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The Third Nutritional Transition and Toward an Equitable Feeding with Entomophagy

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Abstract

Entomophagy defines the consumption of insect as food by humans. Insecta is one of the most widespread group of animals on the planet and is the most diverse group in terms of species. There is evidence that human, throughout its history has consumed insects as food. Insect consumption is still common all over the world yet insufficient. In the course of evolution, the human might have diverged from other apes by shifting it's way of nutrition and then, there has been two transitions in it's nutritional attitudes: The first one corresponds to the agricultural revolution and the second, to the Anthropocene. This manuscript advocates the necessity of the third nutritional transition through entomophagy. With the beginning of the second nutritional transition, human has faced a health bottleneck stemming from the overconsumption of food. The most cost-effective way to overcome this obstacle is facilitating and/or achieving the third nutritional transition by eating insects. Through entomophagy not only our protein gap will be closed but the metabolic syndrome and cancer pandemics will also be prevented in a cheaper and painless manner. Insect breeding will save our species from the ecological deadlock of the environment. Entomophagy is by no means a matter of choice but a necessity.

Keywords: Transition; Nutrition; Insect; Entomophagy

Introduction

Entomophagy defines the consumption of insect as food by humans [1]. Insecta is being consumed by numerous animals however this term indicates the consumption of the insect by humans; animals which consume insects are defined as insectivores. Plants that consume insects are defined as carnivores [2]. The languages of many ethnic groups which consume insects do not contain a specific term which corresponds to "entomophagy" [3]. The reason for this might be that these societies do not differentiate insects and other nutritional resources [4,5]. The action of entomophagy can be classified into two in terms of its aim: consumption of insects as a nutritional resource and as a source of flavour [1].

The primary reason for us to focus on the transformation of the human health problems related to nutrition is the fact that human is the only evolved omnivore species with a wide range of energy resources that uses technology in order to both provide nutrition and change its form of energy consumption [6]. The second reason is that apart from other living organisms, biology as a science which is directly related to human health. Medicine copes with the emerging health consequences whereas biology focuses on the causes with the contribution of other scientific fields. In any case, medicine is not a branch of science; the skills acquired through master-apprentice relation is called a craft. Therefore, the solution to the problem stated in this article is in nutritionists and biologists and a proposal of solution through this perspective is the alteration of the source of protein in the menu of the humans, thus it is the mission of the nutritionists. Living beings provide their source of energy within the environment they live in.

An extraordinary change of the environment results in either the adaptation, migration or extinction of that species. When the energy resources of a species are exhausted before it reaches the reproductive age it will end up in its extinction because it will fail to reproduce [7]. Despite its exceptional ability to transform the environmental conditions it lives in, the human is dependent on the environment for nutrition-energy supplementation. As the environment transformed and humans expanded the geography they live in, their menu has also diversified and thus resulted in the emergence of different supplementation, conservation, preparation and consummation schools of food which we name as Chinese, French, Turkish, Indian, Italian cuisine etc. [8]. If the Chinatowns in western capitals did not exist, Far-East culinary culture would remain as a freak for westerns and, consuming cow milk would be out of question for the people of the Far East [9].

Anthropocene and the Altering Nutrition Requirements

The beginning of the Anthropocene is accepted as 1950's (www.population matters.org/campaigns/anthropocene). This dating is appropriate because the human health problems took a new turn in the same period. Depression, musculoskeletal diseases, obesity, polyphagia, metabolic syndrome, cardiovascular diseases and different types of cancer began to dominate human health and the health system in this period [10]. The baby boom encouraged following the second Great War provided opportunities to the food sector for the nutrition of this new generations whose mothers were actively working, therefore the babies who consumed milk powder and formula food became acquainted with diseases such as obesity, cardiovascular diseases, cancer and related problems as they grew older [11]. Also, the extension of the life spans brought allergies, neurodegenerative and chronic diseases, thus problems like unpredictable investments and expensive treatments. What will happen next? How will our immune system which faints with aging effect the elderly population without even requiring a new virus? Antimicrobial peptides cannot replace expensive antibiotics in controlling the new infectious diseases, there exists a pharmacologic industry-lobby.

