
Zonocerus	Grasshopper	Yoruba:	Orthoptera	Pyrgomorphidae	North Central	Adults

Source: Adeoye et al. (2014)

Table 2.3 Major edible insects of Ghana

Common name	Scientific name	Local name in Ghana	Stage consumed
Palm weevil larva	*Rhynchophorus phoenicis*	Akokono in Twi/Akan	Larva and adult
Beetle larva	*Phyllophaga nebulosa*	Chibionabra in Kasem	Larvae
Termite	*Macrotermes bellicosus* S	Kwena in Kasem	Adult
Shea tree caterpillar	*Cirina butyrospermi* V.	Kan Tuli in Frafra Dagari	Larva
Locust	*Locusta migratoria* L	Gbameda in Ewe	Adult
Grasshopper	*Zonocerus variegatus* L.	Manchogo in Kasem	Adult
House cricket	*Acheta domesticus* L.	Cheri in Kasem	Adult
Field cricket	*Gryllus similis* C.	Paan-terkyiirae in Dagoan	Adult
Ground cricket	*Scapteriscus vicinus* (Scudder)	Tigachari in Kasem	Adult

Source: Anankware et al. (2015)

Table 2.4 Traditional animal source foodstuffs and their edible parts consumed in Western Kenya

Common name	Scientific name	Local name (in Kenya)	Stage consumed
Winged termite	*Pseudacanthotermes militaris*	Hagen	Whole: dewinged
Winged termite	*Macrotermes bellicosus*	Smeathmen	Whole: dewinged
Winged termite	*Macrotermes subhyalinus*	Rambier	Whole: dewinged
Winged termite	*Pseudacanthotermes spiniger*	Oyala	Whole: dewinged
Black ant	*Carebara vidua*	Onyoso	Abdomen: dewinged
Long-horned grasshopper	*Ruspolia differens*	Senesence	Whole: dewinged

Sources: Kinyuru et al. (2012, 2013)

Table 2.5 Edible insects in each of the six geopolitical zones in Nigeria

Zone	Insects
North-East	Grasshopper, locust, cricket, pallid emperor moth larva, emperor moth (Amobi and Ebenebe 2018; Adeoye et al. 2014)
North-West	Grasshopper, locust, cricket, and emperor moth (Amobi and Ebenebe 2018; Adeoye et al. 2014)
North-Central	Grasshopper, locust and cricket, pallid emperor moth larva, emperor moth, mole cricket, green stink bug, termite (*Macrotermes natalensis)*, rhinoceros beetle (*Bunaea alcinoe* Cram) (Amobi and Ebenebe 2018; Adeoye et al. 2014).
South-East	Winged termite, raffia palm grub/African palm weevil, house cricket, mole cricket, termite, grasshopper, locust, caterpillar of butterfly and moth, yam beetle, praying mantis, rhinoceros beetle, greenish beetle, two unidentified species (Ebenebe et al. 2017a)
South-West	Raffia palm grub/African palm weevil, snout beetle, rhinoceros beetle, local silkworm, yam beetle, grasshopper, honey bee, termite, cricket, mole cricket (Banjo et al. 2006; Adeoye et al. 2014)

(continued)

Table 2.5 (continued)

Zone	Insects
South-South	Raffia palm grub/African palm weevil, snout beetle, rhinoceros beetle, yambeetle, grasshopper, bug beetle, termite, honey bee and caterpillar of butterfly, cricket, mopane worms (Okore et al. 2014; Okweche and Abanyam 2017)
Niger Delta[a]	Termite, crickets, locust, grasshopper, African palm weevil, rhinoceros beetle, praying mantis, yam beetle, rice weevil, bean beetle, egg fruit borers, mopane worms, bees, house fly, cotton stainer (Okore et al. 2014)

[a]Niger Delta is a part of South-South Zone. (Source: Amobi and Ebenebe 2018)

Table 2.6 Season of harvest/method of harvest and preservation

Edible insect	Season of harvest/ month of the year	Site of harvest	Method of collection/ harvesting	Method of preparation
Winged termite	May–July	Farmlands and open fields	Light trapping	Drying/ frying
Raffia palm grub	All year round	Raffia palm	Nibbling sound of larvae in the rotting tree/ handpicking from rotting palm tree	Roasting/ Frying
Cricket	October–May	Home stead/farmland and small sand dunes on the bank of water bodies or sandy areas	Light trapping during the rains/digging out from the tunnels during the dry season and handpicking	Frying
Rhinoceros beetle	All year round	Oil palm plantation	Handpicking	Drying

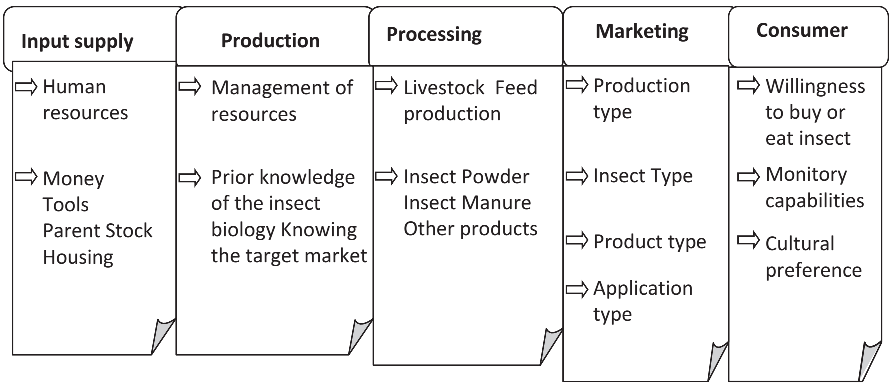
Of all the 22 species of edible insects in Nigeria, four (African palm weevil, termite, locust, and grasshopper) are harvested in large quantities and sold in urban markets, while the rest are consumed locally.

