TECHNICAL DATA SHEET

Section A:
General Information

A.1	**Global Insect Industry**	Entomophagy refers to the practice of consuming insects and their by-products. In 2020, the global market for edible insects was valued at 894 million USD, with expected average annual growth rates (CAGR) of +26.5% during the period 2020 - 2027. The consumption of insects has become popular worldwide as an alternative to strengthen food security and as a source of high-quality proteins and nutrients, mainly in Asian, African, Latin American countries, and more recently, in European countries (O´neal Coto, 2019).
A.2	**Main Markets**	Asia Pacific (39%) Europe (27%) North America (20%)
A.3	**Advantages of consumption**	High nutritional value: some insects have high levels of crude protein from 40-75%, contain all the essential amino acids, are rich in fatty acids, and have a high proportion of dietary fiber. Environmental benefits: efficiency in the use of land and water, lower greenhouse gas (GHG) emissions compared to conventional livestock, sustainable protein source. Low risk of transmitting zoonotic infections: to date, there are no known cases of disease or parasitoid transmission to humans from insect consumption.

Section B:
Exotic Ornamental Species Costa Rica

In Costa Rica, the insect market is in its early stages. Currently, only the cricket (Acheta domesticus) and mealworm (Tenebrio molitor) are part of the list of exotic ornamental species of Costa Rica; which provides the opportunity to produce and market products made from these insects and develop an industry at the national level.

The publication of the ornamental species was carried out through resolution Nº SENASA-DG-R0026-2021 by the Animal Health Service (SENASA). This resolution establishes that both the cricket and the mealworm will be excluded from the application of the Wildlife Conservation Law Nº 7317 and its Regulation Nº 40548-MINAE. Furthermore, SENASA will be the competent body to control veterinary inspection measures, import, export, among other management of the approved species (products, by-products, and derivatives), also with the technical support of the National System of Conservation Areas (SINAC) if required.

B.1

Domestic Cricket *(Acheta domesticus)*

It is a species that belongs to the Orthoptera family, with incomplete metamorphosis consisting of the stages of egg, nymph, and adult (Kobe & Murillo-Hiller, 2021; I. Pérez, 2018). Its biological characteristics allow the male to fertilize about 30 different females in the same cycle and the female can lay 30-40 eggs per clutch, within one to two days after mating (Ayala, 2019; Kobe & Murillo-Hiller, 2021; Vaca, 2020).

Egg incubation can take two weeks, the growth phase until reaching the adult stage extends over seven weeks (seven skin molts), while the total life cycle extends from two to three months depending on environmental conditions (Medina-Milian, 2020; Portillo-Rivera, 2017). This insect can reach an average length of 1.6 to 2.1 centimeters (cm), requires moist substrates to lay eggs, and it is recommended to constantly replace breeding crickets to reduce inbreeding (Medina-Milian, 2020; I. Pérez, 2018; Portillo-Rivera, 2017.

SOURCE

Apolo-Arévalo, L., & Iannacone, J. (2015). Crianza del grillo (Acheta domesticus) como fuente alternativa de proteínas para el consumo humano. Scienta, 17(17), 161-173.

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Erens, J., Es van, S., Haverkort, F., Kapsomenou, E., & Luijben, A. (2012). A bug´s life: Large-scale insect rearing in relation to animal welfare. Wageningen UR. https://venik.nl/onewebmedia/Rapport-Large-scale-insect-rearing-in-relation-to-animal-welfare.pdf

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Hanboonsong, Y., & Durst, P. (2020). Guidance on sustainable cricket farming: A practical manual for farmers and inspectors. FAO. https://doi.org/10.4060/cb2446en

Kobe, A., & Murillo-Hiller, L. R. (2021). Potencial invasor del grillo eurasiático Acheta domesticus (Orthoptera: Gryllidae) en Costa Rica. Cuadernos de Investigación UNED, 13(2), 1-9. https://doi.org/10.22458/urj.v13i2.3529

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B.2	**Mealworm *(Tenebrio monitor)***	The mealworm is an insect of the Coleoptera order in the larval stage of the darkling beetle, measuring approximately 1.8 cm long and 0.4 cm wide (Sarmiento, 2018). The life cycle of the mealworm consists of several stages which, under controlled breeding conditions, extend over 3 to 5 months in the following manner (López et al., 2018; Pérez, 2021; Sarmiento, 2018): Egg phase and incubation, lasting 10 days. Larval period, extending over 10 weeks, with approximately 9 skin molts. This is the stage with the greatest nutritional and economic importance, as it provides the most protein. Nymph or pupa phase, lasting 20 days. Beetle phase, which in turn is divided into young and adult, with a life expectancy of 20 to 30 days. In the adult stage, the beetles are sexually mature. 3. The oviposition period of the female varies between 25 and 140 days, and they are insects that avoid light, preferring quiet and dark places (Sarmiento, 2018)

Section C: Exotic Ornamental Species Costa Rica

Below are detailed the basic conditions necessary to establish a production system for domestic cricket and mealworm in Costa Rica, according to the declaration of exotic ornamental species and the similarity in the productive cycles.

