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Alternative food production and consumption: Evolving and exploring alternative protein supplement potential through Entomoceuticals

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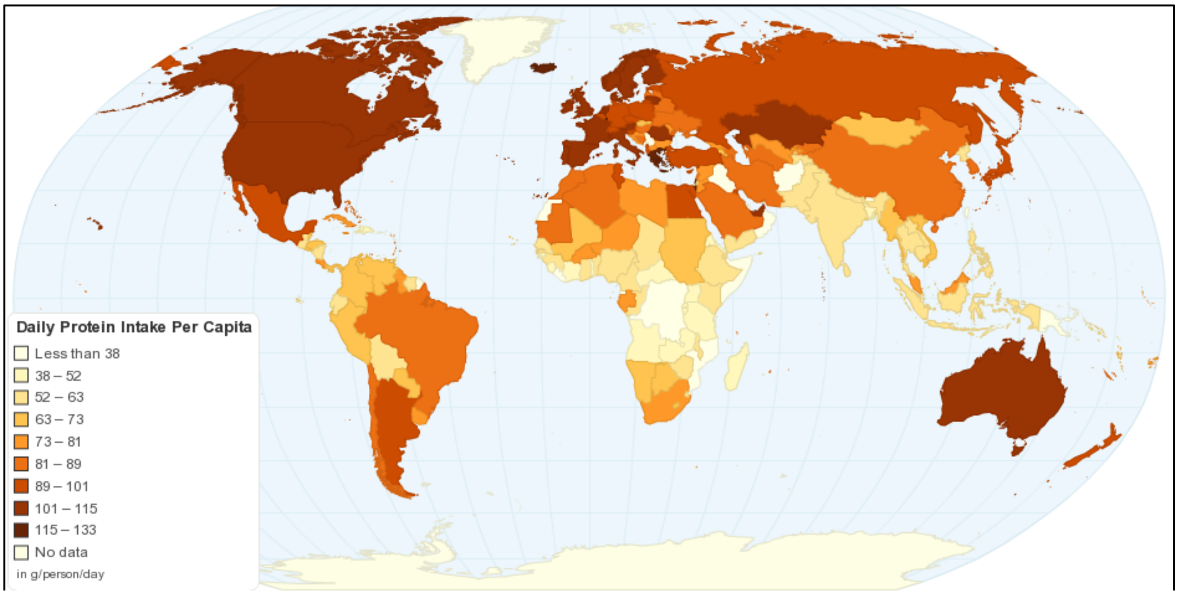
Abstract
Insects are consumed by human right from the evolution of the man. All most every mammal consumes insects in their diet. Insects are consumed unknowingly by humans as a part of the traditional diet in many regions around the world and it most common in the tropical regions such as South-East Asia, Africa, South America, Latin America, and Australia till now. Insects are a sustainable food source and having environmental and health benefits so they need to be included through Entomoceuticals. It consists of many nutritional elements such as protein, fats, and minerals on par with other human food sources. Space required for the production of 1 gm of protein by insect is very low compared with other protein sources such as plant, beef, pork, and chicken with negligible emission of greenhouse gases as compared to livestock. Insects require less space and time to grow and multiply faster as compared with other food sources. Insects are very efficient in converting feed into their body mass. After considering all the above factors insects are far more efficient in the utilization of Natural resources compared with other food sources. Hence insects have huge potential to dominate in future food and agriculture market share.

