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Potentials of Edible Insects as a Food Source

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ABSTRACT: Due to the increasing cost of animal proteins, food and feed insecurity, population growth, and increasing need for protein-rich food in the developed and less developed countries, alternative sources of protein-rich food are highly needed. Edible insects could produce less environmental impact than livestock and that about 2000 insect species are eaten worldwide, mostly in tropical countries. They have adequate protein quantity and quality and high content of unsaturated fatty acids with minerals such as iron and zinc. This work cuts across the reasons people don't consume edible insects and ways edible insects helps against food insecurity It also sheds light on the nutritional value of insects and some other benefits insects offers humans. Considering the economic, nutritional, and ecological advantages of this traditional food source, its promotion deserves more attention both from national governments and agencies.

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The need for safe food with the growing world population is constantly increasing. In 2016, the number of chronically undernourished people in the world is estimated to have increased to 815 million although the food production has increased considerably in the past 50 years (Nisbett *et al*., 2010; Luan *et al*., 2013; FAO 2017). Food is no doubt, the most basic of all human survival needs. Although, so many efforts have been sunk in improving the quality as well as production of world food supplies, food insecurity remains prevalent, particularly in the global southern nations of Asia and Africa, and in Nigeria, malnutrition has resulted in death of many of its citizens. African Food Security Briefs (AFSB) estimated that approximately one out of every three persons in the sub-Saharan Africa is underfed (Akerele *et al*., 2013). Without a well -nourished and healthy population, sustainable economic development in Nigeria and in Africa will remain a mirage. Shortage of animal protein in human diets is more severe in Africa and other developing nations of the world and is currently linked to high rate of infant and maternal mortality (UNICEF Nigeria, 2015).

Food security is a phenomenon which is multidimensional with economic, environmental and social aspects. Unfortunately, the greater share of the population of the undernourished is located in the developing countries. While Nigeria prides itself as the giant of Africa with its economy becoming the largest in 2014, the country struggles with an alarming high poverty rate. (Omorogiuwa *et al.,* 2014).Over 70% of the Nigerian population is surviving on less than a dollar per day while food insecurity rates in the low income urban house-holds and rural areas respectively stands at 79% and 71% (Akerele *et al*.,

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2013). While many African countries suffer nutritional problems associated with low intake of animal protein, public health implications of over consumption was reported in countries like USA (Walker *et al*., 2005). The projected population increase in Africa and other developing nations of the world will definitely aggravate the problem of animal protein deficit, the dilemma is that with increasing population, urbanization and incomes, food consumption, particularly of protein origin such as meat, is expected to rise (FAO, 2013).

While all major nutrients are important, protein is one of the main nutrients required by humans, and protein deficiency can lead to serious health issues. Protein from animal sources holds a distinct advantage, as it contains essential amino acids that are not found in many plant proteins. However, protein from animal sources is not always affordable for a significant portion of the global population (Aiking, 2011).Given the challenges mentioned, an alternative source of protein is needed to assist in ensuring food security for the increasing global population one such source could be insects. Several strategies have been proposed that could reduce the environmental impact of increased meat consumption, including the replacement of traditional meat with the so-called Novel Protein foods that includes edible insects. Entomophagy, the consumption of insects, is rooted in human evolutionary history (Fontaneto *et al*., 2011). Insects have played an important part in the history of human nutrition in Africa, Europe, Asia, and Latin America. Over 1900 species of insects are known worldwide to be part of human diets; some important groups include grasshoppers, caterpillars, beetle grubs, wringed termites, bees, worms, ant brood, cicadas, and a variety of aquatic insects (Bodenheimer, 1951). It is interesting to know that more than two billion people consume insects on a regular basis, and insect eating provides a significant proportion of the animal proteins consumed in some regions (Van Huis, 2013). Since entomophagy is widely practiced, and because it compares favorably with nutrient and environmental aspects of conventional livestock rearing, it has the potential to contribute substantially to reducing under nutrition among an expanding global population (Van Huis, 2013).

