

## Safety, regulatory, and environmental issues related to breeding and international trade of edible insects in Africa

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## Summary

Insect breeding or farming for food and feed is an emerging enterprise that can address the ever-growing demand for protein and curb high unemployment rates in Africa and beyond. However, for the sector to prosper, its value chain needs to be regulated to ensure sustainability and safety for consumers and the environment. Although a few African countries, such as Malawi, Tanzania, Kenya and Uganda, have promulgated standards on the use of insects as food and feed, greater efforts are needed in other countries, and relevant policies governing the sector need to be formulated.

All over the globe, attention to the regulation of the edible insect sector is peaking, and more investment in the industry is foreseen. Safety issues such as the identity of insects to be reared, substrate quality and traceability imposed by importing countries will be critical for expansion of the sector. This paper analyses safety, regulatory, and environmental issues related to breeding and international trade of edible insects in Africa and provides case studies and recommendations for sustainable use of insects for food and feed.

## Keywords

Animal feed – Enterprises – Global food and nutrition security – Healthy diets – Legislation – Protein – Standards – Sustainable Development Goals

## Introduction

Eating insects is a part of local culture for at least 2 billion people in about 113 countries (1-4), and Africa accounts for over 120 million insect eaters (5). Of the 2111 edible insect species known globally (6), around 500 species have been reported in sub-Saharan Africa (7, 8). In Africa, edible insects are mainly collected from the wild for household consumption and informal trade (9–12). Wild harvesting is unsustainable due to the seasonal availability of insects, habitat change and overexploitation (9). Eating or feeding insects to animals is recommended because of their unique nutritional profile, which is

equals or exceeds that of conventional foods (13). Insects are an excellent source of protein, fatty acids, vitamins and minerals (14). Besides traditional entomophagy (the practice of eating insects) in some parts of the world, increasing demand for alternative sources of nutrients for humans and animals has fuelled the need to farm edible insects (2, 5, 15).

Farming edible insects ensures continuous supply and offers alternative and cheaper protein sources compared to soy and fish meals (16, 17). Adopting cost-effective technologies for rearing, harvesting, handling, processing, added value, and packaging is a significant game-changer to ensure constant availability of insect proteins and enhance profit margins for farmers and other stakeholders (7, 8). Insects grow faster with high feed conversion efficiency and have less requirements for space and water than many conventional feed species. The carbon footprint of insect farming is much lower than conventional farming (2, 4, 18). Insect farming is gender-friendly (15, 19, 20) and currently, there are nearly 1000 edible insect farms in Africa, with the industry projected to be worth up to US\$8 billion by 2030 (5). A recent World Bank report estimates that black soldier fly farming alone has the potential to replace 60 million tons of traditional feed production in Africa annually, leading to 200 million tons of recycled crop waste, 60 million tons of organic fertilizer production, besides creating 15 million jobs (5). Therefore, the use of insects as food and feed may help attain some UN Sustainable Development Goals and the aspirations of the African Union Agenda 2063 (21).

Although insect farming is considered an emerging enterprise in Africa (5, 15, 22), critical issues in the production chain need undivided attention if the sector is to prosper. Key among these is safety, and the most debated issues are food hazards commonly associated with edible insects and their by-products. These issues may be related to how the insects have been reared, euthanised, handled, processed and packaged. Biological agents and chemical contaminants are some major health hazards associated with edible insects (2). Safety issues around insects for food and feed cut across environmental, health, agriculture and trade.

Food safety regulations on edible insects are not fully realised in Africa due to a wide range of challenges (23). These challenges include: 1) lack of awareness of food safety on socio-economic matters; 2) lack of established hazard and critical point checklists/systems; 3) limited data and information on health burden, especially food-borne diseases; 4) limited compliance with international agreements on food safety and quality standards; 5) limited enforcement of local, regional and international standards and global best practices; 6) limited resources to support scientific risk analysis and upgrading of food safety regulatory systems; and 7) poor food supply chains and traceability system.

Several authors acknowledged the lack of regulatory frameworks specific to insect farming and their use as food and feed in many countries (18, 24, 25). There is also a lack of harmonisation to improve policy and strengthen the trading environment, especially market linkages, to reduce constraints along the insect-based value chain (25). Several regulatory bodies are nominally in charge; however, procedures and the motivation behind these safety measures on food are often unclear, overlooked or fail to capture specific matters that concern the farming of insects as “mini-livestock”. The lack of understanding of these regulatory and legislative measures vis-a-vis the diversity of edible insects (which belong to several insect orders with very different lifestyles) hampers the sector. The objective of the present paper is to analyse the regulatory elements that govern safety issues in edible insect farming for national and international trade and provide an overview of legal procedure flow among regions and countries in Africa. The production chain and safety and regulation in relation to the environment and trade are summarized in Fig. 1.

## **Environmental related issues**

Over 500 insect species in Africa are recognised as edible, including crickets, grasshoppers, beetles, ants, termites, bees, locusts, caterpillars, cicadas, scale insects, planthoppers, dragonflies, leafhoppers, among other groups (4, 6, 7, 26). These are mostly used as supplementary food items and provide significant nutritional and economic benefits to rural and urban communities (9); although limited by seasonal availability,

edible insects form an essential part of cultural diets. Most edible insect species are collected from the wild. Only a few species are commonly farmed in Africa and other parts of the world. For instance, cricket farming has been practised in Asia, Europe, America and Australia for decades and was recently introduced in African countries (Kenya, Uganda, Mali and Madagascar) around 2013 (27, 28).