Keywords: Insect protein, Entomoceuticals, Entomophagy, alternate food

Introduction

Food and Nutritional insecurity around the world urging the researchers to find a sustainable source of food that having same or high nutrient, protein, minerals, and essential fatty and amino acid to endure the human race. Health care shifting from curative measures to preventive measures, lot of energy diverted in incorporating the protein supplement, minerals vitamins supplements through conventional mode intake eithers through production conversion or through adding at the time of processing. There is another popular way of supplementing protein and other vital nutrient through side dishes or through condiments with attractive flavors is called Entomoceuticals. With livestock production which is accounting for 70 per cent of all agricultural land (Steinfeld *et al*., 2006) [15] and responsible for 15% of anthropogenic greenhouse gas emission and one the largest contributors to global warming. Insects have a high food conversion rate, e.g. crickets require six times less feed than cattle, four times less than sheep, and twice less than pigs and broiler chickens to produce the same amount of protein (FAO). In addition, insects need very little land and energy to produce and they can be produced in short time and throughout the year, unlike other agriculture produce. Finally, insects can serve as a protein-rich ancillary for the ocean fish that are often used as aquaculture inputs, rendering aquaculture a sustainable solution to overfishing in ocean. Increase in meat demand mainly comes from developing economies. A suggested measures to control this rising problem, is to shift towards protein from lower impact animals species. To satisfy this growing demand, insects are the only alternative and sustainable sources of protein. Insects are the good source of protein, ranges from 25% to 65% per 100 gm (Xiaoming *et al*. 2010) [18] they also contain high monounsaturated fatty acids and rich in micronutrients such as copper, iron, magnesium, phosphorus, zinc etc. as well as riboflavin, pantothenic acid, biotin (Rumpold and Schluter 2013) [13]. Insects are sustainable food source, so they need to be included directly in Human food chain. There are many environmental and health benefits of consuming insects.

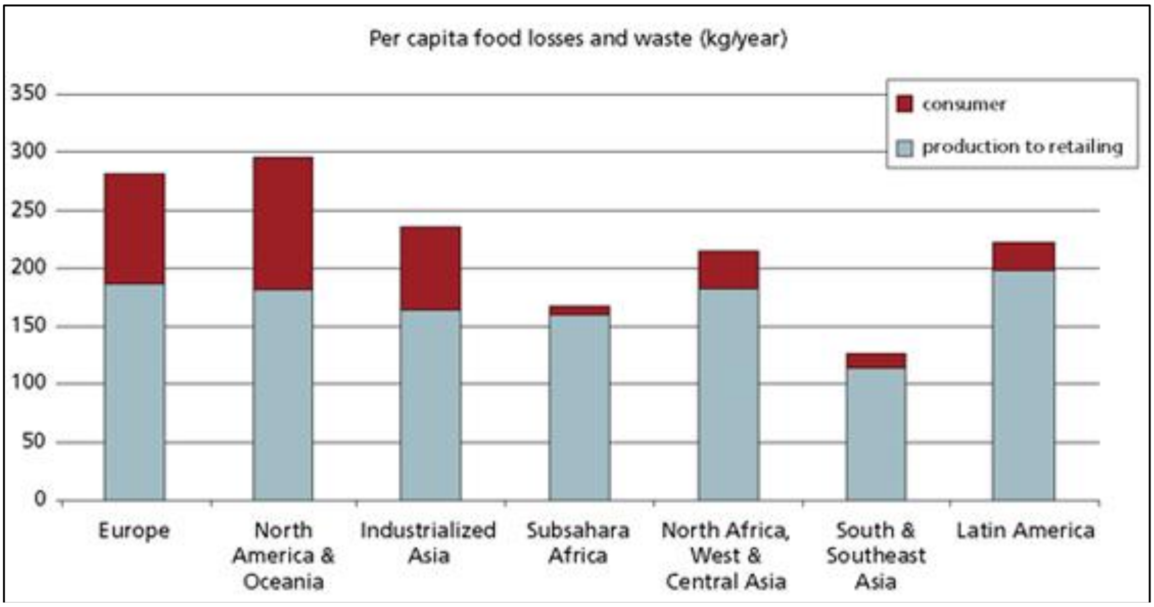


***Source*:** FAOSTAT, 2011

Fig 1: Daily Protein Intake Per Capita around the world from different source

This map shows dietary protein consumption per person. The dietary protein consumption per person is the amount of protein in food, in grams per day, for each individual in the total population. Coming up the averages around the world all over: 77g/person/day, Developed countries: 103g/person/day, Developing countries: 70g/person/day, and Sub-Saharan Africa: 55g/ person/ day.

With increasing of the world population leads to rise in demanding consumers will result in growth in demand for animal origin protein with 75% by 2050 (Alexandratos and Bruinsma, 2012) [1]. Food is wasted throughout the world by processor and consumer, according to the FAO roughly one third of the food produced in the world for human consumption every year approximately 1.3 billion tones is wasted. Every year, consumers in rich countries waste almost as much food (222 million tons) as the entire net food production of sub-Saharan Africa (230 million tons).