Insects have numerous features that make them attractive sources of highly nutritious and sustainable food. Studies revealed that edible insects contain high-quality proteins, vitamins and amino acids that are essential for humans (Rumpold and Schluter 2013). As most insects require less feed, water, and land to produce than conventional livestock, they enable a cost-effective production (Nakagaki and DeFoliart, 1995; Nisbett *et al*., 2010). There is need to harness the potentials of cheap, environmentally friendly animal protein sources like edible insects. Insects possess much higher levels of efficiency (approximately 10 kg of feed = 9 kg of crickets), and unlike cattle and poultry, insects can be fed on organic waste and plant material which would otherwise be discarded. Insects require much less water and energy to farm and can be cultivated at much higher densities than conventional livestock. Besides, animal protein production, insect farming is environmentally friendly.

Insects stand out in their nutritional properties because they contain all the essential amino acids and many polyunsaturated fatty acids (Rumpold and Schlutter, 2013) and a high variety of nutrients such as copper, iron ,magnesium ,manganese , phosphorus, selenium and zinc, plus vitamins riboflavin, biotin, pantothenic acid and in some cases folic acid (Nowak *et al*., 2016; Rumpold and Schlutter, 2013).These nutrients are present at levels as significant as those in conventional sources of protein. The climate change and the environmental destruction from industrial development also negatively affect food productivity. In light of worsening resource shortage, several foods have been proposed as alternatives with insects receiving the most attention (Patel *et al*., 2019). Traditional sources of meat protein may be insufficient to meet the needs of a growing global human population, alternative sources such as insects is a viable alternative (Caparrors Megido *et al*., 2014). Insects are institutionally accepted as food in many regions and historically consumed and also providing sufficient nutritional value for humans (Zielinska *et al*., 2018).

Nutritional value of insects: The nutritional composition of insects have been proven to have optimal nutritional value, especially the protein content in terms of adequate amino acid composition (Payne *et al*., 2015). The amino acid composition in the larvae of yellow mealworm (Tenebriomolitor) is particularly advantageous (Zhao *et al*., 2016). A research investigating four insects frequently eaten in Nigeria (African palm weevil, coconut palm rhinoceros beetle, caterpillar, and termite) found that the essential amino acids lacking in cereal protein, i.e., lysine and methionine, were considerably in high amounts in these insects (Ekpo, 2011). Analysis reveals that the protein content in insects has a range of 40g/100g to 75 g/100 g, the and fat content from 7 g/100 g to 77 g/100g, the mineral content is from 3 g/100 g to 8g/100g on a dry weight (DW) basis (Verkerk *et al*., 2007). According to Zielinska *et al*., it was found that the protein, fat, and mineral content of mealworm larvae was around 52 g, 24 g, and 1 g per 100 g dry sample, respectively (Zielinska *et al*., 2018). A more recent study by Zhao and co-authors found that mealworm larvae contained about 51% protein, 32% fat, and 5% ash on a DW basis (Zhao *et al*., 2016).

Rumpold and Schlüter (2013) list published data on the nutrient content of 236 edible insects. Compared to FAO (2013), it is clear that many of the insects listed meet the amino acid requirements of humans and are also high in mono- and poly-unsaturated fatty acids. For example, the content of unsaturated omega-3 fatty acid and six other fatty acids in mealworms is comparable to that in fish. The study by Rumpold and Schlüter (2013) also shows that many insects are rich in micro-minerals such as copper, iron, magnesium, manganese, selenium and zinc, as well as vitamins such as riboflavin, pantothenic acid and biotin and, in some cases folic acid, all of which are valuable in terms of human nutrition. However, little is known about the digestibility and nutrient utilisation of insects by humans. Studies on animals show that dietary inclusion of insects, instead of conventional protein sources such as soybean and fish meal, does not adversely affect growth. Studies on the growth and performance of monogastric animals (e.g. laying hens and pigs and rats) on mealworm diets seem to be lacking (Makkar *et al*., 2014), but a study with broilers showed growth rates similar to those obtained with conventional feed (Ramos-Elorduy *et al*., 2002).