In our world and probably in all the universes there exists only one species which is harmful for all the niches and other species; namely the Homo sapiens sapiens. It was the same case even before Anthropocene. Throughout its history each ecosystem habited by humans have either collapsed or drastically transformed [6]. During the Anthropocene, human wastes, radiation, plastic, magnetic sphere and energy pollution have become serious threats for the environment. If what led to Anthropocene was Holocene (the last 12 thousand years), the only direct factor of this was the fact that the sole species in all the universes has drastically transformed the features of his own habitat's lithosphere, hydrosphere, cryosphere, atmosphere and biosphere [12]. Human factor can be traced in all the extreme changes in the nutritional cycle in nature, ocean acidity and biodiversity. Compared to the transformations that took place during the Holocene, we see a drastic difference. Human has been the direct and sole responsible for most of the extinctions on earth in all ages [12] however in the Anthropocene, this harmful effect of ours continues to rapidly multiply.

One of the indicators of the Anthropocene is the increase of nutritional demand in correlation with the population growth. Today these two figures indicate the most important problems of our world [13]. The increasing food demand, especially the gap concerning the need for the protein component of food, is widening parallel to the income imbalance between the countries. This need manifests itself as a food demand that cannot be supplied in the poorest Sub-Saharan countries [14]. In 2011 the World combined nutrition production was 870 tons. According to the estimations of FAO, this figure must be increased 70% in 2050 in order to feed the world population with the condition of doubling its protein (meat) component [15]. The efforts in closing this gap are mainly focused on increasing the elevation of the livestock, with the poultry farming has the biggest part and is still growing [16]. The price of the "clean meat" produced in laboratories is very high and we don't know whether it will be affordable in the near future or not [17].

Moreover, the production of the protein resource animals has ceased to be "pastoral" and turned into an industry in order to meet the increasing protein need (Steinfield, et al., 2006). This industrialized animal protein production has both direct and indirect negative effects on the consumers. These effects, along with the ill treatment of the farm animals and the greenhouse gas emissions, manifests itself with obesity, cardiovascular diseases, type II diabetes mellitus and cancer pandemics related to the imbalance in the omega-6/omega-3 ratio and single/multiple polyunsaturated fatty acid ratio [18].

One of the biggest obstacles lying in front of the progress in this field is the excessive prices of forage which constitutes 60-70% of meat production. The ingredients of the most commonly used fowl forage are fishmeal, cod oil, soy bean and cereals, mainly corn. The prices of these ingredients, especially of the fishmeal, have increased even more rapidly than the price of meat during the last decade. More fish needed way over the ones utilized for farm fish elevation, is used as forage, therefore some fish species face the risk of extinction. There is a limit in reflecting the increasing costs to the consumers, so we need new solutions and bring new sources of protein into the game [19].

Impacts of livestock-breeding

According to FAO, livestock breeding has an absolute impact on climate change, air pollution, land management problems, soil and water degradation, deforestation and decrease in biodiversity. Livestock breeding is rapidly growing and causing gigantic environmental problems [20]. It has been estimated that by the year of 2050, meat consummation will reduplicate [16]. Again according to FAO, stock-breeding is one of the three main threats to environment both on local and universal level. Stock-breeding constitutes 18% of the overall anthropogenic greenhouse gas emission; this is even greater than the share of transportation [21]. Stock breeding is the largest anthropogenic land use form. 30% of the earth lands except the glaciers, is constituted of grasslands. 33% of the lands suitable for agriculture and 70% of the existing farm lands are used for forage culture. Negative effects of stock breeding such as over herding, erosion end stiffening of soil, have caused degeneration of the 20% of earths grasslands [22]. Stock-breeding is the cause for 64% of the man-made ammoniac emission, which is one of the main causes of acid rains. Nitridising effect of the cattle waste and acidification of soil contributes to environmental pollution [20]. According to FAO, 64% of the world population will suffer from water shortage by the year 2025. Stock-breeding is one of the first causes of water pollution and drinking water shortage; it also leads to eutrophication, emergence of "dead" lands in coastal regions, devastation of coral reefs and human health problems like antibiotic resistance [23]. Stock-breeding also causes stiffening of the soil and reduces its draining capacity, thus results in the degeneration of the waterbeds, drying of the basins and remission of the ground water level [20].