***Source*:** Food and Agriculture Organization

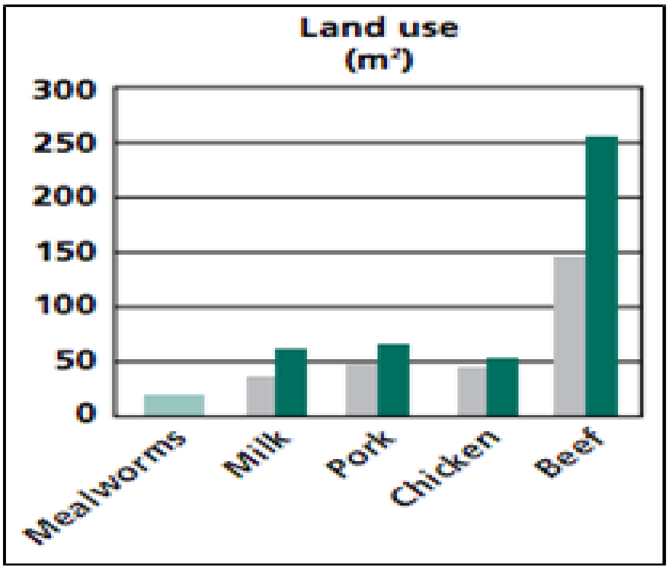
Graph 1: Per capita Food waste throughout the world

In the case insect waste, cost of waste will be very meager in terms of money and other uses of insect-derived products are being explored, such as fertilizer and biofuels. Resources food print will be less because of higher palatability with relative conversion/production rates in insects and less consumption in other animal based products. Use of modern technology in production of agriculture is evolving around the world. This automation in insect production is very much applicable in order to produce in large scale.

Production and capture of insects

Land Use

For every 1 ha of land required to produce mealworm protein, 2.5 ha would be required to produce a similar quantity of milk protein, 2-3.5 ha would be required to produce a similar quantity of pork or chicken protein, and 10 ha would be required to produce a similar quantity of beef protein. It includes land required to grow feed, transportation and raring.



Graph 2: Land required for producing 1kg of protein

Water Use

Water is a key determinant of land productivity in agriculture and in other activities. It is estimated that by 2025, 1.8 billion people will be living in water scarcity regions and countries, two third of worlds would face water stress condition (FAO 2012) [4]. Agriculture alone consume 70% of total fresh water (Pimentel *et al*., 2004) [11]. It is observed that for production of 1 kg animal protein it consume 5 to 20 times more water than to produce 1 kg of plant protein (Chapagain and Hoekstra, 2003) [2]. This figure reaches 100 times if the water required for forage and grain production is included in the equation (Pimentel and Pimentel, 2003) [11]. This concept is described as visual water (Chapagain and Hoekstra, 2003) [2]. According to Chapagain and hoekstra (2003) [2] for production of 1 kg chicken requires 2300 litters of water, for 1 kg pork requires 3500 liters and for 1 kg beef it requires 22,000 liters and this number reaches 44,000(Pimentel and Pimentel, 2003) [11]. According to water organization water that associate with production of 1 kg food will require litter of water that present in the parenthesis, vegetable (322), Cereals (1644), Fruits (962), Pulses (4055), milk (1020), egg (3265), Chicken (4325), Mutton (8763), Beef (15415), Pork (5988). Some portion of water will be saved if we produce insect instead of devoting all our precious water resource into above said food product.

Estimates of volume water required to raise equivalent weight of edible insects are unavailable but results will be low with compared to conventional sources of animal protein. It is estimated that insects more drought resistant than cattle.

