Research article

Journal of Human, Health and Halal Metrics; 2020, 1(2): 37-46
https://doi.org/10.30502/JHHHM.2020.246223.1022

Challenges in breeding and consumption of insects as feed and food in Iran

Yahya Ostadi[1*], Gholamreza Yavari[1], Mohsen Shokat Fadaei[1], Majid Ahmadian[2], Sohrab Imani[3]

1- Department of Agricultural Economics, Payame Noor University, Tehran, Iran.
2- Department of Economic, Tehran University, Tehran, Iran.
3- Department of Entomology, Islamic Azad University, Science and Research Branch, Tehran, Iran.

Submission: 1 September 2020 ***Revision***: 15 September 2020 ***Acceptance***: 21 November 2020

Abstract

Background and objective: Consumption of insects as alternative sustainable source of protein for humans and animals has been promoted. Other than nutritional benefits, insects could increase cost-effectiveness of food or feed systems. The present research aims to use analytic hierarchy process (AHP) to prioritize the challenges lying ahead of breeding and consumption of insects as feed and food in view of consumers.

Materials and methods: This study was done by a descriptive-analytical method. The participants were inhabitants of Tehran (Iran). The current challenges ahead of edible insects were investigated according to opinions of experts in the field and review of the relevant literatures. A questionnaire was prepared and further completed by 20 experts. The challenges were identified as eight criteria including economy, infrastructure, health and food, culture and attitude, management and support, legal limitation, sustainable development, and education. Then, 83 sub-criteria were defined for the eight criteria. In order to prioritize the criteria and the sub-criteria, a hierarchical tree was designed. At the end, paired comparison matrices were analyzed by Expert Choice 11 software and relative/final weights of the criteria and the sub-criteria were calculated.

Results and conclusion: Results showed that "health and food" with final weight of 0.335, "culture and attitude" with final weight of 0.222, and "education" with final weight of 0.190 were the top three challenges. Importantly, incompatibility rate was less than 0.1 in all cases. At sub-criteria level, acceptability of edible insects by people in term of "taste and odor", "existence of pathogenic microorganisms", and "possible poisoning in human" with final weights of 0.049, 0.037, and 0.035, respectively, were considered as the most important challenges. Our evaluation revealed that health-related issues were the main challenges in acceptance of insects as feed and food in Iran.

Keywords: Analytic hierarchy process, breeding challenges, consumption challenges, edible insects

1. Introduction

Rapid population growth in the world is a warning of famine and shortage of natural sources in the future. Keeping the growing population (estimated as nine billion by 2050) away from starvation is one of the main issues in food security [1]. Limited sources of energy, financial crisis, and climate change are monitored by

[*] Correspondence to: Yahya Ostadi; e-mail: yahya.ostadi@srbiau.ac.ir; Tel.:+98-21-44868469, Fax:+98-21-44868445

international authorities [2]. Obviously, price of raw materials and agricultural input for food production have increased dramatically and greenhouse gas emission caused by livestock husbandry has resulted in climate changes [3]. Therefore, other edible resources should be investigated to alleviate the possible food shortage in the next decades. In this regard, insects would be good alternative source against the problem [4].

Food and Agriculture Organization of the United Nations (FAO) in 2013 declared that insects are nutritious and inexpensive sources that their ingestion is favorable and their processing as feed or food reduces the environmental pollution [1]. There are various species of insects and their growth rate is fast. In comparison to animals, insects farming is cost-effective as they do not need much feeding and their growth does not require much space [5]. However, there are limitations in areas where insects are traditionally approved as food.

Although, no comprehensive research has been done about optimum conditions of their harvesting as food source [6], it is reported that 44 species of edible insects are used in 113 countries [1]. Ability of insects to convert low quality organic materials to high quality agents is interesting [7]. Other than environmental benefits that mentioned above, protein content of crickets is significantly higher than animals [4,8]. Elroy fly is rich in digestible protein, essential amino acids, and essential fats other than trace elements intended to animal feed. Elroy fly can be harvested by biological processing of organic waste and agricultural/food waste during 10 days (60% reduced time compared to traditional processing) [9]. Therefore, it may be a good choice to be consumed by people and pregnant women in poor countries [10]. In addition, insect breeding can be a way of money earning for poor families in developing countries [11].