Nutrition Transition and New Problems

When we adapt the transition theory defined by Omran [24] to nutrition, the first nutritional transition of human is not ahead of him but is in his past and what we should understand by the term "transition" should be the shift from hunter-gatherer to sedentary agriculture due to Neolithic agriculture revolution [25]. The second nutritional transition is defined by another indicator of Anthropocene, namely the "fast-food" [26]. Therefore we should define the new nutritional transition which we try to present and argue in the hereby article as the "third" transition. This obligatory transition should be discussed with making a synthesis of the opportunities, potentials and new approaches. This article paves the way for such an approach.

If we are to go back a little in history, we would find out great differences between the nutritional habits of our hunter-gatherer ancestors before and after the Neolithic agriculture revolution [27]. Therefore we call this transition the "first nutritional transition"; this transition has brought a number of problems along with the diversity it promised [28]: nutritional deficiency related to famines and infectional diseases caused by stock-breeding and urbanization were the dominant health problems related to nutritional habits we faced until the 18th century; whereas with the extension of life spam and sedentary life style due to industrial revolution, metabolic syndromes and chronic diseases have become dominant [29,30]. Urbanization of the wilderness areas, climate change and cereal nutritional deficiency related to the utilization of the cereals as bio-fuels, are the factors which dramatize the obstacles facing the efforts to meet the protein need [20].

The first two nutritional transitions seem to have been against us and the salvation of our evolved species might reside in going back to collecting and elevating insects [31]. Today, there are two kinds of health problems related to nutrition: First, low birth weight stemming from deficient protein consummation, anaemia, chronic protein deficiency, short stature and problems caused by acute protein deficiency which we witness especially in natural disasters and mass migrations. These manifest in serious malnutrition and causes death of five million children each year [32]. Insects have an important potential in the treatment of child malnutrition in undeveloped countries [33]. Some of these problems, for example low birth weight, turn into secondary health problems in maturity. These secondary health problems which can be described as filling the nutritional gap during pregnancy, are also related to the quality of the fats of the consumed meat: metabolic syndrome and cancer pandemics are problems related to the imbalance of the omega6/omega3 ratio and single/poly unsaturated fatty acids of the livestock meat produced by stock-breeding [22]. The tertiary problem is the ecological problems we create caused by stock-breeding: greenhouse gas emissions, inundations, water waste, antibiotic resistance, unmanageable wastes, extinction of species especially the insect and raids of insects and pesticides [34]. All these three problems can be solved by shifting from livestock to insect as a protein resource, thus by actualising the "third transition", with little investment. Actualising the third transition with the insects might largely ameliorate the problems of these new diseases [35].

However, it is hard to believe that the dominant executive/economic understanding that tries to turn the problem into a new opportunity for profit are sincerely willing to solve the problems causing most of the chronic diseases related to nutrition and life style [30]. The main obstacle in front of the third transition is not the nutritional habits of the humans but their focus of profit. While the threats of genetically modified organisms are obvious [36], the order given by the former US president Obama to control cancer (which sets back the utilisation of new molecules by the drug industry and ignores the ethical principles) is striking [37,38]. The costly diagnosis technics and treatments which this "rich" country imposes to its citizens because it does not wish to carry the burden of these diseases, are of a nature which can never be afforded by poor countries [39].

The Solution is Enthomophagy

The most cost-efficient and easy way to solve these pandemics might be shifting the protein resource consumed by humans or at least those consumed by the live-stock with insects [40,41]. Insecta is classified within the arthropoda and is called in'secta in Greek due to its structure divided into "sects". Insecta are characterized by a three sected symmetric trunk, head-torax-abdomen, an external skeleton composed of chitin, two wings as a rule, three double pairs of articulated legs, joint eyes and a pair of tentacles. With over a million defined species, insect is one of the widest animal species. This number is above half of the whole living creatures [42].