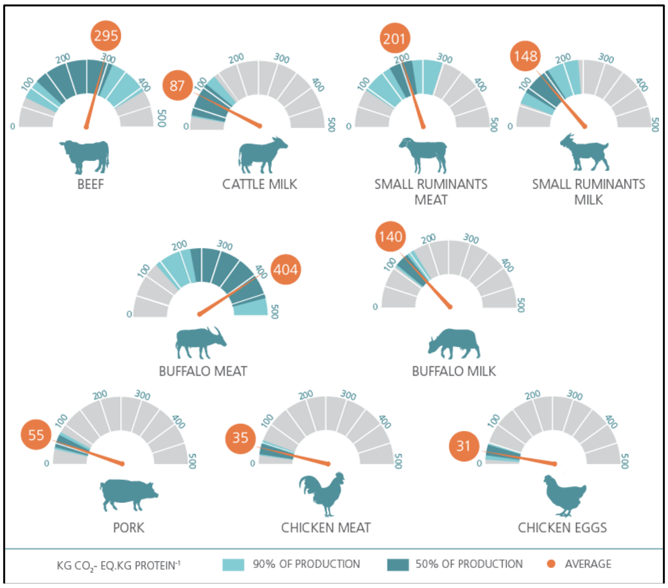
Global Warming Potential

Livestock rearing contributes 18% of total greenhouse gas emission which higher than transport sector (Steinfeld *et al*., 2006) [15]. According to IPCC (2007) Global Warming Potential for CO2 is 1, for CH4 is 23 and for N2O is 289. In insects only cockroaches, termites, scarab beetles emit CH4 (Hackstein and Stumm, 1994), due to presence of Methanobacteria in hindgut (Egert *et al*., 2003) [3]. Global Warming Potential of 1kg fresh insect is 2.5kg of which majority of CO2 is produced by production and transportation of feed and minor portion includes electricity (Oonincx and de Boer., 2012). GWP of other conventional animal food sources are, for production of 1kg chicken resulted in emission of 3.7 – 6.9 kg CO2, for production of 1kg pork emits 3.9 – 10 kg CO2, for production of 1kg beef results in 14 – 32 kg of CO2 production(de Vries M, de Boer IJM., 2010) [17]. When it is indicated per kg of edible protein Chicken produces 36kg of CO2, pork produces 53kg of CO2, beef produces 170 kg of CO2 (de Vries M, de Boer IJM., 2010) [17], insects produces 14kg of CO2 (Oonincx and de Boer., 2012) [9]

Emissions by commodity and emission intensities

Beef meat and cattle milk are the two commodities with the highest total emissions, accounting for 3.0 and 1.6 gigatonnes CO2-eq, respectively. They are followed by pig meat with 0.82 gigatonnes CO2-eq, chicken meat and eggs (0.79 gigatonnes CO2-eq), buffalo meat and milk (0.7 gigatonnes CO2-eq) and small Ruminants meat and milk (0.5 gigatonnes CO2-eq). The rest of emissions are allocated to other poultry and non-edible products.

A way to compare the performance of different commodities is to express the emissions on a per protein basis. By doing so, buffalo meat is the commodity with highest emission intensity, with an average of 404 kg CO2-eq per kg of protein, followed by beef meat, with an average of 295 kg CO2-eq per kg of protein. Meat and milk from small ruminants and milk from buffalo present the third, fourth and fifth highest emission intensities among commodities with averages of 201, 148 and 140 kg CO2-eq per kg of protein. Cattle milk, chicken meat and eggs and pork have lower emission intensities, all below 100 kg CO2-eq per kg of protein. Emission intensities vary greatly among producers, especially in ruminant products. This reflects different agro-ecological conditions, farming practices and supply chains management. Is within this gap between high and low emission intensities where opportunities for mitigation can be found.



Source: Global Livestock Environmental Assessment Model, Food and Agricultural Organization.

Fig 2: Emissions by commodity and emission intensities

Table 1: Protein Content of important food materials

S. No	Food Material	Percentage of Protein Content	Food Material	Percentage of Protein Content
	Cereals			
1	Wholemeal flour	13.2	Beef, dressed carcass	15.8
2	Oatmeal, raw	12.4	Lamb, dressed carcass	14.6
3	Polished rice	6.5	Pork, dressed carcass	13.6
4	Rye flour	8.2	Chicken, raw, meat only	20.5
5	Barley	10.6	Fish	
6	Cornmeal	9.4	Cod, raw	17.4
7	Millet flour	5.8	Haddock, fresh raw	16.8
	Roots and tubers		Plaice, raw	17.9
8	Taro	2.2	Dairy Products	
9	Sago, raw	0.2	Milk, fresh	3.3
10	Tapioca, raw	0.9	Milk, dried, skimmed	36.4
11	Yams, raw	2.0	Cheeses	22.8 to 35.1
12	Sweet potatoes	1.2	Eggs, whole, raw	12.3
13	Potatoes	0.9	Fruit	
14	Plantains, raw	1.0	Apples	0.3
15	Bananas	1.1	Cherries	0.6
	Pulses		Melons	1.0
16	Chickpeas raw	20.2	Peaches	0.6
17	Beans, butter	19.1	Dates, dried	2.0
18	Beans, harvest	21.4	Figs, raw	1.3
19	Lentils, raw	23.8	Plums	0.6
20	Peas, fresh	5.8	Vegetables	
21	Peas, dried	21.6	Cauliflower	1.9
22	Tomato	0.9	Onions	0.9
23				