The most critical environmental questions are related to the right and the capacity to farm insects for commercial purposes and where to farm them. Given that insects are part of wildlife, they typically appear in the laws of many countries as natural resources, making it mandatory for people to get a permit and/or licence from competent authorities for exploitation in most cases (29). Grabowski et al. (29) further stated that, except for Botswana, edible insects are not mentioned in national regulations, which creates a complex, nation-specific situation regarding which insect may be used legally and for what purpose. Regarding collecting insects from the wild, many countries, including those in East Africa, already have robust legislation that could be applied to insects (29). Beyond overexploitation and the potential pest nature of insects, the correct taxonomic identity of insects to be farmed is also an important safety question that needs legal attention. Edible insects represent a minor fraction of the total number of insect species.

Eating insects is often part of a community's cultural heritage, and following many generations of insect-eating, they have developed a deep knowledge of the valuable insects. The existing lists of edible insects are not exhaustive as new edible species are frequently reported. Although culturally, gatherers, collectors, and foragers identify insects based on the smell, sound, season, and host plant (30), it is critical to establish national catalogues and guidelines to identify insects for consumption and/or farming. There is a need to profile insects that could be consumed and mass-reared to avoid misidentification (as some insects can be poisonous) and overexploitation.

## Health-related issues

### Pathogenic risks in edible insect farming systems and biological hazards

Various microorganisms may jeopardise the quality and safety of edible insects as food and feed, in some cases even posing a risk to human and animal health. While insect pathogens do not, in general, pose any threat to humans or vertebrate animals (31), other microorganisms in edible insects and insect-based products may enter the production chain via contaminated substrates and poor hygienic practices during production, handling, harvesting, storing, processing and packaging. Eilenberg et al. (32) outlined the necessity to distinguish clearly between insect pathogens, which are host specific and are thus able to cause epidemics, and other unwanted microorganisms, which are opportunistic and can cause increased mortality, and also food contamination.

Insect pathogenic viruses are true specialists that pose a risk to the insects in production but not to humans or other vertebrates (33). An epizootic outbreak of the cricket paralysis virus, *Acheta domesticus* Densovirus (AdDNV), in commercial cricket farming facilities was reported in Europe and North America (34). Although some species of crickets, including the European field cricket (*Gryllus bimaculatus* DeGeer) and Jamaican cricket (*G. assimilis* Fabricius), are reportedly resistant to AdDNV (34), there is a need to establish early detection of the disease to avoid outbreaks of this pathogen appearing in other regions, especially in Africa. Insect pathogenic viruses are not a concern for human health as they are host-specific to insects. Bacterial species belonging to the genera *Bacillus*, *Staphylococcus*, *Erwinia*, *Pseudomonas*, *Micrococcus*, *Lactobacillus*, *Acinetobacter*, *Streptococcus* and *Clostridium* have been widely associated with edible insects (2). For instance, Leonard (35) identified five bacterial species (*Proteus penneri*, *Serratia marcescens*, *Bacillus thuringiensis*, *Staphylococcus sciuri* and *Enterococcus faecalis*) to be associated with long-horned grasshopper (*Ruspolia differens* Serville). During rearing, these bacteria can cause 53 – 66% mortality in third instar nymphs of

*R. differens* (35). Some of these bacteria are opportunistic and can even be potentially pathogenic to humans and livestock and can also reduce the shelf-life of edible insect products. Endospore-forming and heat resistant bacteria are also of major concern. High levels of microbial pathogens will raise health concerns and consequently affect the consumption and sale of edible insects and insect-based products at a local, national, regional and international scale. Food-spoilage fungi can lead to loss of physical and nutritional quality and threaten consumers' health. Leonard (35) identified nine species (*Candida lusitanae*, *Lichtheimia corymbifera*, *Trichoderma koningii*, *Fusarium equiseti*, *Mucor fragilis*, *Aspergillus niger*, *Epicoccum sorghinum*, *Clonostachys rosea* and *Penicillium commune*) which can cause significant mortality of third instar nymphs of *R. differens* (60-86%). Additionally, harmful yeasts *Candida*, *Pichia*, *Tetrapisispora*, and *Debaryomyces*, and pathogenic moulds *Aspergillus*, *Wallemia*, *Fusarium*, *Penicillium*, *Cladosporium*, *Phycomyces* and *Alternaria* may be presented on the surface of edible insects reared, processed or packaged in hygienically poor conditions (2, 14).

If not hygienically handled, processed, stored or packaged, edible insects become vulnerable to moulds, especially *Aspergillus* spp., *Fusarium* spp., and *Penicillium* spp. that produce mycotoxins that have a negative effect on human and animal health (36, 37). Wastes or side streams such as agricultural materials, mainly grains and nuts used to feed the insects, may contain mycotoxigenic moulds or mycotoxins. These moulds and mycotoxins can reduce the survival of the insects being reared and can accumulate in edible insect products (36). Several mycotoxins that can be traced in edible insects and their by-products include aflatoxin, zearalenone, ochratoxin, fumonisins and deoxynivalenol (36, 38, 39). However, although these mycotoxins may be present in edible insects, they should occur within the permissible level provided by the European Union (40).