2.3 Market Values of Edible Insects Used as Food

According to the report by Persistence Market Research (2018), the global edible insects market is expected to grow tremendously between 2017 and 2024. The global market for edible insects is estimated to reach US$ 722.9 million revenue. Global Opportunity Analysis And Industry Forecast (2018–2023) stated that the edible insect market is expected to reach US$ 1181.6 million by 2023, supported by a CAGR of 23.8% during the forecast period of 2018–2023. Owing to the short generation interval of insects and the high nutritional benefits, it is proposed worldwide as a tool to reduce hunger and poverty especially in developing countries such as Africa. DeFoliart (2002), reported that scores of species of edible insects are prominent items of commerce in the town and village markets of Africa and tropical and semitropical regions of the world. The growing trend on insect as food and feed has necessitated the establishment of large scale insect farms especially in the developed countries (Europe and America) and also in Asia; African countries known to consume one-fourth of the global edible insect inventory (Van Huis 2013) and to have favorable climate for insect growth and multiplication is yet to develop large scale insect farms except for agri protein in South Africa, experimental work of Aspire in Ghana and INSFEED project in Kenya and Uganda. Production therefore is on low scale and mostly on wild collection and many of the edible insects are seasonal.

The value of edible insects in many African countries therefore fluctuates with location, season of harvest, community's attitude to insect consumption, type of insects, and time spent in search for insects. In Nigeria, for instance, insects are consumed in all the six geopolitical zones, and each region has one or two insects that are most cherished. Apart from domestic consumption by the gatherers and their families, the excesses are sold for cash at local markets or by the street corners. Sales to urban markets is rare among some insects but huge in some others, where such sales occur, the insects are often sold to middlemen who sell to retailers. The interaction and number of middlemen involved usually set the final price of the insects for the end consumer. In Gombe state located in north eastern part of Nigeria for example, a measure of grasshoppers, crickets, winged termites and locusts sells for 500–800 and above depending on bargaining power of the customer in various local markets: Babbarkasuwa, Kumo; Tashargwari, Kumo; Gombe old market, Gombe; Saturday village market, Billiri; Wednesday village market, Dukku; Friday village market, Kaltingo; Thursday village market, Dadinkowa; Saturday village market, Malancidi (Amobi M, Personal observation, 2017). In the south eastern Nigeria, winged termites of similar measure sells for $8.22 to $10.96, while in the south southern Nigeria, a similar measure of African palm weevil larva sells for $4.11 and above (Amobi M, Personal Observation, 2017). In the southeast Nigeria, 3–4 roasted African palm weevil larvae sells for $0.37 in the cities while in the villages, the price can be as low as 7–8 larvae at the same $0.37 about 100 g of termite for $0.74.

Despite these challenges, edible insect market continues to thrive and grow tremendously. Kelemu et al. (2015) noted that in southern Africa alone, the trade value of mopane worm is over $85 million. The market for insect usually have a value chain that includes the following:



2.3.1 Input Supply in Edible Insect Value Chain

Edible insects in Africa is at subsistence level and mainly gathered from the wild in many African countries. The insects are handpicked or harvested through indigenous techniques for capturing. Tools such as brooms, water, sound, lights traps, and other forms of traps are used for catching insect. Adeoye et al. (2014) reported a case in Lagos state Nigeria where women pay money to palm wine tappers to collect African palm weevil larvae from felled raffia palms especially in swampy areas that are inaccessible. Ebenebe and Okpoko (2016) also reported similar intervention by palm wine tappers at Ngbo swamp, Ebenebe town in Anambra State, Nigeria. The women involved in the APW larvae business purchase directly from wine tappers and sell to consumers. The women are often owners of restaurants, hotels and other forms of eateries where the African palm weevil larvae are sold to men who use it together with beer to cool off after a hectic day job. Young people who do not have localized business centers are often seen hawking the roasted insects in open or glass sealed containers. Insects like grasshopper and locusts are gathered largely from the northern part of Nigeria especially by women and children. The preparation forms of insect intended for sale include dried, cooked or boiled, and fried (Fig. 2.2). The present subsistence level of insect business is not yet specialized and therefore does not attract funding either in form of loan from banking industries or grant from other funding agencies.

2.3.2 Production Factor in Edible Insect Value Chain

Large-scale production in any business endeavor is the standpoint on which profitability of the business is hinged. Mass production is the only means of ensuring low cost of production and profitability of the insect business. High productivity

