INSECTS AS FOOD AND FEED FOR ANIMALS (REVIEW)

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ABSTRACT
This paper discusses the current state and priorities of using insects as food and feed for animals. it is technically feasible to produce insects on a large scale and to use them as alternative sustainable protein rich ingredient. The crude protein (CP) content of insect meal varies between 40 and 60%, it is rich source of Ca (5-8% DM) and P (0.6-1.5% DM) and it is particularly rich in lysine (6-8% of the CP). Insects can feed on waste biomass and can transform this into high value food and feed resource. Insect5 meal can replace expensive protein meal in the diet of farm animals. Animal products obtained from animals fed on insect meal-based diet were found to have no distinctive organoleptic qualities and are acceptable to the consumers

INTRODUCTION
Access to animal protein remains a major obstacle to the expanding livestock industry in Africa due to increasing costs of animal feeds, high costs of fishmeal, fish oil, soybeans, and grains (Niassy and Ekesi, 2016). Food insecurity situation prevailing in many developing countries and future challenges of feeding over 9 billion people in 2050 (Makkar *et al.*, 2014). The demand for animal products is expected to be 58% and 70% higher in 2050 than their levels in 2010 and a large part of this increase will originate from developing countries (FAO, 2011) Cost of feed has been reported to constitute over 70% of the total cost of production (Akinmutimi and Ezea (2006). Oilseed cakes, cereal bran and brewers dried grains often used as feed supplement are scares, costly and sometimes they are adulterated (Adediran, 2002)

Insects are the largest and the most diverse group of organisms in the animal kingdom, with over 1 million species identified. Niassy. and Ekesi (2016), reported that globally over 2,000 species are known to be edible and Africa alone consumes ~500 different species. Insect rearing could be one of the ways to enhance food and feed security (van Huis *et al.*, 2013).

Veldkamp *et al.* (2012) has demonstrated that it is technically feasible to produce insects on a large scale and to use them as alternative sustainable protein rich ingredient in pig and poultry diets, particularly if they are reared on substrates of bio-waste and organic side streams. One kg of insect biomass can be produced from on average 2 kg of feed biomass (Collavo *et al.*, 2005). Insects can feed on waste biomass and can transform this into high value food and feed resource. This review tries to look at insect as food and feed for livestock sub-sector.

Insect meal in Animal Feeds and Feeding

In yellow catfish, 25% replacement of fishmeal by black soldier fly larva powder produced no significant difference in the growth index and immunity index when compared with those in control group (Zhang *et al.*, 2014). Diets containing the larvae meal were reported to be palatable as a soymeal based diet (Newton *et al.*, 1977). In Nigeria, early weaned pigs were fed 10% of a 3:1 mixture of dried rumen contents and maggot meal in the diet replacing 10 % wheat offal without any adverse effect on performance (Adeniji, 2008). Sows and their offspring were fed a diet containing processed housefly maggot meal with no adverse effect on piglet performance, health and organoleptic properties or on the sows' physiology and breeding performance (Bayandina and Inkina, 1980). In Thailand, weaned pigs were fed on soybean based diet supplemented with 10% maggot meal to replace fishmeal and provided isoenergetic and isoproteic diet. This diet had no negative effect on body weight gain or feed conversion efficiency (Viroje *et al.*, 1989).

Alligator (*Alligator mississippiensis* Daudin). Dried black soldier fly pupae (reared on food waste) fed to juvenile alligators in a 3-month trial were less accepted than a commercial feed and therefore not recommended, even though they were able to promote growth (Bodri and Cole, 2007). The prawns fed black soldier fly larvae frass were of a lighter colour and no difference in prawns taste was found (Tiu, 2012).

Nutritional Value of Insect meal

The CP content varies between 40 and 60%. Lipid content is even more variable and ranges between 9 to 26%. Older larvae contain less CP and more lipids (Aniebo and Owen, 2010). Maggots contain a low (usually lower than 9%) but not negligible amount of crude fibre (CF) (Zuidhof *et al.*, 2003), but higher values have been reported for acid detergent fibre (ADF). P contents in housefly maggots are of similar order as in black soldier fly larvae but Ca levels are lower by about 15 times (Odesanya *et al.*, 2011). Lysine content in housefly maggots, similar to that in black soldier larvae, is also high (from 5. to 8.2 g/ 100 g CP with an average of 6.1 g/100 g CP) (Zuidhof *et al.*, 2003). Locusts and other Orthoptera species are generally rich in CP (50-65%), though some lower values (<30%) have also been reported (Makkar *et al.*, 2014). Essential amino acid composition of insect meal to have been reported by (Alegbeleye *et al.*, 2012) to be reasonably good. The amount of fat is extremely variable and depends on the type of diet being fed to the insect. Reported values are 15-25% for larvae fed on poultry manure (Arango Gutierrez *et al.*, 2004), 28% on swine manure (Newton *et al.*, 2005), 35% on cattle manure (Newton *et al.*, 1977) and 42-49% on oil-rich food wastes (Barry, 2004). The larvae of solder ant are rich in Ca (5-8% DM) and P (0.6-1.5% DM) (Newton *et al.*, 1977; Arango Gutierrez *et al.*, 2004). The lysine is particularly rich (6-8% of the CP).