Even if it might take some time for the humans to get into the habit of consuming insects because of cultural attitudes in some regions of the world, adding insect into to the forage of the livestock might be a solution; the cost of the meat can be reduced by feeding them with insects and the protein quality can be increased [43]. However, in spite the fact that the studies which provide detailed information concerning the macro and micro nutritional composition of the insects are becoming widespread, the attention the humans attribute to the opportunities the insects offer is far from being adequate [44]. There exists satisfactory knowledge about the nutritional value of the insects as protein resources for *Tenebrio molitor* (Coleoptera), *Hermetia illucens* and *Musca domestica* (Diptera) larva, but the knowledge on other insects are insufficient [45]. What we know is that the most important nutritional component of insects are proteins and lipids [46]. Extracting these lipids in order to produce biodiesel is another promising opportunity [47]. The chitin which is a polysaccharide that constitutes the external skeleton of the insect, though maintained in just small amounts for the moment, seems to have an industrial and economic importance as a source of nutrition [48]. The delicacy that has to be shown for sterility in the production and consummation of other nutritional resources is not needed in insect production [49]. Still, there is necessity in analysing the entomophagy toxicity risk.

Risk of Toxicity

FAO has brought forward numerous traditional and potential practices related to the direct human consummation and breeding opportunities of the insects and its contribution to food security [50]. According to FAO the number of studies focusing on the value of insects and their bi-products, processing and conservation security should be increased [40,51].

Entomophagy sure has certain risks but these risks are also valid for all other kinds of foods [52]; even the food prepared by traditional methods might have negative effects on human health and we know that only a few of these negative effects are being officially recorded in most of the countries [3]. However, throughout the world, there is no evidence of insects as the source of food poisoning in the health records; this data bias is probably related to the fact that insects are being consumed in the poor regions of the world where health recording systems are inefficient [53]. Another reason might be that food poisoning from insects do not cause serious health problems.

Besides, whether chemical or biological, in order to engage insect consuming with the cause of poisoning diagnosed at the laboratory, we need detailed epidemiologic analyses which are not possible to execute for the moment. Recollection and cultural factors might also be other obstacles. Insect consummation is a cultural behaviour and the toxicity potential of the consumed insect should not no doubt has been evaluated by the consuming societies [54].

There are of course poisonous insects and being cautious is better than being regretful; if the source of the food is unknown it should not be consumed. A healthy diet means a reliable source above all. However, the toxicity of an unknown insect is not the only potential danger. Extensive pesticide utilization is the most important obstacle of human insect consummation because these chemicals might accumulate in insects [34]. For example when extensive insecticide is used against Schistocerca gregaria (Orthoptera) locusts which are natural resources of food in some regions, these and other insects become inconsumable for a long period [55]. Another underestimated danger is the fact that locusts too feed with the plants which are exposed to insecticides [52]. The consumed insects are not cultivated in farms; they are collected from the nature, so it is unknown to which harmful substances they have been exposed to. Constant expansion of agricultural fields results in extensive utilisation of pesticides and other toxins [34]. Where the insect lives and what it consumes is important: even the harvest fly cicadas (Hemiptera) which remain sedentary for most of their lives might be consuming pesticides and other chemicals through the liquids they suck from trees [56].

Furthermore, those who are allergic to marine products such as mussels and shrimps should be cautious and begin to consume insects in small amounts [54]. Secondly, raw insects should never be consumed if they are not elevated and produced in reliable sources; it is impossible to understand whether the raw insect has been exposed to pesticides; it is also difficult to detect if the insect carries pathogens and other organisms which might cause diseases on humans [51]. Most insects are herbivores and cause less problems of such nature compared to consumed omnivore animals. Even so, it is recommended to cook insects at the appropriate temperature prior to consummation against the risk of parasites [50]. Lead poisoning cases due to consummation of Sphenarium genus Caelifera (Orthoptera) have been reported. The risk of allergic reactions stemming from this same insect also exists [57].

Sometimes insects are being consumed regardless of the risk of toxicity. In Carnia region, Italy, children consume members of Zygaenidae (Lepidoptera) family in spite of their potential toxicity. Caterpillar and adult moths of this family produce hydrogen cyanide precursors. However, the adult moths while containing low levels of cyanogenic chemicals in their corps, they also store high concentrations of sugar, which makes the Zygaena a toothy dessert. These moths are abundant in the early summer and are easily collected by hand, and the low cyanogenic content in their corps renders the Zygaena a low risk, costless seasonal delight [58].