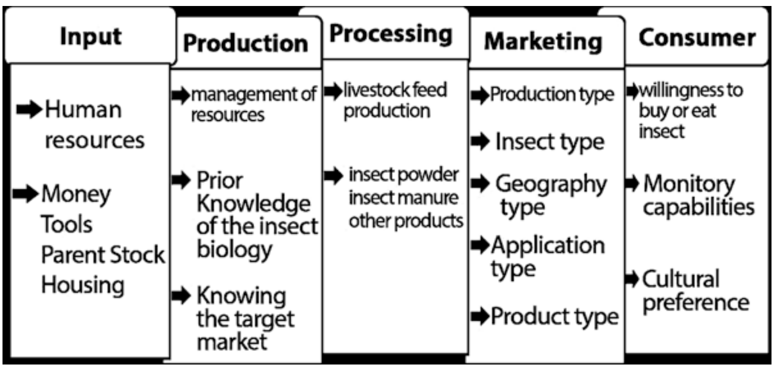


Fig. 2.2 Value Chain of Edible Insects

and profitability requires a good knowledge of the insect biology, disease problems of such insects, and health risks associated with edible insect consumption (Chai et al. 2009; Graczyk et al. 2005). Many rural dwellers who are in the business of gathering edible insects from the wild do not have knowledge of the insect, technique of captive rearing, and pathogens and parasites that can hamper their productivity or usability. Disease outbreak can marked the entire insect rearing business. Production in this line of business also requires the market for the produce. Braide (2012) cited in Kelemu et al. (2015) noted that leaves of host plant of emperor moth (*Bunaea alcinoe* S.) are primary source(s) of microorganisms associated with foodborne illnesses in the guts and skins of the larvae. Mastery of the biology of each of the edible insect species is sine qua non in sustaining mass production of the insect.

As important as the knowledge of the biology of the animal, is the knowledge of the target market. Camilleri (2017) opined that knowing the target market is a prerequisite for the development of customer-centric strategy which specify the target markets. Large-scale profit making edible insect business is still at experimental stage in most parts of Africa. At the subsistence level found in most parts of Africa, edible insect market is mainly consumer market either on the roadside or designated market centers or hotels and restaurants. Large scale export market is monopolized by few players such as AgriProtein established in Elsenburg, South Africa by Jason and David Drew. AgriProtein feeds black soldier flies with municipal waste and sells them as feed for the livestock industry. The largest insect farm in Africa sited near Cape Town (an extension of AgriProtein), is a farm conceived by a group of scientists and environmentalists eager to find protein alternatives owing to high production cost of livestock. AgriProtein plans to roll out 100 fly factories by 2024, and a further 100 by 2027. Another large scale farm is established by the Aspire group in Ghana. Aspire operates in Ghana and the USA; in Ghana they commercially farm palm weevil larvae and run a program which empowers peri-rural farmers to raise palm weevils locally. In Kenya and Uganda, a large-scale insect farm is coordinated by Insect for Feed for Poultry and Fish Production (INSFEED) funded by International Development Research Centre, Canada and the Australian Centre for International Agricultural Research (ACIAR).

In Nigeria, USAID Market II (United States Agency for International Development Project on Aquaculture Development In Nigeria), Next Generation Nutrition (NGN), Netherlands and the Netherland government sponsored the training of 14 Nigerians on rearing of black soldier fly larva for replacement of fish meal in livestock and fish feed in the Netherlands and Belgium. Between second to 11th October, 2017. During the training the group were trained in three Universities in the Netherlands (Wageningen University of Research (WUR), Thomas Moore University, University of Leuven and Hagues School and many large-scale insect farms (Next Generation Nutrition, Hertogenbosch, Protix, Millibeter, Proti-farm) and subsidiary industries (Feed Design Lab, Christiaens, Bonda, Blue Acres Aquaponics, Furen & Nooijen, and Skreeton). The group is already championing the developing the black soldier fly larva production under the name Quality Insect for Feed and Food in Nigeria (QUIFFAN). Mass production of edible insects could help solve food insecurity problems in the continent.

2.4 Marketing by Production Type/Processing

Processing of edible insects into more durable, more attractive forms is important strategy for improving acceptability. As earlier stated, this is already a common place in America and Asia. Globally, the edible insect market demand from flour application was valued over USD 19.5 million in 2017. Omotoso (2006) investigated the functional properties of *Cirina forda* larvae powder and particularly obtained high oil and water absorption capacities. Osasona and Olaofe (2010) also observed a high water absorption capacity and oil absorption capacity, respectively, of *C. forda* larvae powder and concluded that the larvae powder could be applied especially in baked products due to its high water absorption capacity, as a flavor retainer and to improve the mouth feel of food products because of its high oil absorption capacity. Omotoso (2006) also observed relatively high emulsion stability and emulsion capacity sand therefore suggested that the larvae powder could function as a texturizing agent in food products. Similar reports have also been recorded for many other insect flour especially cricket. Food products that use grasshoppers and cricket powder owing to its essential minerals, amino acids, and pastry-improving qualities will further increase edible insect market demand. Cricket flour is reported to possess gluten-free properties and so is used in food products which propel the market demand.

In Africa, insect consumption is either raw, cooked, boiled, stewed or even dried (Ebenebe et al., 2017b), processing of insects into other product types: chocolate bars, beer, ice cream, flakes, and noodles as found in Europe and America is still at experimental stage in Africa. Thus seasonal fluctuations affect supply negatively as insect to sell or eat may not be available in certain seasons of the year. Given the

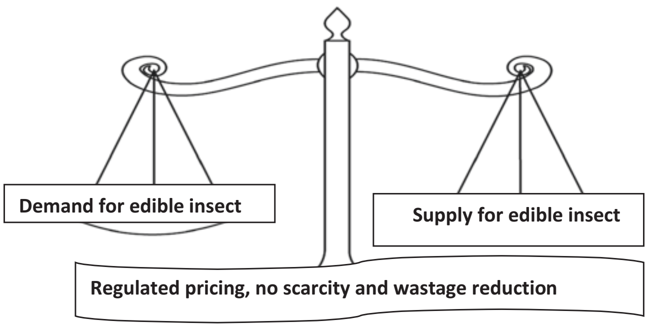


Fig. 2.3 Edible insect demand and supply at equilibrium

Table 2.7 Reasons why some people do not practice entomophagy

Insects	Reasons
Termites	Associated with breakdown of coffin and corpse buried underground
Variegated grasshopper	1. Some communities associate the obnoxious odor in the insect with evil spirits. 2. Unpleasant spots on the insect.
African palm weevil	Appears like a bloated maggot (housefly larvae)
Rhinoceros beetle	Some grow in goat manure and so they are unhygienic
Cricket	1. Unavailability 2. Regarded as food for children