It is difficult to generalize the nutritional composition, but (Rumpold and Schluter 2013) consulted more than 50 literature references. Data from 236 of the more than 2000 edible insect species show that, despite the large variation, they provide satisfactory energy and protein, meet amino acid requirements for humans, are high in monounsaturated fatty acids and polyunsaturated fatty acids, and rich in several minerals and vitamins (Rumpold and Schluter 2013). Of particular interest are the high iron and zinc content in comparison to conventional meat. Therefore, entomophagy has been proposed to combat the deficiencies of these minerals in developing countries (Christensen *et al*.,2006), in particular in view of the fact that the percentage of the world population at risk for these deficiencies is more than 17 % for zinc (Gibson,2015) and 25 % for iron (McLean *et al*., 2009). Species considered for consumption in the western world, like mealworms and crickets, have a protein content ranging from 19 to 22 %. This is comparable to conventional meat products in terms of protein quantification (Yi *et al*., 2013). The essential amino acid levels in the insect species investigated by these authors were comparable with soybean proteins, but lower than for casein.

Why are edible insects not eaten? Reluctance to eat insects in many modern societies is a strong barrier against the commercialization of insect-containing food products. It can be argued that entomophagy is a failed diffusion. (Shelomi, 2015), since its adoption never reached or approached universal acceptance in its target population (Rogers, 2003). This barrier is mainly triggered by a cultural representation, according to which insects cause either fear (of dirt and diseases) or curiosity (Yen, 2009). Furthermore, the disgust factor is deeply embedded in the Western psyche, since insects are mainly viewed as pests, no matter how great the amount of literature underlying their nutritional and sustainable features (Van Huis *et al*., 2013). This could be partly explained by the lack of exposure to the taste, flavour, visual and tactile sensations of edible insects (Deroy *et al*., 2015) together with the geographical availability of other proteinaceous sources of food, such as cattle, pigs and poultry (Harris, 1999).

The lack of knowledge and exposure can only raise the levels of fear and misconception towards entomophagy. For instance, the naïve categorization of insects implies a group including even spiders, lizards, scorpions, as well as snakes and bats (Costa-Neto, 2000). Fortunately, the mass media and the institutions in Europe are increasingly focusing on the subject. Until the harmonization of the European regulatory framework, some Member States decided to self-regulate their internal markets. For instance, on 15 October 2014 the Dutch Office for Risk Assessment and Research stated that three kinds of insects could be produced and sold in the Netherlands, namely two kinds of mealworms and crickets. Likewise other countries, such as Belgium, France, UK and Denmark, are self-regulating the commercialization of edible insects. In 2010, the United Nations' Food and Agriculture Organization (FAO) published a report on the importance of edible insects; however, it largely failed in convincing European and American consumers to change their habits. On the other hand, TV shows negatively portrayed the insect-eating experience.

For many people in Western societies, insects are regarded as pests and entomophagy is often associated with disgust and primitive behaviour (FAO, 2013). This attitude might be one reason why insect rearing has been neglected in agricultural research in this part of the world. The disgust factor is a serious issue when promoting entomophagy. As the American psychology professor Paul Rozin has said: "the last and critical step in promoting insects as food is getting people to eat them". Rozin *et al*. (2014) predicted insect acceptance in Americans using both demographic and psychological variables. The predictions included traits such as:

Disgust /primitive behaviour
Beliefs about the risk of consuming insects
Beliefs about the benefits of consuming insects
Desire to have new and stimulating experiences
Risk tolerance, food neophobia (resistance to try new foods)
Gender (males more willing to try out new foods than females)
Social status (seen as food for the poor)

It appears that people will accept eating insects if the presentation looks and smells familiar and if insects are not served intact (Dicke *et al*., 2014). Therefore the promotion of insects cannot focus solely on communicating the functional benefits, but must also pay attention to the products so that they suit the expectations of consumers within their own cultural context (Tan *et al*., 2014). FAO (2013) states that the disgust factor must be addressed in both communication and education in order to promote entomophagy in Western societies. However, it stresses also that communication with the media in tropical areas (where entomophagy is well established) should focus on insects as a valuable source of nutrients.

