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# Value chain of edible insect production: a bibliometric study

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**Abstract.** Projections by the Food and Agriculture Organization of the United Nations (FAO) of a significant increase in protein production by 2050 to feed an estimated 9 billion people raise concerns about healthiness and sustainability, as this growth is linked to the challenges non-increase in land use, decrease in energy and water consumption and reduction of CO<sub>2</sub> emissions. This scenario makes the food and food ingredients industry look for innovative ways of producing proteins. The production of edible insects is part of this quest. The objective of this article is to analyze the evolution of the scientific field of the role of insects in human food in a sustainable way, considering the state-of-the-art study (reference to the current state of knowledge about a particular topic being study) as a tool to analyze the value chain of edible insects. The bibliometric results show the evolution of publications referring to the term “edible insects”, which were qualitatively categorized into three main topics: 15 articles about insects as food and feed, 34 articles about food science, and 1 article about veterinary humanities and social sciences. This article may be useful for researchers interested in the topic, especially those who wish to respond to the challenges imposed to meet the global demand for sustainable protein.

**Keywords:** Edible insects, Insect cultivation, Sustainability, Value chain

## 1. Introduction

According to updated projections from the Food and Agriculture Organization of the United Nations (FAO), a 60% increase in protein production will be needed by 2050 to feed a world population that will reach around 9 billion people [1]. A major challenge to meet this demand is related to how to do it without increasing the use of resources such as land, consuming less energy and water, and reducing CO<sub>2</sub> emissions. To meet this challenge, FAO points out the need to use alternative sources of proteins. An alternative to keep up with the increase in this demand is the production of edible insects as a sustainable proposal for human consumption [2].

Despite the worldwide attention on the topic, a bibliometric review on the Web of Science on the term “edible insects” resulted in only 50 articles, demonstrating a research gap. The objective of this article is to analyze the evolution of scientific articles on the role of insects for human food in a sustainable way. In this article the study of art will be considered to analyze the value chain of edible insect production.

## **2. Literature review**

### **2.1 Climate and environmental changes and the cultivation of insects**

Global warming has become a problem, mainly due to the great impact it has on agriculture and consequently on food security, triggering climatic events that have affected food sustainability [3]. In this way, it has become a focus of interest for researchers from different areas, who strive to solve its negative and often irreversible effects [4].

As adaptation and mitigation strategies to combat the effects of climate change in 2015, 195 countries and the European Union (EU) signed the first universal global climate agreement, pledging to stop the rise in the planet's temperature below 2°C above pre-industrial levels, significantly reducing the impacts of climate change

According to Huis and Oonincx [5] to reduce such impacts, some measures can be taken, such as reducing demand for livestock products, reducing manure emissions, and increasing carbon sequestration in pastures. As a quarter of all anthropogenic greenhouse gas emissions from global food production, insect consumption has been suggested as a sustainable and healthier route to animal protein consumption [6].

Climate and environmental changes have contributed to the increasing popularity of this consumption. Thus, it has become increasingly important to protect traditional practices of harvesting edible insects, especially in countries where the practice is already a daily habit, as in several parts of Africa, and thus guarantee the availability of these resources for future generations [7].

### **2.2 Food safety and consumption of edible insects**

According to the Committee on World Security, food security exists when all people always have access to sufficient food to meet their needs, considering four pillars: availability, access, use and stability, in which the nutritional dimension is considered a part. integral to food security [8].

Simion et. al [4] consider the risks are global and access to food has become a challenge not only for developing countries, but an economic priority around the world, as many causes have contributed to the increase in food insecurity, such as: increasing population growth, global warming, use of food resources, natural disasters, and armed conflict. According to FAO data (2018), 60% of people who suffer from hunger are in countries affected by conflict and 40% are in countries that suffer from drought.

According to Van Huis [2], edible insects can contribute to food security and be the solution to the lack of nutrients, especially as a source of protein. In addition, the production of edible insects emits low greenhouse gas emissions, requires reduced land, and has high conversion efficiency, and insects can partially replace ingredients in compound feed for livestock and aquaculture, allowing cereals used as animal feed will be used for human consumption.

Countries such as Belgium, Switzerland and the Netherlands have shown favorability for the production and consumption of insects. Switzerland has supported the sale of crickets, locusts, and mealworms since 2015, while Belgium in 2014

concluded that it seems highly unlikely that insects raised in controlled and hygienic circumstances will become infected, although the heating step is essential before being infected. available for consumption [8].