[a]Source: Ebenebe and Okpoko (2014)

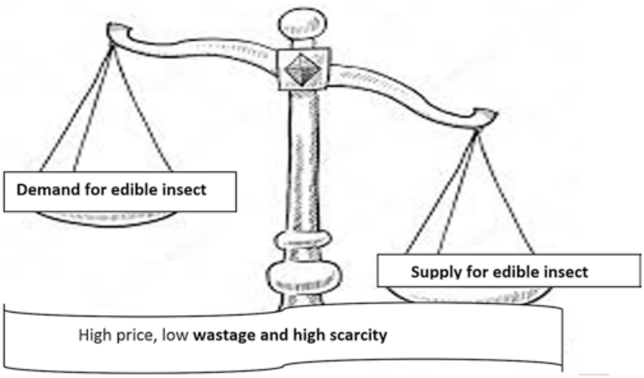


Fig. 2.4 High demand and low supply

issues raised in Ebenebe and Okpoko (2016) especially the fact that many Nigerians associate insect consumption with poverty, the demand and supply in the 1980s to earlier part of 2000 was at equilibrium (Fig. 2.3) (Table 2.7).

When the supply for edible insects is equal to the demand for them, it resulted into a stable market known as equilibrium point (Fig. 2.4). This stage is what every market is trying to attain. It is characterized by regulated pricing, no scarcity, and reduced wastage. However, the point at which the supply and demand is at equilibrium is low, there is need for upward shift of this point to reflect the true realities on ground.

2.5 Edible Insect Supply and Demand Gap

The increasing demand of edible insects in developing countries is a result of rapid rate of population growth and the malnutrition problems. Globally, a high demand for edible insects is driven by socioeconomic changes such as rising incomes, increased urbanization, and aging populations as the contribution of protein to

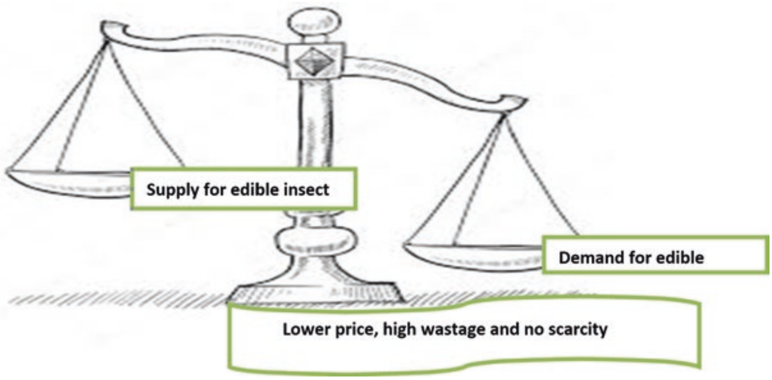


Fig. 2.5 Supply–demand gap

healthy aging is increasingly recognized (Henchion et al. 2017). In Africa, increases in demand for edible insects is presently driven by awareness of the nutritional values of edible insects, impact of consumption on edible insects on the environment and human health. FAO has aroused people's interest on the nutritional importance of edible insects and its environmental health potentials especially in the face of human induced climate change. Meludu and Onoja (2018) reported that edible insects are abundantly eaten in Nigeria and other Africa countries however the impending decline in population of edible insects reported by (Akunne et al. 2013) with the rate of deforestation. Gathering from the wild and subsistence scale of production can no longer meet the demand. Like in any other market system, the supply–demand gap for edible insects is in a situation when the supply of edible insects is higher than the demand that is lower price, high wastage, and low scarcity (Fig. 2.3). The condition when the demand is higher than supply of edible insects referred to as edible insect demand–supply gap. This is characterized by high price, low wastage, and high scarcity of insect products. Presently in Africa edible insect market is at this stage.

While the farmer aim at equilibrium, the consumer needs a condition where the supply is more than demand, so priced can be forced down (Fig. 2.5). The only way this can be possible is by establishing large scale insect farms.

2.6 Reasons Why Demand for Insect Protein Is Growing in Africa

2.6.1 Shortage of Animal Protein/Malnutrition in Africa

FAO (1991) recommended that animal protein requirement for normal growth and development is 34 g/person/day but in most African countries. In Nigeria animal protein consumption level is 7–10 g/Person/day while her counterparts like Somalia and Mauritania were getting 32–34 g (Okoro 2000). In America and some other developed countries animal protein consumption is 54 g/person/day. The poor state of animal protein consumption is responsible for Kwashiorkor reported in some African countries (Hamidu et al. 2003), Geoffery Njoku the communication expert of UNICEF, in 2008 reported on the infant mortality, low intelligent quotient, short stature, and sometimes maternal mortality in Nigeria. In these African nations where meat and fish are expensive, edible insects can provide an alternative source of animal protein and help to avoid protein deficiency problems.