Insect orders consumed and ratio of consumption: According to (Cerritos, 2009), insects are eaten according to this percentages;
•Beetles are the most widely consumed insects globally (Coleoptera: 31percent).This is because they contain about 40percent of all known insect species. Both adult and larvae of Coleoptera are eaten.
•Consumption of caterpillars (Lepidotera) is popular in sub-Saharan Africa which is estimated at 18percent and they are eaten as caterpillars.
•Bees, wasps and ants (Hymenoptera) is estimated at 14percent.These are consumed in their larval or pupal stage.
•Grasshoppers, locusts and crickets (Orthoptera), this is estimated at 13percent, they are consumed in their mature stages.
•Cicadas, leafhoppers, planthoppers, scale insects and true bugs (Hemiptera) this is estimated at 10percent.This orders are eaten in their mature stages.
• Termites (Isoptera) estimated at 3percent.They are eaten in their mature stages.
• Dragonflies (Odonata) estimated at 3percent.
• Diptera estimated at 2percent.
• Other orders (estimated at 5percent)

Other beneficial roles insects play: Besides serving as sources of food, insects provide humans with a variety of other valuable products. Honey and silk are the most commonly known insect products. Bees deliver about 1.2 million tonnes of commercial honey per year (FAO, 2009b), while silkworms produce more than 90 000 tonnes of silk (Yong-woo, 1999). Carmine, a red dye produced by scale insects (order Hemiptera), is used to colour foods, textiles and pharmaceuticals. Resilin, a rubber-like protein that enables insects to jump, has been used in medicine to repair arteries because of its elastic properties (Elvin *et al*., 2005). Other medical applications include maggot therapy and the use of bee products – such as honey, propolis, royal jelly and venom – in treating traumatic and infected wounds and burns (Van Huis, 2003a).

Researchers inserted a spider's dragline silk gene into goat DNA in such a way that the goats would make the silk protein in their milk. This "silk milk" could then be used to manufacture a web like material. Chitosan, a material derived from chitin that makes up the exoskeleton of insects, has also been considered as a potential intelligent and biodegradable bio based polymer for food packaging. Such natural packaging using the "skin" of insects can acclimatize the internal environment, protecting the product from food spoilers and micro-organisms. In particular, chitosan can store antioxidants and exhibits antimicrobial activity against bacteria, moulds and yeasts (Cutter, 2006; Portes *et al*., 2009). Termite hills and their complicated network of tunnels and ventilation systems serve as useful models for constructing buildings in which air quality, temperature and humidity can be regulated efficiently (Turner and Soar, 2008). Drawing on nature – or rather imitating it – to solve human problems is called biomimicry. The branch of entomology – or the scientific study of insects – that explores the influence of insects on culture (e.g. language, literature, art and religion) is known as cultural entomology (Hogue, 1987). Contributions from this field have helped highlight the distinct role that insects have assumed in literature (in particular children's books), movies and visual art, as well as their place as collection items, ornaments and more generally as inspiration for creative expression.

Conclusion: Livestock production is facing serious challenges, dietary changes are needed. Insects as mini-livestock offer many environmental benefits compared to conventional livestock, while nutritional quality is similar. The benefits are in terms of greenhouse gas emissions, land area needed, feed conversion efficiency and the potential to be grown on organic by-products. If insects are promoted as food and feed, they need to be farmed. As poultry, pigs and fish use more than 75 % of the global feed produced, the potential of industries to produce insects as protein source is huge. When grown on organic by-products, food safety issues need to be considered because of possible contam inants. The acceptance of insects as food gains momentum in western contries and a number of strategies to convince consumers are employed such as incorporating them into familiar products.

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