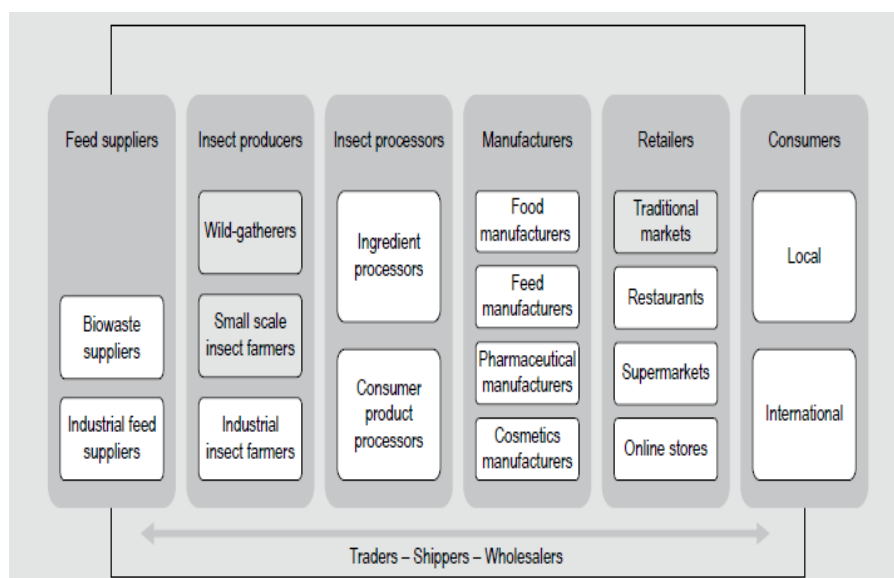
### 2.3 Edible insect value chain

The topic of edible insects involves several areas of research, such as: nature conservation, food, feed, organic waste recycling, poverty reduction, business development, food and agricultural policy and legislation, involving many stakeholders who meet at different operational levels of the value chain [9].

Research on the consumption of edible insects has grown over the last few years, bringing together international scientists to present their analyzes and findings related to the applicability of consumption as a new source of protein, both for human food and for animal feed, in addition to considering the different stages of the value chain. An example of this scientific interest and commitment was the symposium held in 2018 in the Netherlands, which marked 10 years of research in this area [10].

Odongo et. al [11] investigated the commercialization of edible insects in Uganda and Burundi, describing the value chain and market opportunities, revealing results in which the edible insect trade presents an alternative source of livelihood from collectors, street vendors and traders alike. of rural and urban areas. Research data showed that a specific kilo of edible insect cost US\$3.00, while beef and fish cost US\$3.50 and US\$1.95 respectively.

Considering that insect value chains can suffer structural differences according to the analyzed country, Mermúdez-Serrano [12] elaborated a value chain of edible insects, considering an overview of the main actors involved, showing in Figure. 1.



**Figure 1.** Main actors in the edible insects' value chain

The value chain of edible insects is composed of the main actors involved in production, processing, and international marketing, but does not consider the interrelationships between the different actors, since these relationships depend on the context in which they are inserted [12].

#### 2.4 Regulation of edible insects

Since November 25, 2015, the EU, through Regulation 2015/2283, considers insects as a novel food, subjecting them to a simpler, clearer, and more efficient authorization procedure, in which insect-based foods can be marketed in throughout the territory, explicitly clarifying that insects can be consumed whole or in parts [12][13].

However, this type of regulation does not occur in most countries, in which the lack of regulation is caused. Decision makers interpret insects as pests and not as potential food, directly affecting entrepreneurs as the challenges in marketing and product development increase, in addition to generating irrational exploitation, ineffective collections, promotion of monopolies, over-intermediation and poor conservation of the animals. resources [12][14].

According to Vantomme [9], FAO can help member countries by gathering and comprehensively disseminating the following information on edible insects, showing in Table 1.

**Table 1.** FAO - Information on edible insects

Topics	Information
Nutritional composition	Nutritional composition tables for more insect species, promoting similar methodologies across countries on nutritional compositions of insect consumption, easily comparable with other major protein sources such as fish, chicken, pork, beans and pulses
Bioavailability of micronutrients	Such as iron, zinc and others, mainly due to the massive occurrence of these deficiencies in the tropics, leading to stunted growth in children. This is very important in many developing countries characterized by protein-deficient diets and where, for example, mixing cassava flour with ground insect powder could easily improve local diets.
insect processing	Extracts in recomposed foods: extraction of proteins and by-products such as fats, chitin, minerals, vitamins in hamburgers, spreads, energy bars, etc.
Legal and regulatory frameworks	Support inclusive legal and regulatory frameworks for insect consumption, such as novel foods, Codex Alimentarius, food safety standards, and healthy food regulations

### 3 Methodology

Considering the study of art to analyze the consumption of insects for human consumption in a sustainable way, the qualitative approach was adopted. This article was prepared through bibliographic research. Bibliometric analysis emerged with the aim of studying and evaluating scientific production activities in the early 19th century. Its development took place having as main landmark the studies from empirical laws on the behavior of literature [15].