Finally, the sporophyte bacteria might spoil the consummation of raw or cooked insects which presents another food security risk. Therefore even if there are very simple methods that prevent this spoilage, the processing conditions of the consumable insects should be inspected [59].

From Past to Present

Prior to inventing tools for hunting and then agriculture, insects seem to have constituted a great party in human diet. Researchers have found silk worm cocoons (*Theophilia religiosae*) with probably edible pupas in the ruins of a 4-5 thousand year old settlement in China, Shanxi. Cave paintings in Spain, Altamira which depict the collection of wasp hives, are probably indicating the existence of an entomophage tribe. On coprolites discovered in the Ozark caves, United States, ant, coleopteron larva, pediculus, tick and acarina have been found. These ancient entomophagy behaviours have come to the present day with little change compared to other agricultural practices [2]. Still, societies in different geographies and cultures which represent 80% of world population consume insects [60]. While insect is rarely consumed in the developed world as food, in Latin America, Africa, Asia and in undeveloped regions of Oceania insect is a widely consumed, cheap and sustainable source of protein [61]. Though the numbers vary in different resources, it has been recorded that in over 130 countries, more than 3 thousand ethnic groups consume over 2 thousand different insect species as food [43]. In Thailand, Vietnam, Cambodia, China, Africa, Mexica, Colombia and New Guinea insects are being consumed not only as a source of nutrition but also for their taste [43].

All over the world, the most commonly consumed insect is (it might be another indicator of the Anthropocene) the forest pest, a member of Coccoidea (Hemipetra) family which we consume in Coca-Cola in liquid form; these inactive pests which do not resemble much to insects are being consumed by the native Americans for their narcotic effects and are also used as fabric dye. Dr. John Pemberton and Asa Griggs merit the greatest insect procurer title by having contrived to make people drink this insect's liquid.

One of the new practices is the encouragement of elevating Hermetia illucens (Diptera) domestically in Europe. When the larvae grow into an edible size, they are collected with the help of an apparatus developed especially for this purpose. The adult members of this fly have low risk of transmitting infectious disease agents because they do not have a developed mouth form. The production of its larva requires nearly no water and its waste contains no CO_2. The larvae of this fly are considered as one of the most fertile protein converters within the insecta [62-64].

Insects also contain essential carbohydrates, fats, minerals and vitamins. Most of the insects are also rich in lysine which is an amino acid the populations who mainly feed on cereals lack. Even in countries which might be considered relatively developed, considering that a great portion of the population feeds on food based on flour, the gravity of the problem and the need for its solution becomes evident [14].

Conslusion

As a result of the growing cost of animal proteins, food and forage reliability, environmental pressure, population growth and the growing demand of the middle class for protein, the value of insects as nutrition and forage has become even more important in the 21st century. Because the insects are exothermic animals, insect elevation offers a great opportunity for energy conservation. Compared to effects of stock-breeding on the environment, insecta might enable us to feed on a miniscule part of our livestock consummation. Insect farming as a mini-breeding form is a more reasonable and eco-friendly way of obtaining healthy and cheap nutritional resource. Insects can reproduce much more rapidly than the livestock, they are easy

to cultivate and require less food compared to other animals. The more we introduce the insects into our food preferences, the less pesticide will be used. Moreover, insect breeding doesn't require a troublesome butchery and farm work, tractors or veterinary care. However, in order to replace traditional stock-breeding with insect breeding, the human conception on insects has to be changed, pressure for preserving the habitat should be made and economical restrictions should be implied to ensure the place of insects within the food chain.

The definitive junction which differs our species from other apes might be the shift in our nutritional habits; thus we can make use of our ability to change our nutritional habits and culture once again and save our species from extinction which is probably not very far. Insecta, can be a good (and last!) chance for us to close the gap between the poor and the rich world and societies in terms of nutritional requirements. Introducing insects to the human menu is no longer a question of choice but an obligation.

Conflict of Interest: NO

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