2.6.2 Alternative to Meat Protein

Meat consumption especially red meat has been associated with many chronic diseases like sclerosis, hypertension, diabetes, and other heart conditions; the need to stay healthy has elicited a new interest in alternative protein resource. Essential fatty acids (EFA) like linoleic and linolenic acids are present in sufficient quantity in many insect larvae (Ekpo and Onigbinde 2004). According to Van Huis (2013), beef contains more palmitoleic, palmitic, and stearic acid than mealworms, while mealworms contain higher values of essential linoleic acids than beef. Ekpo and Onigbinde (2004) reported that APW larval oil has high medicinal value in terms of its high iodine value which according to them is an index of the degree of unsaturation of the oil. Edible insects can conveniently be used as an alternative meat protein.

2.6.3 Insects Have a Huge Potential in Animal and Fish Feed Production

The quantity of fishmeal required for production of fish and livestock feed is quite astronomical with the high level of human population that require meat and fish protein for survival. The high cost of fishmeal for livestock and fish feed, necessitates the use of alternative cheaper animal protein ingredient. At present, around 10% of global fish production goes to fishmeal (i.e., either whole fish or fish remains resulting from processing) and is used mainly in aquaculture (FAO 2012b). The animal feed supply business stated that the international trade in animal feed has an estimated turnover of nearly $400 billion every year. Van Huis (2013) noted that in 2008, aquaculture used 61% of world fishmeal production and 74% of fish-oil production. Insect appears to be perfect replacement for fishmeal in livestock feed and fish feed production.

Rumpold and Schlutter (2013) noted that Acridids (grasshoppers) have been identified as one potential feed component for poultry feed since they have higher protein contents than other protein sources such as soybean meal and fish meal and are rich in the micronutrients Ca, Mg, Zn, Fe, and Cu (Anand et al. 2008). According to him, in the Philippines, grasshoppers are fed to chickens raised on pasture. The chicken fed on pasture (and grasshoppers) are to have a delicious taste and are sold for a much higher price than chickens reared on commercial chicken feed (Litton 1993). Oyegoke et al. (2006) also investigated the dietary potential of the moth larvae *Cirina forda* as a poultry feed component rich in proteins in comparison to fishmeal, a complete replacement of the fish meal by larvae powder resulted in no significant differences in growth rate and weight gain of broiler chicks. Rumpold and Schlutter (2013) therefore opined that the larvae powder represents a potential alternative for the highly nutritious and rather expensive fish meal.

2.7 Examples of Large Scale Insect Farm and Other Insect Projects in Africa

2.7.1 AgriProtein

AgriProtein is the first and foremost large insect farm in Africa. The farm is established in Elsenburg, South Africa by Jason and David Drew. AgriProtein rears fly larvae (on an industrial scale) on organic waste and harvests the larvae to make natural, high-protein animal feed products The company focuses on nutrient recycling (i.e., recycling of organic waste) by insects to develop insect meal/insect larval meal used to replace expensive fishmeal in fish and livestock feed. By using common house fly larvae fed or black soldier fly larvae fed on abundant waste nutrient sources, AgriProtein has developed and tested a new large-scale and potentially sustainable source of protein. The bioconversion process therefore uses low-cost waste materials and generates a valuable commodity (insect larva for feed production). According to Van Huis (2013), the production process starts with rearing stock flies in sterile cages, each holding over 750,000 flies. Various types of waste are used, including human waste (faces), abattoir blood, and spent food. Depending on the species, a single female fly can lay up to 1000 eggs over a 7-day period, which then hatch into larvae. Housefly larvae go through three life stages in a 72-h period and are harvested just before becoming pupae. The harvested larvae are dried on a fluidized bed dryer, milled into flake form and packed according to customer preferences. Van Huis (2013) further stated that the product contains nine essential amino acids, with high levels of cysteine and similar levels of lysine, methionine, threonine, and tryptophan—similar to marine fishmeal. The company aims at production 100 tonnes of larvae per day. At present an Austria-based engineering group Christ of Industries has partnered with waste-to-nutrient company AgriProtein to build up to 25 fly farms a year. The maggot-based animal feed meal developed by AgriProtein is more than 15% cheaper than other alternatives and has been proven to be highly nutritious for livestock, especially chickens (poultry), fish, and pigs.

2.7.2 Aspire, Ghana

Aspire Food Group is an international Social Enterprise dedicated to provision of sustainable means of farming edible insects. The company has offices both in Ghana and USA, In Ghana, Aspire farms African palm weevil larva which is a delicacy in most parts of Ghana. The company develops and teaches farmers in Southern and Central Ghana on the techniques of rearing Africa Palm weevil in their homes instead of felling the oil or raffia palm. They intend to scale up production and also develop packaged products so that they can export to other countries and at the same time advance further research in African palm weevil.

2.7.3 INSFEED: Insect Feed for Poultry and Fish Production in Kenya and Uganda

INSFEED is a project funded by International Development Research Centre, Canada (IDRC) and Australian Centre for International Agricultural Research (ACIAR) in collaboration with Egerton University, University of Nairobi, Sanergy Ltd., Kenya Bureau of Standards (KEBS), Unga Feed, Lasting Solution in Kenya and Makerere University; UNBS, NaLiRRI, NaFiRRI, UGACHICK in Uganda. The major thrust of research in the project is identification of suitable insect species, assessing the potential market and nutritional attributes of the products, and development and adaptation of cost-effective insect rearing, harvesting, and post-harvest techniques for smallholder producers. It will also establish the risk factors associated with the insect-based feeds along the food chain and their mitigation. Strategies as well as conduct research to inform policies for promotion of safe, sustainable and cost-effective use of insect in the feed sector. The project is coordinated by Dr. Komi Fiaboe, who is instrumental in getting regulatory changes needed to allow insect feed to be approved for use in all animals and fish feed in both countries (Bryne 2018).