According to FAO report, edible insects are rarely regulated by governments. In comparison, insect farms are food source for livestock which do not need special safety standards. Some of edible insects currently used in livestock and poultry feeding in different countries are *Lepidoptera* order of *Bombyx mori* [7,12], *Coleoptera* order of *Tenebrio molitor* [7,12-14], *Orthoptera* order of *Grylloidea* and *Acrididea* families [7,15], *Diptera* order of *Hermetia illucens* and *Musca domestica* [7,12]. However, FAO is trying to scale up insects' processing in favor of their widespread export to western countries beyond its official restrictions [9].

Breeding and consumption of edible insects as feed and food has been faced to problems and there is no appropriate strategy in some countries. In this regard, we studied the current challenges for the first time in Iran. One of the important challenges is halal status of insects that is important in Muslim countries such as Iran. Hereby, the challenges are further identified and ranked.

2. Materials and methods

2.1. Steps of analytic hierarchical process

Identification and ranking the challenges in breeding and consumption of edible insects in Iran was done by a questionnaire followed by weighing the main criteria and sub-criteria with analytic hierarchical process (AHP) using Expert Choice 11 software. AHP is one of the most popular multi-purpose decision making techniques. It was firstly introduced by Thomas L. Saati from Iraq in 1980. AHP is a graphical representation of a real complex problem, topped by the main problem. Criteria, sub-criteria, and competing options (were reduced before and not mentioned in the current study) are drawn further. This making decision tool is used when there are several competing options. It is based on pairwise comparisons [5].

First, the decision tree defines general goal of study. At this level, the problem is defined which is further hierarchically linked to the affecting parameters. Our problem in the current study was challenges in breeding and consumption of edible insects in view of consumers in Tehran.

The second level includes listing the criteria affecting the problem and are a basis for decision making. They are identified by literatures review, searching at scientific networks, and opinions of entomology experts aware of the challenge. The

criteria in our research was included to eight parameters of economy, infrastructure, health and food, culture and attitude, management and support, legal limitation, sustainable development, and education.

At third level, sub-criteria is studied that was resulted in 83 parameters in the current work based on literatures review and the experts' opinion in the field. They were listed under the criteria (at level two) as level three of the hierarchical structure.

The fourth level focuses on the competing options. The sub-criteria at level three are further compared two by two and competing options are found. As mentioned before, the main purpose of the current study is to find the challenges ahead of breeding and consumption of edible insects. Therefore, the level four is not considered.

2.2. Paired comparison

Criteria and sub-criteria were compared to each other pairwise by experts (n=20) and weighting them was done by scorning from 1 (equal or similar importance) to 9 (the most important or preferred) in the form of questionnaire. To find out consistency of paired comparisons, the statistically unacceptable responses were removed from the questionnaire and the points achieved by pairwise comparison were entered as input into Export Choice 11. Accordingly, inconsistency rate was less than 0.1 that was acceptable.

Weighting was included to relative weight and final weight. For this purpose, paired matrices at different levels of hierarchy were formed and calculation was done by Eigenvector method [16].

Relative weights were calculated by setting a rank to each criterion divided by total rank. Then, by considering ranks' weight and criteria/sub-criteria relative weights, we determined the final weights. For this, ranks of all criteria/sub-criteria were determined when prioritizing. At the end, multiplication of sub-criteria final weights and ranks' weight was reported as final rank [3].

3. Results and discussion

3.1. Criteria and sub-criteria of the study and decision hierarchy tree

Analysis of AHP questionnaire which was completed based on the opinions of entomology experts and literatures review led to identification of eight criteria and 83 sub-criteria by which a decision hierarchy tree was drawn (Figure 1).