Benefits of Rearing Insect as Feed

Insect rearing could be one of the ways to enhance food and feed security (van Huis *et al.*, 2013). They grow and reproduce easily, have high feed conversion efficiency (since they are cold blooded) and can be reared on bio-waste streams. One kg of insect biomass can be produced from on average 2 kg of feed biomass (Collavo *et al.*, 2005). Insects can feed on waste biomass and can transform this into high value food and feed resource. Study (Veldkamp *et al.*, 2012) has demonstrated that it is technically feasible to produce insects on a large scale and to use them as alternative sustainable protein rich ingredient in pig and poultry diets, particularly if they are reared on substrates of bio-waste and organic side streams. Adult black soldier flies are not attracted to human habitats or foods and are not considered a nuisance (van Huis *et al.*, 2013). Larvae modify the microflora of manure, potentially reducing harmful bacteria such as *Escherichia coli* 0157:H7 and *Salmonella enterica* (Erickson *et al.*, 2004). Black soldier fly larvae process organic waste very quickly, restraining bacterial growth and thereby reducing production of bad odour to a minimum (Makkar *et al.*, 2014).

Rearing Requirement for Insects

Several methods for rearing black soldier flies on substrates such as pig manure (Newton *et al.*, 2005), poultry manure (Sheppard *et al.*, 1994) and food wastes (Barry, 2004) have been designed. Poultry manure is the most common substrate cited in the literature for housefly rearing (Hardouin and Mahoux, 2003), large populations of flies can be obtained from relatively small amounts of substrate; for instance, 450 g of fresh manure can feed 1500 maggots (Hardouin and Mahoux, 2003). Other substrates mentioned in the literature include: pig manure (Zhu *et al.*, 2012), cattle blood and wheat bran (Aniebo *et al.*, 2008), cattle blood and gut contents (Dankwa *et al.*, 2002), cattle gut and rumen contents (Ekoue and Hadzi, 2000), fish guts (Ossey *et al.*, 2012) and a mixture of egg content, hatchery waste and wheat bran (Ebenso and Udo, 2003). The temperature should be maintained between 29 to 31°C and relative humidity should fall between 50 and 70%. It has been reported by (Barry, 2004) for rearing black soldier flies. Optimum temperature ranges of 24-40°C or 27.5-37.5°C have been reported (Sheppard *et al.*, 2002) for mating and oviposition. Wide ranges of relative humidity are tolerated: 30-90% (Sheppard *et al.*, 2002) or 50-90% (Barry, 2004).

Production and Harvesting Methods

Maggots are harvested by several methods. In the flotation method, the manure is mixed with water and the larvae and pupae float out to be collected with a sieve. In the screening method, the manure is spread in a thin layer on a screen net (3 mm) placed over a basin: the larvae try to escape the sunlight by passing through the screen and fall into the basin (Sogbesan *et al.*, 2006). The collected larvae are washed, killed in tepid or hot water and then dried and milled. More sophisticated collection methods that make the larvae self-collect has been designed (El Boushy *et al.*, 1985).

Nutritional Deficiency

Most insect meals are deficient in Ca and its supplementation in the diet is also required, especially for growing animals and laying hens. The levels of Ca and fatty acids in insect meals can be enhanced by manipulation of the substrate on which insects are reared (Makkar *et al.*, 2014). The presence of chitin might have reduced feed intake and nutrient availability and therefore reduced growth performance and nutrient utilization (Kroeckel *et al.*, 2012). Replacement of SBC with 100% insect meal was deleterious to hen-egg production (Agunbiade *et al.*, 2007).

Effect of Insect meal on Animal Product

Aroma and texture of channel catfish fed larvae were acceptable to the consumer (Bondari and Sheppard, 1981). Dried black soldier fly pre-pupae meal was fed to early weaned pigs as a replacement (0, 50, or 100%) for dried plasma (meal in the diet: 0% during phase 1, 2.5% during phase 2, and 5% during phase 3), with or without amino acid supplementation. Without amino acid supplementation, the 50% replacement diet gave slightly better performance during phase 1 (+4% gain, +9% feed efficiency). However, the 100% replacement diets did not perform as well as the control (overall performance reduced by 3 to 13%). Additional refinement (cuticle removal and rendering) may be necessary to make black soldier fly prepupae meal suitable for early weaned pigs (Newton *et al.*, 2005). Meat obtained from broilers fed a maggot-based diet was found to have no distinctive organoleptic qualities and are acceptable by consumers (Awoniyi, 2003). Aroma and texture of Blue tilapia (*Oreochromis aureus*) fed black soldier fly larvae were acceptable to the consumer (Bondari and Sheppard, 1981). It has been reported that free-range chickens fed on grasshoppers have a preferred taste and have a higher market price than those fed on conventional commercial feed (Khusro *et al.*, 2012).

CONCLUSION

Insects are important providers of ecosystem services, apart from providing food and feed; for example, insects play an important role in pollination, biological control and the decomposition of organic litter. Insects have been accepted as traditional food in many different cultures (Van Huis *et al.*, 2013).

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