2.7.4 FasoPro

FasoPro is not a large-scale insect farm, rather an initiative of a young engineer from the International Institute of Engineering of Water and the Environment (2 IE). FasoPro project born in the business incubator of 2 IE. It is a kind of off take, where the company buys the edible insects harvested by women gatherers in the locality for further processing and more attractive and healthy packaging. It is located a small town called Somousso, about 400 km from Ouagadougou, the capital of Burkina Faso. Over a hundred women are engaged in managing the shea trees. The women harvest the caterpillars from these centuries-old fruit trees that abound in the region.

The women coordinating the Somousso collection center were organized by the developer, Kahitouo Hien and the plan included five villages (Somousso, Bare, Piére, Yegueresso, and Sare). FasoPro group buy their harvest unpackaged in kilograms, a method which benefits the gatherers. At present, a standard box of about 3 kg is used for measuring the caterpillar at costs between 600 and 700 CFA in Bobo-Dioulasso, market. However, where the caterpillars are boiled or dried a measure with the standard box trades for around 2000 F CFA (Tao). According to Kahitouo Hien the developer of FasoPro, the trained farmers had the ingenious idea of preserving the caterpillars in cans, a method of transformation and conservation that extends their period of consumption, stabilizes prices, and increases production. His ultimate goal is to fight child malnutrition and poverty in rural areas. The engineer wishes to create a permanent nutrient resource containing 63% protein that lasts beyond the winter season and the labeling of the local product.

Ms. Ouattara, owner of the agroecologic farm Guiriko, coordinates the union of women's groups engaged in this activity. Their mission is to gather the 10 tonnes needed to start the pilot phase. To achieve this, they regrouped into associations to sort the correct species and to precondition them according to the technical standards provided by the developer.

2.8 Factors Affecting Supply of Edible Insects

1. *Storage*: Insect farming in a closed or indoor environment is an important means of making insect and insect products available throughout the year. As production increases there will be need to store the food to avoid wastage (Fig. 2.5). Processing insect into a more attractive and acceptable product will ensure reduction of wastage (Ebenebe 2016).
2. *Availability of organized market*: Unavailability of organized market where consumer can get or secure edible insects is affecting its marketability in Africa. Organized market that will stabilize price in all parts of each of the African country. Establishment of cooperative societies aimed at promoting edible insect conservation is required.
3. *Packaging*: It was clear that insect food alone would not be able to defend itself in a crowded market place of other proteins source. We needed to synthesize a culture around insects, to serve as a platform for their popularity. Aguirre-Joya et al. (2018) and Ebenebe (2016) recognized that fanciful packaging of edible insects will attract more consumers, reduce waste and to create novel applications for improving desired features of a product, such as stability, quality, safety, variety, and convenience for consumers.
4. *Technology and research*: Insect based technology is needed for mass production, processing, and marketing of edible insects. Data gathering surrounding insect as food feed should be encouraged to deepen the knowledge of people and further grow the sector in Africa.

5. *Consumer acceptance of edible insects*: Africa especially Nigeria is known to relish insect, but due to advancement in education, urbanization, and civilization, edible insect acceptance dropped. The perception that only poor people eat insects (Ebenebe 2016) started to thrive, especially among younger generation, which needs to be changed. Taboos and cultural influences affecting the urge to eat insect need to be visited; training and awareness campaigns showcasing the benefits of eating insect should be encouraged.

2.9 Marketing by Insect Type

The continent is home to the richest diversity of edible insects, an inventory of 250 species of edible insects were recorded. Among which 78% are Lepidoptera (30%), Orthoptera (29%), and Coleoptera (19%), and 22% Isoptera, Homoptera, Hymenoptera, Heteroptera, Diptera, and Odonota, respectively (Van Huis 2003). In Nigeria however,22 edible insect species from six orders were compiled. Of these, 77.3% were Lepidoptera (27.3%), Coleoptera (27.3%), Orthoptera (22.7%) and 22.7% Isoptera, Hemiptera and Hymenoptera (Alamu et al. 2013). Marketing edible insects according to their type requires knowledge of the cultural acceptability of the insect in the region before venturing into it. Tables 2.1, 2.2, 2.3, 2.4 and 2.5 showed edible insect types consumed in many parts of Africa.

2.10 Marketing by Product Type

Research and development strategies have improved the awareness of the enormous importance of edible insects as a global food. Edible insects have gone beyond basic processing methods other than eaten raw, roasted, sun dried, fried, and boiled in more developed countries increasing acceptability and usage. Edible insect is now incorporated into many food products sweet bars, flakes, noodles, ice cream, and beer, this owing to the fact that a food's preparation could strongly influence its desirability by changing its hedonic sensory qualities and perceived appropriateness. In Africa, there are few insect products. In Nigeria, an infant formula containing insect protein that goes with the name "Cerovil" was developed by Dr. C.I. Ebenebe. In Kenya, termites and lake flies were baked, boiled, and cooked to increase shelf life and processed into conventional consumer products such as crackers, muffins, sausages, and meat loaf to encourage entomophagy (Ayieko et al. 2012). In the western world, products like insect flour, burger, pasta, juice, smoothie, wine, and so on can be found sold online (Entomarket 2018). Despite the acceptability of edible insects in Africa, processing edible insects into acceptable products has not been fully explored. Therefore, there is a need for creating of more culturally acceptable products to increase insect marketability in Africa.