The presence of protozoan parasites in edible insects is associated with the quality of substrates used to rear them and the processing they undergo (2). Protozoans such as *Entamoeba histolytica* and *Giardia lamblia* have been found in edible insects (2). *Coccidia* spp. can be

found in edible insects, especially when reared on poultry manure as feed substrate (2).

### **Pesticides residues and toxic, trace metals**

Pesticides residues and toxic metals in reared insects can be associated with particular insect species, their source before being reared, sources and type of substrates used and contamination of the rearing unit (2, 39). For instance, the bioaccumulation of cadmium has been reported in crickets, Black Soldier Fly (BSF), *H. illucens* L.; arsenic in yellow mealworms; and lead in *R. differens* (39, 41, 42). Prior to consumption, edible insects should not exceed certain maximum permissible levels of heavy metals (lead, cadmium, arsenic and mercury) and trace metals (iron, manganese, copper and magnesium) (2). High concentrations of cadmium and mercury have been reported in yellow mealworms, *Tenebrio molitor* L., reared on substrates from treated agricultural side streams that accumulate fungicides (myclobutanil, diniconazole, metaxylyl, benalaxyl and epoxiconazole) (2).

### **Other substances**

According to FAO (2), edible insects and insect products may contain, accumulate or release noxious substances. These substances include bioaccumulated organic compounds (organic contaminants, plasticisers, and halogenated flame retardants), dioxin-like polychlorinated biphenyls (PCB), spiked levels of mineral oil hydrocarbons and histamines. Other undesirable contaminants such as antimicrobials, allergens and inherent anti-nutritional substances (phytic acids, tannins, saponins, phenolics, thiaminase, cyanogenic glycosides and oxalates) may accumulate in edible insect products during production and processing (2). Poorly processed and packaged edible insect products may contain undesirable objects and hard parts of the insects such as wings, rostrum, stings and spines.

### **Allergies arising from eating insect-based products**

Insects and crustaceans are related members of the phylum Arthropoda. Since allergic reactions to crustaceans are potentially severe, a cross-

reactivity and co-sensitisation of the immune system between edible insects, crustaceans and mites pose a potential health concern (43).

Indeed, cases of cross-reactivity/co-sensitisation between edible insects and crustaceans leading to food allergy have been clinically relevant with an unknown underlying molecular mechanism attributed to allergens, specifically arginine kinase (44 and references therein). Food allergy due to consumption of edible insects has been described for silkworms, mealworms, caterpillars, locusts, grasshoppers, cicadas, bees and sago worms (45). There are opportunities for further research on allergies due to eating insects, including diagnostic allergy tests that could lead to the identification of vaccines.

### **National, regional and international regulatory frameworks for edible insects**

As insect farming is gaining prominence, questions on safety are increasingly important. Countries that are known to practise entomophagy lack regulatory policies that would potentially benefit the insects for food and feed sector. These countries rely on a precautionary approach or the World Health Organization (WHO) and Food and Agricultural Organization (FAO) information on insect-based diets (18). Most studies have clearly shown that there are more stringent rules on the use of insects as “*novel food and feed ingredients*” in countries with no history of entomophagy but have food policies that prioritise food safety (18, 46). Country specific regulations have also been formulated in some countries (47).

Traditionally, collected insects are eaten raw, dried, roasted, smoked, stewed, fried or boiled. Certain additives (e.g., salt, honey and spices) can enhance palatability and shelf life during storage. Insects are consumed whole, degutted or transformed into powder or paste. These indigenous methods of handling insect products are often substandard in terms of food safety (11, 37).

Insect entrepreneurs are increasingly becoming more accountable for issues relating to sources of their insect products, equivalence and instrumentation used. Equivalence implies that a unit of insect products

in a certain location or from a certain producer equals the same in the entire geographical area and costs the same. This requires adequate instrumentation, usually handled by the ministry responsible for trade or industry, to protect the interest of consumers. Over time, efforts have been made to develop these parameters; since insect farming starts from choice of substrate, definition of substrate homogeneity and growth parameters are critical for insect production as they determine the nutritional value of the final product and its commercial value. On the other hand, there might be genetic variabilities in performance of insects which might inspire breeding initiatives for more profit.

Based on food safety, insects as food and feed should be free from biological, chemical and allergenic compounds that can potentially be harmful to humans and animals (48). Edible insects should be free of or should have the minimum recommended levels of toxigenic and pathogenic fungi (*Aspergillus spp.*, *Fusarium spp.* and *Penicillium spp.*), bacteria (*Staphylococcus spp.*, *Bacillus spp.* and coliforms) and heavy metals (chromium, lead and cadmium) (49, 50). These legal regulations should guide trading, food safety, and environmental impact – for sustainable food security by ensuring insects are sustainably harvested from the wild to limit overexploitation or sustainably farmed and marketed freely countrywide, regionally and globally. Considering food safety, consumer acceptability and environmental sustainability, legal regulations can be tailored towards culture and/or harmonised regionally or globally.