3.2. Prioritize the criteria affecting the problem

Among the eight criteria, "health and food" with final weight of 0.335 was detected as the first priority and "management and support" with final weight of 0.029 was the last priority (Table 1). At sub-criteria level, within the parameters under "health and food", "taste and odor" with relative weight of 0.143 was preferred among all and "shelf-life uncertainty" was the least-preferred parameter with relative weight of 0.036 (Table 2).

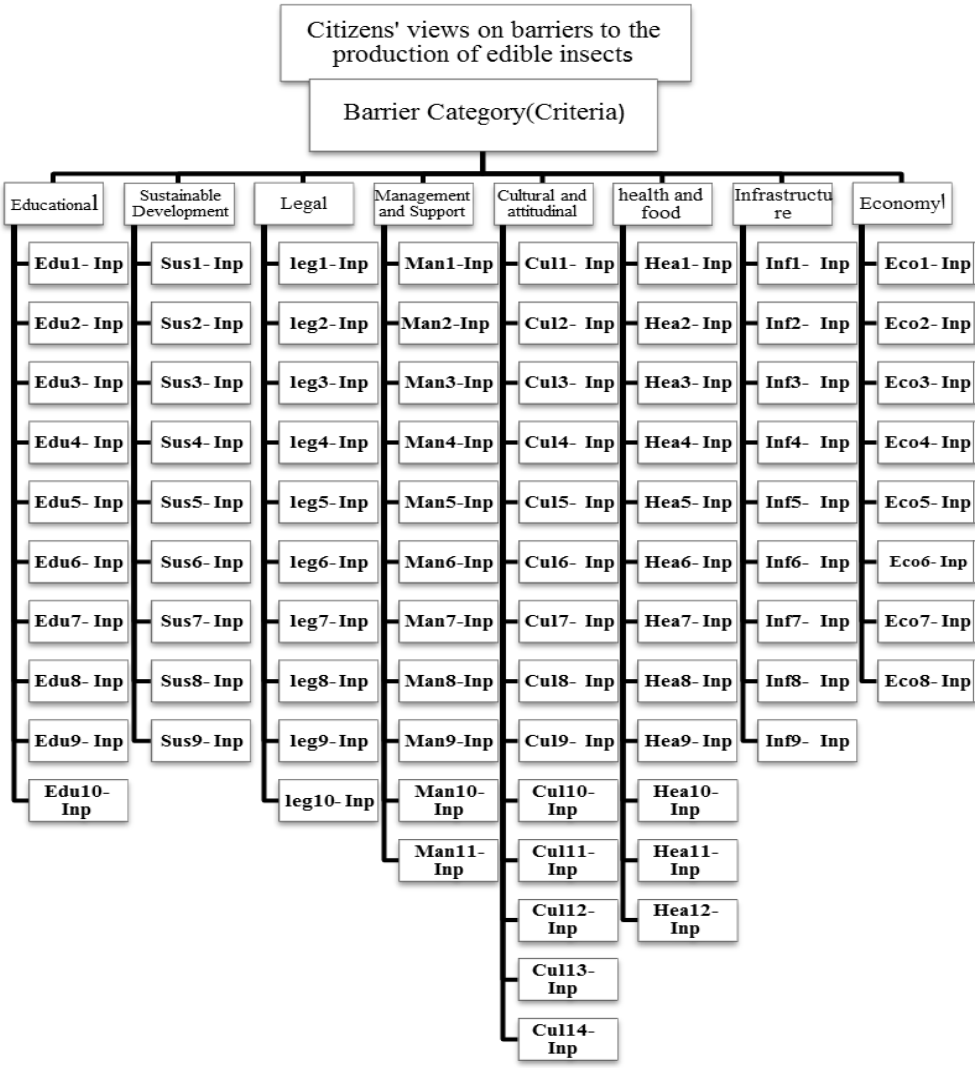

Figure 1- Decision hierarchy tree of the challenges in breeding and consumption of edible insects in Iran; Eco: Economy, Inf: Infrastructure, Hea: Health and food, Cul: Culture and attitude, Man: Management and support, Leg: Legal limitation, Sus: Sustainable development, Edu: Education