2.11 Marketing by Application

Edible insect can also be marketed based on what their intending use is. Edible insects have been used to formulate feed for livestock including poultry, pigs, and fish (Stamer 2015; Kenis et al. 2014) as well as dogs and other pets. Food product made from edible insect could also be used by zoos to feed their animals (Entomarket 2018; Van Huis 2013, 2015).

2.12 Marketing by Geography

Species dominance of edible insects varies from region to region. The species coverage of some insect may span throughout a country while some may be restricted. The more widespread a species is the more acceptable it is and vice versa. In Table 2.1, *Apis mellifera* is found in all parts of Nigeria, therefore its acceptance level is all over Nigeria but others are region specific. There is possibility for exporting edible insects within and beyond Africa.

2.13 Processing of Edible Insects

Some ethnic groups in Africa eats insect raw (Van Huis 2013), while in other tribes processed them into a more palatable product to eat. In Nigeria, *Rhynchophorus phoenicis* commonly known as palm weevil, is processed by frying before eaten (Opara 2003). *Oryctes monoceros*, a common pest of coconut tree, is eaten raw, boiled, smoked or fried (Ifie and Emeruwa 2011). *Microtermis nigeriensis*, a very common food found in almost all ecological zones in Nigeria is usually processed by washing, salting to taste and mild frying or roasting. This delicacy is usually rich in oil; therefore, there is no need for oil while frying (Igwe et al. 2011). It can also be consumed raw by some tribe in Yoruba land (Fasoranti and Ajiboye 1993). The larvae of *Bunaea alcinoe* a common pest of forest trees in the country is reported eaten boiled and sun dried (Fasoranti and Ajiboye 1993; Agbidye et al. 2009). The large African cricket, *Brachytrupes membranaceus*, is a pest of forest nurseries with severe defoliation. They are commonly processed roasted in mild fire and fried. Edible insects can also be processed into other products for value addition. Akullo et al. (2017) stated that termite flour has a high potential in fortifying food products and feed with acceptable sensory and nutritional qualities.

In Africa, use of insects to feed animals has been documented in Angola, Benin, Burkina Faso, Nigeria, Togo, Cameroon, Democratic Republic of Congo (DRC), and South Africa (Mutungi et al. 2017).The most widespread industrial method of harvesting insect species is by chilling them to freezing temperatures. This process causes the insects to enter a state of sleep much like a coma as their body temperature lowers. After an extended period of being frozen, which varies by species but is generally 2–3 days, the insects die without regaining consciousness. As compared with modern methods of slaughtering traditional livestock, the pain levels are believed to be drastically lower than those of cows, pigs, and chickens; however, we lack the full understanding of the ways insects experience pain or if they indeed do at all (Dossey et al. 2016). Insect are usually processed by drying before grinding into fine form, which is then used for feed formulation.

Milling edible insects into flour is reportedly a way to take away the icky factor from eating insects (Dossey et al. 2016). Most commercial food products are processed the same way they are processed at home. Commercial production might use motorized machine for processing, this makes marketing of edible insects easier and wider area is often covered. Saprophagous insects such as black soldier fly and house fly have been used to produce manure which is of value in biodegradation and aquaculture. Combination of waste treatment capacity together with generation of a valuable product makes the black soldier fly technology a highly promising tool for waste management in low- and middle-income countries. It offers small entrepreneurs the possibility of income generation without high investment costs, and concurrently reduces the environmental impact. Improving existing methods of processing of commonly consumed insects is important if edible insects are to meet the global market. Massive research needs be encouraged along the line of processing.

2.13.1 Market Values of Products from Edible Insects

Given that consumption in marketing terms involve processes of using consumer products in order to satisfy desires, real or imaginable needs so that the products are used up, transformed or deteriorated in such a manner as not to be either reusable or recognizable in their original form. Edible insect consumption market will therefore include whole insects, insect products, other uses especially services rendered by insect.