In Africa, standards have been developed in Malawi, Tanzania, Kenya and Uganda (48). Moreover, these countries have set the stage for benchmarking by other African countries, and Rwanda is currently drafting similar standards to support individuals and industry players interested in edible insects to invest in the sector. These standards do not restrict the insect type or substrates for rearing.

With the increased globalisation of food markets, African countries should have food standards recognised internationally in order to participate in international trade. Most African countries rely on traditional food control systems, and food safety legislations aligning

with international requirements (Codex Alimentarius) have been least adopted (51). Thus, the World Trade Organization/Sanitary and Phytosanitary (WTO/SPS) Agreement specifies national standards that agree with Codex Alimentarius. Additionally, Food Hygienic Practices (GHP), Good Manufacturing Practices (GMP) and the Hazard Analysis and Critical Control Points (HACCP) system are recommended to ensure food safety and quality assurance in the region (51). FAO (2) has partnered with regional economic communities (RECs) and trading blocs *viz.* the Common Market for Eastern and Southern Africa (COMESA), the East African Community (EAC), the Southern African Development Community (SADC), the Economic Community of Central African States (ECCAS), the West African Monetary and Economic Union (UEMOA/WAEMU), the Central African Economic and Monetary Community and the Economic Community of West African States (ECOWAS) to assess national food control systems and to strengthen food trade, national SPS capacity, functioning of international standard-setting bodies, regulatory cooperation policies, leveraging private sector engagement and harmonising food standards to include COVID-19-related protocols. Jaffee et al. (52) provide an executive summary of a situation analysis, and most African countries can be considered to be either in “traditional” or “transitioning” stages towards “modernising” food systems. While African countries are in the “transitioning” stages of recognising edible insects as “foodstuffs” or “animal feed”, it is expected that most existing food laws and policies would apply to edible insects as well.

Edible insects are not listed in the Codex Alimentarius, which is considered a global problem (53). There are limited attempts to incorporate diversity of edible insects into Codex Alimentarius, especially food safety aspects (54). Until they are added to the Codex as foods rather than impurities, there will be an insurmountable barrier for them to becoming legally well-accepted foodstuff, regardless of what consumers accept. Hazard Analysis Critical Control Point (HACCP) is also an international food safety management system. It provided an international guideline that is systematic and science-based to regulate food safety, especially microbial load, throughout the food chain. HACCP has been adopted widely by regulatory authorities

because of its perceived benefit in increasing international food trade (47).

Several regional regulations and regulatory bodies have been established. For example, European Union regulations under the European Food Safety Authority (EFSA) were established by the European Commission to regulate food safety relevant to edible insect-based products in the European market (55). According to the EU, farmed insects are considered “*livestock*”; therefore, livestock health and biosecurity measures and regulations are applied to farmed insects (2). So far, only seven insect species *Musca domestica* L., *Tenebrio molitor* L., *Gryllus assimilis* Fabricius, *Alphitobius diaperinus* Panzer, *Gryllobates sigillatus* F. Walker and *A. domesticus* have been authorised as feed for farmed and pet animals in EU markets (53, 56). Applications for authorisation as “*novel foods*” have been made for about 17 insect species. In 2021, migratory locust *Locusta migratoria*, crickets *Acheta domesticus* and yellow mealworm *Tenebrio molitor* were authorised by the EU as the first insect as “*novel food*” for human consumption and marketing (57). The lesser mealworm *Alphitobius diaperinus*, crickets *Gryllobates sigillatus*, BSF *H. illucens*, and honey-bee drone brood *Apis mellifera* (male pupae) are at an advanced stage of authorisation (57).

However, in the case of EU standards, insect species used for food and feed must be reared on a substrate that fulfils certain prescribed safety conditions for insect production (53, 56, 57). According to the EU, insects used as food and feed should not be reared on waste streams (2, 57); however, insects meant for biomass conversion for economic gains can be reared on waste streams (2). Though EU restrictions are designed to eliminate the risk of prion contamination of the edible insects, they limit their use to close nutrient loops, this is also the case for Africa. Thus, policies and laws are needed which allow insect harvesters, small- and large-scale insect farmers and processing industries to get accreditation and market their products (48).

## **Comparative regulatory framework on edible insects in Kenya, South Africa, Zimbabwe, Nigeria, Cameroon, Zambia, Ghana and Burkina Faso**

### **Kenya**

The Government of Kenya has ensured that safe food trade practices are consistent with WTO/SPS measures and other international standards (58). Kenya has agencies that implement food laws, and they operate under the Ministries of 1) Public Health and Sanitation; 2) Industrialization, Trade and Enterprise Development; 3) Agriculture, Livestock and Fisheries; and 4) Environment and Forestry. Some of these agencies include the Kenya Bureau of Standards (KEBS), Weights and Measures Department (WMD), Kenya Agricultural and Livestock Research Organization (KALRO), the Department of Public Health (DPH), Kenya Food Safety Authority (KEFSA) (59). The regulation of the insect production chain in Kenya is summarized in Fig. 2.