3.3. Prioritize the sub-criteria affecting the problem

According to Table 2, "taste and odor" with final weight of 0.049, "existence of pathogenic microorganisms" with final weight of 0.037, and "possible poisoning in human" with final weight of 0.035 were the first to third priority, respectively. Importantly, all of the top three sub-criteria were related to "health and food" criteria. Moreover, "insufficient information about storage conduction" and "poor communication of entomology experts and manufacturers for introduction of edible insects" under the criteria of "management and support", and "insufficient information about handling of edible insects" related to "infrastructure" criteria were the last priority (the all had final weight of 0.001) (Table 2).

Table 1- Prioritization of the criteria in finding the challenges in breeding and consumption of edible insects in Iran

Criteria	Final weight	Final ranking
Health and food	0.335	1
Culture and attitude	0.222	2
Education	0.190	3
Sustainable development	0.085	4
Economy	0.054	5
Infrastructure	0.045	6
Legal limitation	0.040	7
Management and support	0.029	8
Incompatibility: 0.08		

Table 2- Prioritization of the sub-criteria in finding the challenges in breeding and consumption of edible insects in Iran

Criteria	Sub-criteria	Relative weight	Priority in criterion	Final weight	Final rank
Hea	Taste and odor	0.143	1	0.049	1
Hea	Existence of pathogenic microorganisms	0.108	2	0.037	2
Hea	Possible poisoning in human	0.102	3	0.035	3
Cul	Disgust against edible insects and their products	0.119	1	0.033	4
Hea	Not sure about safety and health of the products	0.095	4	0.033	5
Hea	Toxicity of colorful insects and their unpleasant taste	0.092	5	0.032	6
Hea	Not-accustomed to taste of edible insects	0.091	6	0.031	7
Hea	Complications of insects' consumption such as weakness, nausea, lack of consciousness and even death	0.089	7	0.031	8
Cul	Avoidance of insects' consumption by people	0.101	2	0.028	9
Edu	Failure to promote the conception of insects' eating	0.171	1	0.028	10
Cul	General fear of insects consumption	0.099	3	0.027	11
Cul	Negative attitude to insects as pest and source of communicable diseases	0.098	4	0.027	12
Cul	Forbidden insects except for Locust in view of Islam	0.092	5	0.025	13
Edu	Lack of educational programs related to the subject at school	0.148	2	0.024	14
Hea	Risk of eating raw insects	0.071	8	0.024	15
Cul	Imitation of the other in consummation of edible insects	0.082	6	0.023	16
Hea	Pesticides' residue in edible insects	0.063	9	0.022	17
Hea	Failure to comply with health regulations	0.059	10	0.021	18
Cul	Insects are undesirable food	0.070	7	0.019	19
Edu	Lack of informing (face to face) with regard to edible insects in the country	0.113	3	0.019	20
Edu	Lack of experienced promoter and producers to train the people	0.113	4	0.019	21
Hea	The possibility of heavy metals residue in edible insects	0.052	11	0.018	22
Cul	Failure to develop the local market due to specific cultural and social avoidance	0.059	10	0.016	23
Cul	Eating habits at each region	0.060	8	0.016	24
Cul	Lack of public awareness of edible and non-edible insects	0.059	9	0.016	25
Edu	Failure to provide extensive advertisement in the social media	0.089	5	0.015	26
Cul	Threats and negative promotions in consumption of insects	0.051	11	0.014	27