The study used Thomson Reuters' Web of Science database, the former ISI Web of Knowledge, which is an online scientific information wizard. This database allows scholars access to journal articles, books, and other scholarly documents in all fields of science. In addition, Thomson Reuters Web of Science journals have impact factors in the Journal Citation Report (JCR).

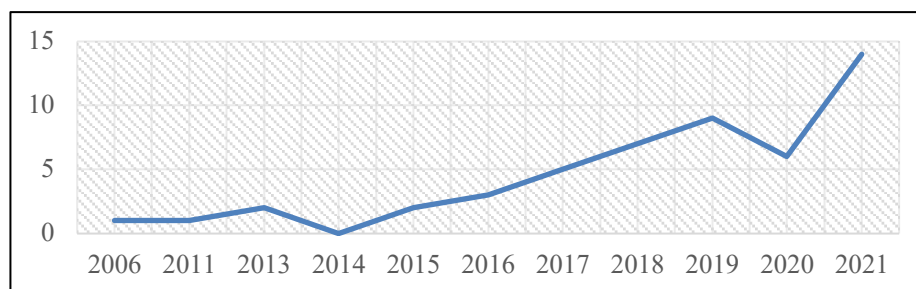
To answer the research objective the search string “edible insects” was defined. After using the search string in the Web of Science database, the following criteria were used to select the articles included in this systematic review: Articles published in peer-reviewed journals or conferences that answer questions and research:

- Articles published in the last 16 years, from 2006 to 2021;
- Studies available for download in the defined search bases.
- Duplicate studies were excluded from the sample.
- Articles that did not answer the research question were excluded.

Bibliometrics was carried out with the purpose of gathering knowledge about edible insects and other areas of knowledge, aiming to find primary studies on the subject and the solutions pointed out in the literature.

### 4 Analysis and discussion of results

The research examined articles published from 2006 to 2021 in the Web of Science database, focused on insect consumption, totaling a sample of 50 articles. The bibliometric indicators used considered: research publications on insect consumption; number of research papers on insect consumption published between 2006 and 2021; areas of knowledge in which the authors have published research on insect consumption and the authors published: insects as food and feed, food science and veterinary humanities, and social sciences. Food insects being the most studied topic with 34 articles. Bibliometric indicators are shown in Figure 2.



**Figure 2.** Scientific production on insect consumption.

The period from 2006 to 2015 has an average of 1.5 articles per year. From 2016 to 2019, there was a linear growth of 2 articles per year, representing an annual average of 6 articles. After a decrease in 2020, it is possible to observe a significant increase in 2021 with the publication of 14 articles, demonstrating the evolution of research in the analyzed period. Based on the selected articles, the scientific journals were qualitatively categorized as follows: insects as food and feed, food science, and veterinary humanities and social sciences. The main contributions of the most recent publications are shown in Table 2.

**Table 2.** Categorization of selected surveys

<b>categorization</b>	<b>authors</b>	<b>Main Contributions</b>
Insects as food and feed	Mermúdez-Serrano (2020) [12]	It analyzes the potential for cultivation and processing of edible insects in Latin America, using the systemic competitiveness approach to list the main opportunities and challenges for the development of the sector in the region, considering the coordinated efforts between all the actors involved in the different systemic levels: entrepreneurs, research institutions, government, and society
	Niassy et. al (2018) [16]	Organization of the 22nd meeting of the Association of African Insect Scientists (AAIS) in Wad Medani, Sudan, in 2017, aiming to support impactful research that will produce genuine edible insect products, sustain value chains that improve food and nutrition security, and support sustainable livelihoods in Africa
	Vantomme (2015) [9]	Analyzes the main activities and achievements of insect recognition as a contribution to food security, suggesting ways forward, particularly from the FAO perspective
Food science	Ayieko et. al (2021) [17]	Selectively summarizes current trends related to the consumption of edible insects among residents, consumers in the food and beverage industry, and its prospects as a major draw in tourist destinations
	Nyangena et. Al (2021) [9]	Reviews the discussion of how climate change has affected food production and cash crops, along with animal production, the resulting human nutritional imbalances, and the impact of climate change on edible insects
	Kyung Kim et al (2019) [18]	It summarizes current trends related to insects as food resources among consumers, industry, and academia, revealing that entomophagy is experiencing a steady increase worldwide, despite its unfamiliarity to consumers influenced by western eating habits.
Veterinary humanities and social sciences	Musundire et. Al (2021) [7]	It proposes a path that can accelerate the recognition and appreciation of edible insects as important food and feed resources in Sub-Saharan Africa, including improved policies to support good stewardship of these resources for sustainability.