Food safety constitutes part of a broader National Food and Nutrition Policy (58). The Ministry of Health and Sanitation coordinates the food safety legal frameworks through the Department of Public Health (DPH). These legal frameworks guide 1) provisions on food safety measures along the food chains (farm to fork); 2) the nature, substance and quality of food; 3) packaging, labelling and advertising; and 4) standards of food. DPH oversees the enforcement of the Public Health Act, Chapter 242 and the Food, Drugs and Chemical Substances Act, Chapter 254.

Different authorities have formulated Kenya Environmental Sanitation and Hygiene Policy (KESHP), *inter alia*, the Ministry of Health, the Environmental Sanitation and Hygiene Interagency Coordinating Committee (ESH-ICC), all the 47 County Health Departments, Ministry of Environment and Natural Resources, and the National Environmental Management Authority (NEMA) (60). The National Government and Ministries of Health, Environment and Natural resources, Trade and Industry and County Governments through the collaboration of the National Environmental Sanitation Coordinating

and Regulatory Authority (NESCRA), NEMA and Water Services Regulatory Board (WASREB), is mandated to ensure implementation of KESHP for solid and liquid waste management (60). The county governments have been vested with the responsibility of implementing the Food Safety and Hygiene aspect of KESHP through controlling sale of prepared foods, ensuring market facilities for handling, display and preservation of meat, fish, and other perishable foods meet the required hygienic standard to prevent contamination and decomposition, and regularly inspecting all food outlets and slaughterhouses (60).

The Kenya Bureau of Standards (KEBS) has been mandated to practically ensure that food standards meet the international standards of the International Organization for Standardization (ISO) and Codex Alimentarius Commission (CAC), following the philosophy of WTO/SPS. KEBS, in consultation with other relevant agencies through an established technical committee, has gazetted standards for insects used as food and feed. These standards provide specific requirements of the edible insect as a whole insect, insect product and powdered insect products either sourced from domesticated farms or wild.

The KEBS (KS 2922-1:2020 and KS 2922-2:2020) require that the edible insect products meet a set of the general and specific requirements and specifications of additional ingredients (61). The standards specify the inclusion of approved food additives, hygiene of prepared and packaged products, and limits of pathogenic microbes and contaminants (heavy metals and mycotoxins) in dried insect products (KEBS, 2020a) (61). Packaging and labelling should practically conform with Weights and Measures Act Cap. 513, and other Standard Act Chap. 496 with the adherence to the following specifications: KS EAS 38 (Labelling of pre-packaged foods), KS EAS 803 (Nutrition labelling), KS EAS 804 (Claims) and KS EAS 805 (Use of nutrition and health claims) of the Laws of Kenya (61). Additionally, the use of insects as animal feed follows standards set by Kenya in 2016 (KS 2711:2016), which recognise insect products as either whole, ground or defatted insect meal (62). The standards specify the general requirements, nutritional requirements, microbial requirements, limits of heavy metals and pesticide residues, aflatoxins, packaging and

labelling and sampling. Code of practice for producing and handling insects for food and feed (KS 2921:2020) has also been gazetted (63). The code specifies requirements for sustainable establishment and operation of wild-harvested or domesticated insect farming, production, harvesting and post-harvesting handling of insects for food and feed.

The Ministry of Industrialisation, Trade and Enterprise Development creates an enabling environment for a globally competitive, sustainable industrial, enterprise and cooperative sector through appropriate policy, legal and regulatory frameworks. This ministry collaborates with other agencies, such as the Kenya Revenue Authority (KRA), the Special Economic Zones Authority (SEZA), the Export Promotion Council (EPC) and the Kenya National Chamber of Commerce and Industry (KNCCI) (64). Formulation of the National Trade Policy (NTP) has enhanced Kenya's efficiency in domestic, regional and international trade (64).

Collection, transportation and farming of edible insects must conform with the Wildlife (Conservation and Management) Act Cap.376, protecting and conserving wildlife in Kenya. Harvesting insects from the wild for large-scale farming requires permission from Kenya Wildlife Services (KWS). Prior to permit issuance, one must provide an order of conformity to wildlife domestication processes and approval on livestock transportation and the method of transportation. The Ministry of Environment through NEMA may also regulate the policies related to the environment through the Environmental Management and Co-Ordination Act, 1999, including management and conservation of natural resources and the environment.

### **South Africa**

In South Africa, four government departments oversee food safety and quality legislation (Table I). Niassy et al. (23) analysed the legislation flow in South Africa. The status quo remains, and insect farming, especially the BSF, is gaining momentum and a regulatory framework is needed to support this.

## Zimbabwe

The Ministry of Environment and Tourism of Zimbabwe has comprehensive environmental legislation concerning environmental issues. Natural Resources Act (1941), the Forest Act (Chapter 19:05) (1949) (control trade in forest produce and illegal use of forest resources), Environmental Management Act (Chapter 20:27) (management of natural resources and protection of the environment), Parks and Wildlife Management Act (Chapter 20:14) (preservation, conservation, propagation or control of the wildlife, fish and plants). These regulations apply to wild-harvested edible insects. The Forest Act of Zimbabwe (Chapter 19:05) regulates the harvest of wild harvest insects. This act is supported by the Cultural and Heritage Law, which empowers traditional chiefs to govern the collection and trade of edible insects within their areas of jurisdiction. This is closely connected to the conservation of habitats, including forests and water bodies, through the Environmental Management Act (Chapter 20:27) and the Parks and Wildlife Management Act (Chapter 20:14) implemented by the Environmental Management Agency (EMA), the Parks and Wildlife Management Authority (PWMA), respectively.