Edu	Insufficient expertise and knowledge of manufacturers in production of edible insects	0.083	7	0.014	28
Edu	Difficult training of illiterate and inexperienced users for production of edible insects	0.083	8	0.014	29
Edu	No distribution of educational brochures and publications among farmers and consumers	0.087	6	0.014	30
Sus	Failure to conduct food management system in term of acceptability and popularity	0.189	1	0.013	31
Hea	Uncertainty in shelf-life of edible insects	0.036	12	0.012	32
Cul	People are not interested in using insects as feed for pet and ornamental fish	0.037	13	0.010	33
Cul	Adherence to traditional and local culture	0.038	12	0.010	34
Edu	Lack of insect farms and insectarium in the country	0.063	9	0.010	35
Sus	Uncertainty in stability and safety of edible insects	0.155	2	0.010	36
Sus	Uncertainty about sustainability in occupational and social health of edible insects' production	0.147	3	0.010	37
Cul	No tendency of people to eat livestock, poultry and fish fed by insects	0.033	14	0.009	38
Eco	No success in domestic market	0.187	1	0.008	39
Edu	Lack of national exhibition to raise knowledge of consumers	0.050	10	0.008	40
Eco	Lack of specialized markets of edible insects	0.165	2	0.007	41
Inf	Low tendency of people to eat insects	0.237	1	0.007	42
Sus	Failure to conduct food management system in production of edible insects in term of economic efficiency	0.110	4	0.007	43
Eco	Inability in competition with other countries to supply edible insects for regional and international markets	0.144	3	0.006	44
Eco	No governmental policies to cover initial costs through interest-free loans	0.137	4	0.006	45
Leg	No halal certificate for edible insects in the country	0.118	2	0.006	46
Leg	Lack of reference laboratories for analysis of edible insects in the country	0.122	1	0.006	47
Leg	Lack of administered certification process to assure the consumers and producers	0.117	3	0.006	48
Sus	Failure to conduct food management system in production of edible insects in term of environmental protection	0.087	6	0.006	49
Sus	Instability of sustainable economy in households production of edible insects	0.097	5	0.006	50
Eco	Inability in competition with other products in the market	0.116	4	0.005	51
Leg	Lack of reliable reference to make sure of compliance with production standards	0.103	5	0.005	52
Leg	Uncertainty in quality assurance and quantity of products by the competent authorities	0.109	4	0.005	53
Leg	Lack of high quality certificate adopted with geographical and cultural standards	0.100	6	0.005	54
Inf	No success in local markets due to specific culture and social infrastructure	0.188	2	0.005	55
Sus	Uncertainty in sustainable protection of local resources when production of edible insects	0.071	8	0.005	56
Sus	No sustainable participation of public in production of edible insects	0.074	7	0.005	57
Sus	No sustainable participation of non-governmental sectors in production of edible insects	0.071	9	0.005	58

Eco	Inadequate or inefficiency of marketing of manufactured products in the country	0.104	6	0.004	59
Leg	No appropriate labels designed to be attached on the manufactured products to assure the consumers and producers	0.085	9	0.004	60
Leg	Lack of authorized standards of quality at national level	0.090	7	0.004	61
Leg	Lack of certificate of product health or environmental quality mark in the country	0.086	8	0.004	62
Man	Lack of policies and strategies in agriculture for breeding and use of insects	0.134	6	0.004	63
Man	Lack of activities with regard to edible insects at public and government level	0.144	1	0.004	64
Man	Lack of financial support with regard to research and development, production, and marking of edible insects	0.135	2	0.004	65
Eco	No estimation of price of edible insects by the consumers in the country	0.066	8	0.003	66
Eco	Impact of economic status and livelihood of people on use of edible insects	0.081	7	0.003	67
Leg	Lack of regulations and strict supervisions in branding of edible insects through production process	0.069	10	0.003	68
Inf	Lack of advertisements to increase knowledge of people about nutritional value of edible insects	0.123	3	0.003	69
Inf	Lack of specific institution or organization responsible for administration of edible insects' production	0.089	5	0.003	70
Inf	No need to production of edible insects where insect consumption is avoided	0.117	4	0.003	71
Man	Lack of proper organization of farmers and villagers in production of edible insects	0.117	3	0.003	72
Man	Lack of appropriate supportive policies provided by government with regard to edible insects	0.105	4	0.003	73
Man	Insufficient engagement of research centers to study about edible insects	0.102	5	0.003	74
Inf	No or restricted access of the products to local, national, and international markets	0.057	8	0.002	75
Inf	No appropriate market to supply edible insects in the country	0.071	7	0.002	76
Inf	Lack of accredited laboratories for studying edible insects in the country	0.072	6	0.002	77
Man	Insufficient managerial skill to produce edible insects	0.059	9	0.002	78
Man	Lack of expert human resources in production and development of edible insect	0.070	8	0.002	79
Man	Unclear mechanism and structure of supportive institutions with regard to edible insects in the country	0.083	7	0.002	80
Inf	Insufficient information about handling of edible insects	0.045	9	0.001	81
Man	Poor communication of entomology experts and manufacturers for introduction of edible insects	0.046	10	0.001	82
Man	Insufficient information about storage conduction	0.033	11	0.001	83