2.13.2 Market Values of Edible Insect Services

2.13.2.1 Medicinal Services

The name given to the medicinal usage of animals and its derived products is zootherapy (Marques and Costa-Neto, 1994). Traditionally, insects and insect products are used in preparing concoction for treatment of several ailments (e.g., *Camponotini brutus* for treatment of wounds, *Belanogaster* spp. for treatment of various diseases in children; Banjo et al. 2003). Termites and crickets apart from being used as food are also used for rituals. Lawal et al. (2003) reported the traditional utilization of honey bee among Ijebus which include rituals, forceful command, defense, and favor. Molan (2006) stated that the ancient Egyptians and Greeks used honey for wound care. Simon et al. (2009) posited that honey works differently from antibiotics, which attack the bacteria's cell wall or inhibit intracellular metabolic pathways. According to them, honey is hygroscopic, meaning it draws moisture out of the environment and thus dehydrates bacteria. Its sugar content is also high enough to hinder the growth of microbes, but the sugar content alone is not the sole reason for honey's antibacterial properties. When honey is diluted with water, reducing its high sugar content, it still inhibits the growth of many different bacterial species that cause wound infections. Today the first medically certified honey-based licensed product: Medihoney™ has been developed as a medical product for professional wound care in Europe and Australia. The global market price of honey stands at $3.63/kg and the two leading African countries in honey production. FAO estimated that Africa accounted for roughly 9% of global honey production (155,789 t), representing a 10% increase since 2000, which has since increased to 13% by 2016 and Ethiopia leading with 50,000 t, followed by Tanzania (30,000 t), Angola (23,300 t) and Central African Republic (16,200 t). Ethiopia is also the fourth largest beeswax producer in the world. Honey exports throughout the continent appear to have grown sharply by 613% from 2000 to 2013, representing an increase to 3195 t, worth €8.9 million. Nigeria only fulfills 10% of its total domestic consumption demand (380,000 t), while it annually imports €1.84 billion worth of honey, according to David Victor Musa, general manager of Barg Natural Honey (Nigeria) and US Agency for International Development consultant (Spore 2017). Srivastava et al. (2009) has made a detailed documentation of insect uses in traditional medicine; over ten insects are described as medicine in native medicine. According to him, trembling red ant locally known as "*L. Nkaam*" used for the treatment of muyeem (bronchitis). Again, grasshopper locally known as Mpaylaar in Zaire is used for the treatment of violent headaches. Another important insect in traditional medicine he documented is that of worker wasp locally known as "*Ngankoy*" in Zaire that strengthens a weak infant, the community believes that the nest of the worker wasp has a substance, which gives life strength to the weak. He also mentioned the use of cockroach locally known as "Kembaar" in Zaire to cure scabies/mange in animals. Praying mantis locally known as"*Kayakua*" in Zaire are also used for the treatment of epilepsy while builder/worker caterpillar locally known as "*KenbulMpiak*" in Zaire, cures hemorrhage during childbirth or during pregnancy.

2.13.2.2 Magical Insects

Cherry (2005) described the branch of magic associated with insect as imitative magic based on the assumption that "likes produces like" (Frazer 1998). By this principle individual can produce any effect they want by imitating it. The most common use of insects in imitative magic hinges on expression of behavior, special power or morphological trait associated with the insect (Cherry 2005). Van Huis (2003) noted that in sub-Saharan Africa, it is believed that the morphological trait or specific behavior of an arthropod can be acquired by humans when they treat themselves with the insect or a preparation made from it. The most commonly used insects in this regard are the sacred scarab of ancient Egypt, the cicada and butterfly. These three insects are associated with religious concept of rebirth. For the sacred scarab of Egypt (*Scarabaeus sacer* L.), it is reported that amulets to protect the dead were carved in the form of scarab and buried with the body with the intent of ensuring rebirth of such person. The nymph crawling of the as the insect sheds off the nymphal skin is symbolic of the spirit of the deceased leaving the body and emerging out of the dead body (Kristy and Cherry 2000).

Apart from regeneration and rebirth magical doctrines, insects use in imitative magic also includes the aspect of the impartation of ferocious tendencies to humans by some ferocious insects (Cherry 2005). Van Huis (2003) posited that in Africa, wasps are crushed and put into incisions made on the back of the hand of warriors/wrestlers to give the person a punch like the sting of wasp.

Another aspect of imitative magic that involve the use of insect is based on the proposition of Berenbaum (1995) for the "doctrine of signatures" in which she opined that God provided all things for human use provided in signs such as shape or color to show their use. Van Huis (2003) reported that some of the best examples of this medical magic occur in sub-Saharan Africa. According to him, in Chad, children who are slow to walk can be stimulated by using fast running ants which are crashed into powder and rubbed into incisions made on the legs of the children. Similarly, Cherry (2005) reported that in several countries of Africa, cicadas, cricket and other singing insects are crushed, mixed with herbs and eaten to obtain a pleasantly high and clear voice among women.

Imitative magic is also extended to the aspect of manipulation of insects (Campbell 1988 cited in Cherry 2005) to behave in certain desired way or yield higher products. Cherry (2005), reported that the pygmies of Africa use imitative magic to enhance their honey harvest from bees. According to him, the natives first simulate unfruitful efforts in the hunt for honey in form of a dance facilitated by singing. The dance culminate into setting up of a great hone fire. The fire is accompanied by a song of magic that will travel with the smoke to call the bees to come back to make more honey. In the south east Nigeria, Ebenebe et al. (2017b) reported on the magical invocation of bees into an enemy's house with the intent of having the bees sting the enemy to death. Another insect reported by Ebenebe et al. (2017b) is the larva of butterfly locally called "Nwaigu" usually found on leaves of very tall trees, which freely fall to be harvested as the natives call/sing its name "Nwaigu, Nwaigu, Nwaigu" or "Wee, Wee, Wee." The more the song, the more the number of larvae that hit the ground to be caught (Figs. 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, and 2.12).

Fig. 2.6 Locust (Fara) from village market, Kumo

Fig. 2.7 Grasshopper (Fara) with various measuring containers Gombe, Gombe State

Fig. 2.8 Boiled cricket (*Brachytrupes* spp.)

Fig. 2.9 Grasshopper sale in Nigeria

Fig. 2.10 African palm weevil larva displayed for sale with African chicken at Oba, Idemili South, LGA, Anambra State

Fig. 2.11 Winged termite collected

Fig. 2.12 Winged termite roasted

2.14 Conclusion

There is high prospect for edible insects in Africa, but seeing it as a business opportunity is new. Edible insects are highly nutritious, environmentally friendly and it is tipped to end protein crisis in Africa. With the global awareness of edible insect at its peak. Africa must grab this opportunity and invest heavily in edible insects. The market for edible insects is large in Africa, but the supply is low, meeting this supply gap is the greatest challenges we face in Africa edible insect sector. Therefore, increase in awareness, research, mass production, packaging, and marketing should be encouraged.

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