The Ministry of Health and Child Care is mandated to ascertain the quality and safety of food through a number of acts. The Public Health Act provides that all abattoirs must be registered, and slaughtering of all animals and birds meant for human consumption should be licensed by the local authority. All premises involved in the sale, manufacture, production, processing or treatment of food are inspected and certified in accordance with the Food and Food Standards Act. The Standard Association of Zimbabwe (SAZ) has set safety standards for regular foods. It regulates the quality, risks and hazards associated with food and feed. It monitors residue levels (heavy metals), critical microbial levels, packaging and recommendation for shelf-life.

Several studies are currently underway to develop policy recommendations regarding insects as food. There are no specific standards for edible insects in Zimbabwe; however, standards related to regular food would apply to edible insects.

The AgriFoSe2030 programme project on edible insects for food in Zimbabwe is working with SAZ to generate scientific evidence for informing food standards guidelines for four insect species, namely *Imbrasia belina* mopane worms, termites *Macrotermes* sp. (alates and soldiers), edible beetles *Eulepida mashona* and edible stink bugs *Encosternum delegorguei*. Recommendations will be made in relation to specific harvesting, processing, packaging and consumption practices.

The National Biotechnology Authority of Zimbabwe offers an oversight role in monitoring that all consumed food in Zimbabwe is not contaminated by genetically modified substances.

Concerning insects as feed, the Ministry of Lands, Agriculture, Fisheries, Water and Rural Resettlement regulates registration of animal feeds, including those with insect proteins. The same ministry also issues export and import permits for edible insect trade.

## **Nigeria**

Usman and Yusuf (25) noted that Nigeria, the most populous country in Africa and with a rich diversity of edible insects, has no specific regulations on use of insects for food and feed. Yet over 20 species are reportedly consumed in the country. However, several Ministries, Departments and Agencies could regulate the safety of insects as food. The Federal Ministry of Health (FMOH) is at the forefront in formulating national policies, guidelines and regulations regarding food safety and quality. Food quality and safety, general public health surveillance and complaints in the 36 states of Nigeria is supervised by the States Ministry of Health in collaboration with the Local Government Authorities (LGAs) (23). Other ministries including the Federal Ministry of Industry, Trade, and Investment (FMITI), Federal Ministry of Environment (FME) and Federal Ministry of Science and Technology (FMST) are also critical in regulation related to edible insects (Table II).

To develop a clear and comprehensive framework for policies on edible insects in Nigeria, Usman and Yusuf (25) proposed a top-to-bottom

approach involving all stakeholders and consolidating role players and government departments/agencies that should deal with such legislation to ease its implementation.

## Cameroon

Cameroon has one of the richest biodiversity in Africa and is a hotspot for edible insect consumption (7, 65, 66). Insect rearing is gaining rapid interest both as feed (BSF for fish farming) (66) and food (palm weevil grubs), legislation is very silent and not adapted to the huge tendency observed in urban regions. Laws mentioning safety inspection of animal products are old (1986 and 2000). Therefore, the consequences are the failure of businesses to meet regulatory standards for export, where Cameroon has been a major player in Non-Timber Forest Products (NTFPs) since the release of the 1994 Law on Forest and Environment. Food systems regulations copied from western philosophy need to be customised and adjusted for sustainable livelihood.

## Zambia

Insect trade in Zambia is a reliable alternative source of income and livelihood for both rural and urban communities (68). The Mopane worm (*I. belina*) (caterpillars) could contribute up to 62% of total income for rural households (69). Stull et al. (70) have emphasised the nutritional value of insects and the need for insect farming to alleviate poverty. However, insect farming is very much in its infancy. A conducive regulatory environment is crucial to ensuring the safety of insects as food and feed.

Despite having a high diversity of edible insects, Zambia has no specific regulations on the use of insects as food and feed. There are several institutions which can deal with the regulatory aspects. These include the following: Zambia Environmental Management Agency (ZEMA), whose duty is to issue environmental certificates, permits and approvals, undertake environmental monitoring, in case of over-harvesting of insects by cutting trees and branches and enforce regulations; The National Biosafety Agency (NBA) can also attend to such matters and the Ministry of Agriculture and cooperatives.

Recently, the New Deal Government has introduced a new Ministry of Green Economy and the Environment. This is the most appropriate and promising Ministry to deal with regulatory framework issues on the environment, insect farming and trade of insects as food and feed in the country.

## Ghana

In Ghana, there are nine major edible insects: the African palm weevil larvae *Rhynchophorus phoenicis* Fabricius, termites *Macrotermes bellicosus* Smeathman, ground crickets *Scapteriscus vicinus* Scudder, field crickets *Gryllus similis* Chapman, house crickets *Acheta domesticus* Linnaeus, grasshoppers *Zonocerus variegatus*, locusts *Locusta migratoria* Linnaeus, beetle, *Cirina butyrospermi* Vuillot, *Phyllophaga nebulosa* Harris (13, 71). However, the production of these insects in Ghana is on a small scale. In most areas in Ghana, insects are commonly consumed as food, and some people have expressed food safety concerns about eating insects. The Food and Drug Authority, on the other hand, has implemented regulations that govern the production of novel food items under Section 6 of the Food and drugs act, 1992 P.N.D.C.L. 305B (<http://elibrary.jsg.gov.gh>). Furthermore, Ghana's environmental protection agency lacks measures that govern and regulate insect farming.