Eco: Economy, Inf: Infrastructure, Hea: Health and food, Cul: Culture and attitude, Man: Management and support, Leg: Legal limitation, Sus: Sustainable development, Edu: Education

In accordance to our results, an investigation in Netherland revealed that doubts about health of edible insects were of the main reasons of rejection by people [17]. Similar results were observed in Greece, Italy and India, in term of health and safety [2,18]. In Europe, price of edible insects and their higher production cost than vegetable protein (despite the same nutritive value) were reported in this regard [13]. In South Africa and Australia, use of edible insects in fish

and poultry feeding was initially suggested to alleviate cultural and social barriers [9,19]. However, despite the environmental and nutritional benefits, it is unlikely that the consumers will accept insects as food source in Europe or North America in the near future because of its low palatability [19]. Research in Netherland and India showed that some people could not tolerate taste of insects [7,15]. It was also disgusting in view of the people in the Czech Republic [4]. Americans believed that insects may communicate the diseases and viral infection among people [17].

In comparison, positive responses were achieved in some countries. Some of Indian believed that raw crickets contain bacteria which are killed by cooking and frying. In agreement, the Australian believed that microbial contamination and toxin residues in edible insects are lower than the protein products currently used [6,15]. Interestingly, some edible insects were greatly accepted in China due to their medicinal properties [19]. In Belgium, Italy and South Africa, edible insects are processed in powdered form that is popular. However, the clergies in some communities such as Italy do not allow insects' ingestion by people [9,20-22].

Despite no strict regulation in some nations that restricts the widespread research in this area [9,17,22-25], government of Thailand has provided extensive support for breeding and consumption of edible insects [17,26]. Some other countries such as South Africa, Mexico and the United Kingdom have been advertising about edible insects which has led to organization of the farmers [9,27,28]. Along with, conducting educational programs in order to increase number of people accustomed to edible insects and acculturation toward its acceptance play great role. For example, 91% of students and 90% of adults in South Africa were cared about safety of edible insects [9]. Furthermore, 83.3% of people agreed with new education about edible insects in schools' courses at various levels [9,29].

4. Conclusion

Breeding and consumption of insects as food is currently refused by the Iranian. Considering the all challenges studied at this research, "health and food" challenge was preferred by people in Tehran. They worried about intake of chemical and biological hazards by consumption of insects. In this regard, biological contaminants can be removed by processing such as cooking and freezing. Chemical contaminants such as toxins and heavy metals can be prevented under controlled harvesting within closed environments and use of no chemicals in breeding. In Islam, consumption of insects except for Locust is forbidden for human. Therefore, other insects can be used as feed for livestock, poultry, and marine animals in Iran or processed for export to other countries in which their consumption as food is allowed. The results of current research have positive impact on further policies and strategies which will be made by governmental and non-governmental sectors in promotion of edible insects. This research was done for the first time to find out the important challenges in development of edible insects in Iran. Definitely, further research by more variables are required.

5. Conflict of interest

The authors declare no conflict of interest.

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