## 5 Conclusion

The objective of this article was to analyze the evolution of scientific articles and the role of insects for human food in a sustainable way. To achieve this objective, a bibliometric analysis was carried out in the Web of Science database. A list containing 50 articles published between 2006 and 2021 was diligently extracted and analyzed.

The bibliometric results of the term “edible insects” showed the evolution of publications. The period from 2006 to 2015 has an average of 1.5 articles per year. From 2016 to 2019, there was a linear growth of 2 articles per year, representing an annual average of 6 articles. After a decrease in 2020, it is possible to observe a significant increase in 2021 with the publication of 14 articles, demonstrating the evolution of research in the analyzed period. The content of scientific journals was qualitatively categorized into three main topics: insects as food and feed, food science, and veterinary humanities and social sciences.

From the analysis of scientific productions, it was possible to identify an increasing number of publications about edible insects, especially from 2017, strengthening the expansion of the field.

This article may be useful to researchers interested in the topic, especially those who wish to respond to the challenges imposed to meet the world demand for protein without increasing land use, consuming less energy and water, and reducing CO<sub>2</sub> emissions by 2050.

## References

1. UN. Global perspective human stories. Available at: <https://news.un.org/en/story/2015/01/488592#.VL6UBefF8kR> (2015).
2. Van Huis, A., Itterbeek, J.V., Klunder, H., Mertens, E., Halloran, A., Muir, G., Vantomme P.: Edible insects: future prospects for food and feed security. In: FAO Forestry paper 171, (2013).
1. Nyangena, D.N, Kinyuru, J., Imathiu, S.: Climate change: a natural streamliner towards entomophagy? *International Journal of Tropical Insect Science*, 41, pp. 2133–2147 (2020).
2. Simion, V.E., Țoniș, B-M.R., Amfim, A., Dourado, O.M., Sekovska, B., Dijmărescu, I.: Entomofagy - A Viable Solution for Supporting Food Security. *Amfiteatru Economic*, 21(51), pp. 462-479 (2019).
3. Van Huis, A., Oonincx, D.G.A.B.: The environmental sustainability of insects as food and feed. *Agronomy for Sustainable Development* 37: 43 (2017).
4. Miglietta P., De Leo, F., Ruberti, M., Massari, S.: Mealworms for food: a water footprint perspective. *Water*, 7, pp. 6190-6203 (2015).
5. Musundire, R., Ngonyama, D., Chemura, A., Ngadze, R.T., Jackson, J., Matanda, M.J., Tarakini, T., Langton, M., Chiwona-Karltun, L.: Stewardship of Wild and Farmed Edible Insects as Food and Feed in Sub-Saharan Africa: A Perspective (2021).
6. Van Huis, A.: Edible insects contributing to food security? *Agriculture & food security* (2015).
7. Vantomme, P.: Way forward to bring insects in the human food chain. *Journal of Insects as Food and Feed*, 121-129 (2015).
8. Lakemond C.M.M., Veldkamp, T., Van Huis, A.: Edible insects: the value chain. *Journal of Insects as Food and Feed*, 5(4), pp. 245-246 (2019).

9. Odongo, W., Okia, C.A., Nalika, N., Nzabamwita, P.H., Ndimubando, J., Nyeko, P.: Marketing of edible insects in Lake Victoria basin: the case of Uganda and Burundi. *Journal of Insects as Food and Feed*, 2018; 4(4), pp 285-293 (2018).
10. Bermúdez-Serrano, I.M.: Challenges and opportunities for the development of an edible insect food industry in Latin America. *Journal of Insects as Food and Feed* (2020).
11. Van Huis, A.: Edible insects are the future? *Proceedings of the Nutrition Society*, 75(3), pp. 294-305 (2016).
12. Ramos-Elorduy, J.: Threatened edible insects in Hidalgo, Mexico and some measures to preserve them. *Journal of Ethnobiology and Ethnomedicine* 2: 51 (2006).
13. Araújo, C.A.A.: Bibliometria: evolução histórica e questões atuais. *Em Questão*, pp. 11–32. Available at: <https://seer.ufrgs.br/index.php/EmQuestao/article/view/16> (2006).
14. Niassy, S., Musundire, S., Ekesi, S., Van Huis, A.: Edible insect value chains in Africa. *Journal of Insects as Food and Feed*: 4 (4), pp:199 – 201 (2018).
15. Magara, H. J., Niassy, S., Ayieko, M. A., Mukundamago, M., Egonyu, J. P., Tanga, C. M., ... & Ekesi, S. Edible crickets (Orthoptera) around the world: distribution, nutritional value, and other benefits—a review. *Frontiers in nutrition*, 7, 257. (2021).
16. Kim, T. K., Yong, H. I., Kim, Y. B., Kim, H. W., & Choi, Y. S. Edible insects as a protein source: A review of public perception, processing technology, and research trends. *Food science of animal resources*, 39(4), 521. (2019).