## Burkina Faso

Edible insects are also considered as part of Non-Timber Forest Products (NTFPs) and regulated under Law on Forest and Environment. However, the law is not specific to edible insects considering that most edible insects are considered pests and do not require protection. Indeed, the caterpillar *Cirina butyrospermi* Vuillet, 1911 also referred to as “Chitoumou” is a pest to the shea butter tree and its collection, processing as traditional food is accepted. Therefore, there are no food systems regulations that take into account insects. As in Ghana, the only safety requirement for trading edible insect products is by providing laboratory test results and a registration certificate. The importing entity is left with most of the responsibility during importation in the international markets.

The Sustainable Use of Insects to Improve Livestock Production and Food Security in Smallholder Farms in West Africa (IFWA) project implemented by CABI aimed to develop appropriate fly larvae and termite production and utilisation methods for smallholder farming systems in Burkina Faso based on waste material. The project also attempted to engage stakeholders, the general public, the scientific community and policymakers to share innovation. However, insect farming for food and feed is in its infancy; hence comprehensive regulation is required.

## **Conclusions**

The safety issues related to insect farming are at the junction between environmental, social, health and economic concerns. The study revealed that most African countries had not developed safety regulations for insect breeding, although legal instruments pertaining to food laws would be relevant. Kenya, Uganda, Tanzania and Malawi are exceptions in having standards for use of insects as food and feed. This encouraging step may serve as an example, but the law is not integrated to the complexity of the production chain and the socio-economic aspects that govern their introduction in the food system are not taken into account. The lack of enforcement and capacity to do so are also major issues. While the EU has introduced legislation that is very specific to the type of insect and the substrate quality used for insects as food or feed, the standards developed so far in Africa are less demanding.

Safety concerns may require regulations in terms of capacity and location to protect community safety through certification. In Benin the certification process through Agence Beninoise de la Sécurité Sanitaire des Aliments (ABSSA) is one of the most comprehensive examples that encompasses all the safety dimensions of the insect food or feed production chain (environment, health, agriculture and trade) to protect the consumer. Under the ABSSA process, an entrepreneur undergoes three technical visits, sampling and testing of the products, after which a certificate is issued.

Insect farming has bright prospects in Africa, as it is an efficient response to the global market for low-cost alternatives to protein and youth unemployment. The findings of this study encourage national and regional food systems to integrate safety measures in insect farming in food and feed regulations, borrowing from emerging countries such as Kenya and Uganda, while harmonizing these policies at the global level for a more dynamic sector.

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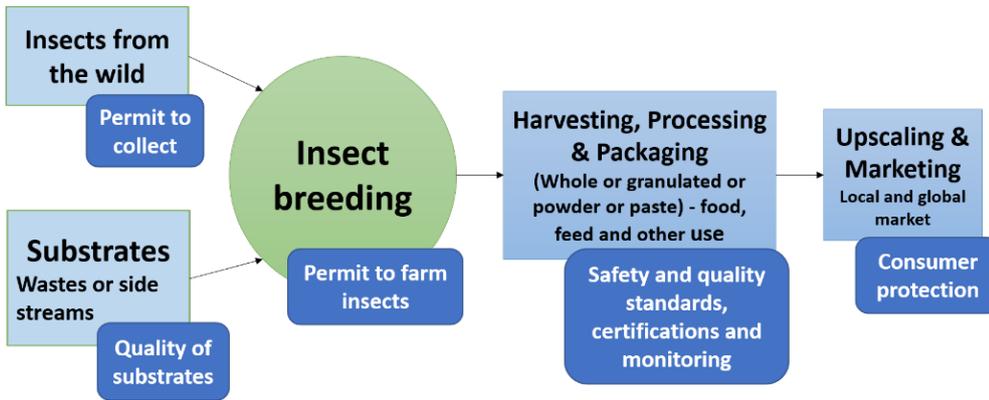
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**Table I.** Legislative bodies and legislations related to edible insects in South Africa