C.1	**Infraestructure**	It is recommended to create sheds with an adequate roof that protects the insects from the sun and rain; the walls should allow air movement, and the floor is preferred to be concrete to facilitate cleaning, hygiene, and minimize the presence of pests (Hanboonsong & Durst, 2020). There should also be washbasins and shoe disinfection areas to enter the plant, as well as sealed shelves for storing food and utensils (Hanboonsong & Durst, 2020; Medina-Milian, 2020).
C.2	**Caging**	In small and medium-sized farms, plastic, cardboard, wood, or glass boxes can be used, and on a large scale, solid concrete basins are recommended, with ventilation systems in the roof or walls that allow aeration, for which aluminum wire mesh or snake-proof mesh is used (Apolo-Arévalo & Iannacone, 2015).
C.3	**Drinking troughs, feeders and hiding places**	In the case of cricket production, the drinking troughs and feeders should be wide, preferably with a flat bottom and low height so that the insects can easily access the water and food (Apolo-Arévalo & Iannacone, 2015). The cages must contain a sufficient number of hiding places, which are usually made with cardboard materials; these provide a safe and comfortable habitat where insects can grow and shed their exoskeletons during molting (Hanboonsong & Durst, 2020; Medina-Milian, 2020)..
C.4	**Nest and hatchers**	In the case of domestic crickets, it is necessary to have a separate container for the nesting boxes with a capacity of 15 cm in diameter, with a moist substrate that attracts the females for the deposit of fertilized eggs and a metal mesh cover that allows the lay and prevent the eggs from being damaged by other females or males (Apolo-Arévalo & Iannacone, 2015; Hanboonsong & Durst, 2020). For the establishment of a new farm, the breeder is recommended to buy the initial eggs from other producers (Hanboonsong & Durst, 2020). Once the farm has been established, the breeding can become self-sufficient in the production and fertility of eggs for new production batches.

SOURCE

López, V. C., Vanegas, D. D., Jiménez-Alonso, G., & Ruiz-Urquijo, J. C. (2018). Design of a cost system for the production of Tenebrio mollitor (mealworm) at the Technological Research and Development Center—CIDT- Tenjo, Cundinamarca, for strategic decision making. Case study.
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C.5	**Temperature**	In the case of domestic crickets and mealworms, the ideal temperature for proper growth ranges between 20 to 35 °C. Direct and continuous exposure to moisture, sunlight, and cold should always be avoided, as it could cause mass death (Apolo-Arévalo & Iannacone, 2015; Sarmiento, 2018).
C.6	**Feeding**	In the case of domestic crickets and mealworms, the ideal temperature for proper growth ranges between 20 to 35 °C. Direct and continuous exposure to moisture, sunlight, and cold should always be avoided, as it could cause mass death (Apolo-Arévalo & Iannacone, 2015; Sarmiento, 2018)
C.7	**Harvest and collection of insects**	Once the insects reach the optimal collection point (depends on the species and the conditions of feeding and controlled habitat), the first activity consists of removing the feeding containers, then the hiding places should be separated to facilitate the collection (Hanboonsong & Durst, 2020). Before the sacrifice process, it is recommended to have a period of four hours without food availability, in order for the insects to carry out the digestion process (Portillo-Rivera, 2017).
C.8	**Processing of insect powder**	The processing and packaging of insects and by-products should be carried out in a place separate from the breeding cages, with proper disinfection and cleaning (Hanboonsong & Durst, 2020). The activities that comprise the processing of insect powder are simple and well-defined, and they may vary according to the producer's criteria. Generally, they are summarized in: sacrifice, scalding, dehydration, grinding, and packaging (Pérez, 2018). a) Sacrifice consists of a freezing process and can vary in time depending on the efficiency of the equipment. b) Scalding, they are placed in boiling water (95-100 °C) to reduce the microbial load and eliminate possible pathogens (Medina-Milian, 2020). Excess water is removed with a strainer to speed up dehydration (Medina-Milian, 2020). c) Dehydration also depends on the efficiency of the equipment used. In some cases, it has been performed at 60 °C for eight continuous hours, 150 °C for six hours, or 85 to 95 °C for 8-10 minutes, without altering its appearance and texture (Medina-Milian, 2020; Portillo-Rivera, 2017) d) In the final stages, the dried crickets are ground with sieving of the resulting powder to remove large particles and facilitate a homogeneous powder (Ayala, 2019; González, 2019).
C.9	**Cleaning, disinfection, and waste disposal**	The cages should be disinfected with 5% diluted chlorine, the cardboard trays used as hiding places should be brushed and air-dried (Hanboonsong & Durst, 2020). This same procedure should be carried out for the feeders, drinkers, egg-laying containers, and any equipment or tool used in production, every three or four days maximum (Apolo-Arévalo & Iannacone, 2015).

SOURCE

Portillo-Rivera, E. O. (2017). Pilot estimation of the costs in the production and processing of cricket flour (Acheta domesticus), as a source of protein for the human diet, on the Santa Marta farm, Morazán, El Salvador [Degree, Zamorano University]. https://bdigital.zamorano.edu/

Sarmiento, A. P. (2018). Establishment and implementation of a breeding protocol for the mealworm Tenebrio molitor (Coleoptera: Tenebrionidae), in support of the conservation program of the golden poison frog Phyllobates terribilis (Anura: Dendrobatidae) in the Wakatá Biopark, Jaime Duque park [Grado, UNAD (National Open and Distance University)]. https://repository.unad.edu.co/handle/10596/17749

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