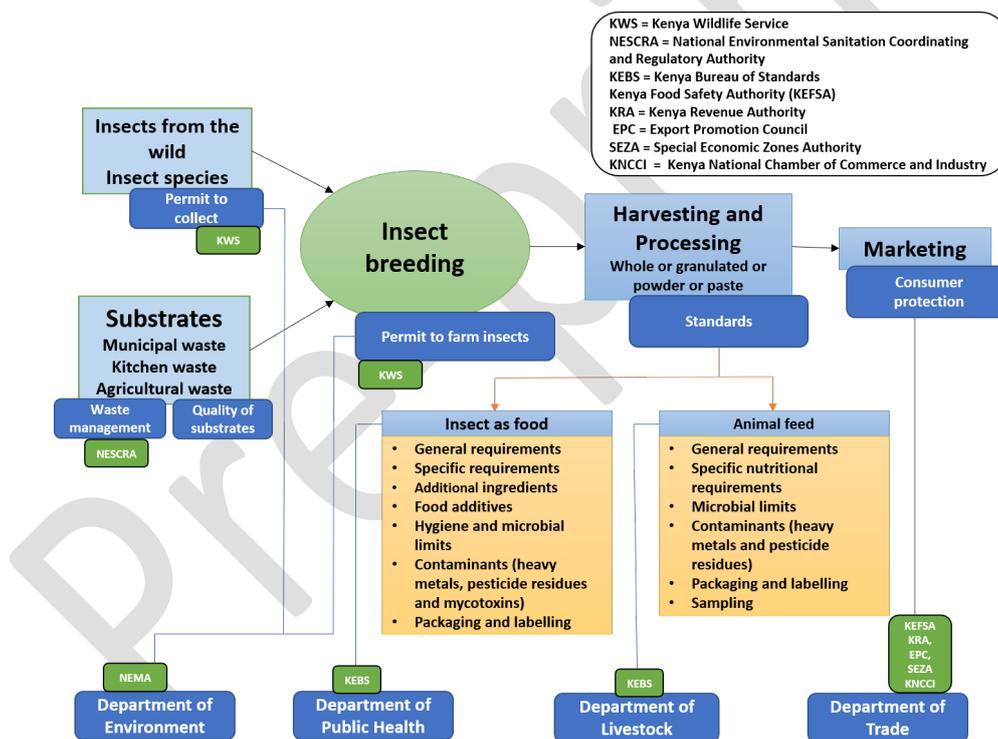
Department	Responsibilities	Acts/Laws
Department of Agriculture, Land Reform and Rural Development (DALRRD)	Regulates safety and quality of agriculture and animal products	Agricultural Product Standards Act, 1990
		Animal Diseases Act, 1984
		Animal Identification Act, 2000
		Animal Improvement Act, 1998
		Animals Protection Act, 1962
		Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947
		Meat Safety Act, 2000
Department of Health (DoH)	Ensure all foodstuffs for human consumption are safe. Also acts as a contact point for Codex, and therefore, it has adopted standards and guidelines provided by CAC	Performing Animals Protection Act, 1935
		Foodstuffs, Cosmetics and Disinfectant Act, 1972, which specifies the manufacturing, labelling, sale and importation of foodstuffs
		National Health Act, 2003 which addresses the hygiene aspect of foodstuffs
Department of Trade and Industry (DTI)	Act through the South African Bureau of Standards (SABS) to control foodstuffs such as canned meat fishery, meat and other animal products.	International Health Regulations Act, 1974, which provides hygiene requirements of foodstuffs at ports and airports Standards Act, 1993

**Table II.** Legislative bodies and legislations related to edible insects in Nigeria

Ministries/Departments	Agencies	Responsibilities	Acts/Laws
<b>Federal Ministry of Health (FMOH)</b>	National Agency for Food and Drug Administration and Control (NAFDAC) is one key food regulatory body established by decree 15 of 1993 (now NAFDAC Act Cap N1 Laws of Federal Republic of Nigeria, 2004).	Regulates and controls the importation, manufacture, exportation, advertisement, distribution, sale and use of food, drugs, cosmetics, chemicals, detergents, medical devices and packaged water. In 2013, NAFDAC created the Directorate of Food Safety and Applied Nutrition (FSAN) to intensify food control activity and professionalism (23).	Food and Drug Act (Cap 50).
	National Primary Health Care Development Agency (NPHCDA)	Mandated to provide education on approved methods of food preparation, handling, consumption and needs of food and nutritional security for healthy lives	Public Health Services Acts (Cap 165)
<b>Federal Ministry of Industry, Trade, and Investment (FMITI)</b>	Standard Organisation of Nigeria (SON)	Complements the mandate of NAFDAC by specifying standards for packaging materials. Standardises and regulates the quality of all products in Nigeria	SON Act No. 14, 2015, Cap. 59
	Federal Produce Inspection Services (FPIS)	Supervising the exportation of agricultural commodities, including checking on the quality, weight, fumigation and packaging standards	Produce Enforcement of Export Standard Law
<b>Federal Ministry of Environment (FME)</b>	National Environmental Standards and Regulations Enforcement Agency (NESREA)	Protects the environment by conserving biodiversity and natural resources through enforcing environmental standards, regulations, rules, laws, policies and guidelines	NESREA Act 2007, now Cap N164, Laws of Federation of Nigeria 2010
<b>Federal Ministry of Science and Technology (FMST)</b>	Federal Institute of Industrial Research Oshodi (FIRO), Sheda Science and Technology Complex (SHESTCO) and National Biotechnology Development Agency (NABDA)	Provides scientific research and developmental support to food safety policies, linkages and programs. They develop innovative technologies for food processing and handling	
	Federal Competition and Consumer Protection Council (previously Consumer Protection Council (CPC))	Create consumer awareness, protect consumers from unscrupulous practices and exploitation, and ban the sale of unsafe foods	Consumer Protection Council Act, Cap 25, 2004



**Fig. 1**  
 Classical flow chart of the insect production chain and the regulatory issues in relation to safety



**Fig. 2**  
 Regulatory procedure of the insect production chain and the emergencies in relation to safety in Kenya