Source: Paul and Southgate, 1978; Holland, *et al*., 1985.

Table 2: Nutritional Status of commonly available insects (Gram(s)/100 Grams)

Insect Particular	Protein	Fat	Minerals	Carbohydrates	Energy
Beetles	3.7-54	3.7-52	1-3	12-34	126-574
Flies	17.5-67	4.2-31	1.24-8	8.38-23	199-460
Bugs	33-65	7-54	1-19	7-19	329-622
Bees, wasps, sawflies and ants	1-81	1.3-62	0-6	5-94	234-593
Butterflies and moths	13.2-69.6	7-77	2-8	3-41	126-762
Grasshoppers, crickets and locusts	13-77	2.4-25.14	2-27	16-30	117-436

Source: Ruann Janser Soares de Castro *et al*. (2018).

Nutrient content comparison of essential food commodity and some commonly available insect around the world are listed in the above two table no.1 and 2 reveals that most of the insect are having more nutrient content than the food crop, meat and fish.

Feed conversion

Demand for meat increases eventually demand for feed and grains increases in multi-folds. This is because, to produce animal protein far more plant protein is required for it. According to Smil (2002) [14] to get 1kg live weight of chicken required to feed 2.5 kg feed, 5kg for pork and 10 kg of feed for beef is required. For crickets to gain 1kg live weight they are require 1.7 kg of feed (Collavo *et al*., 2005).

Percentage of Animal Edible

Nakagaki and DeFoliart (1991) [14] estimated that up to 80 percent of a cricket is edible and digestible compared with 55 percent for chicken and pigs and 40 percent for cattle.

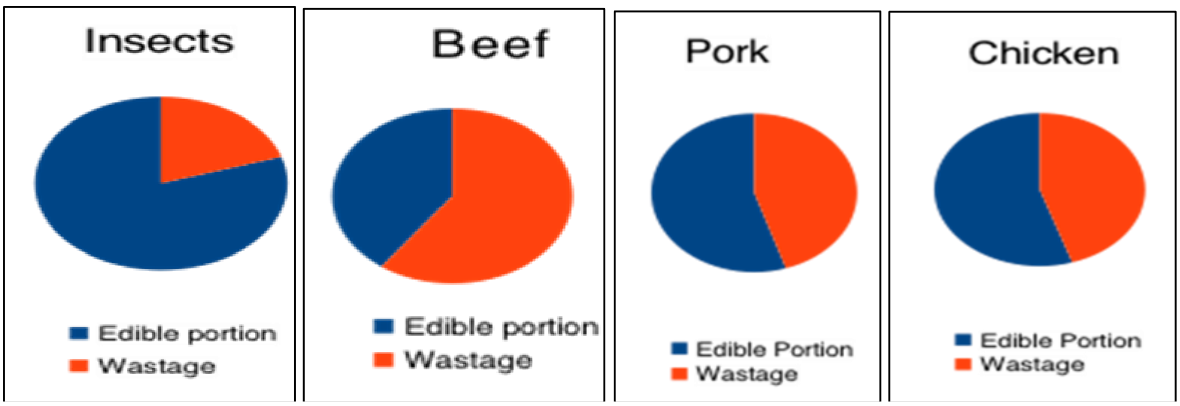


Fig 3: Percentage of Animal Edible

Challenges

1. Most of the countries lack a regulatory framework equipped to handle the potential risks that may arise out of allergy and other related issues.
2. Lack of interest and acceptance of people is most important criteria in mass production and marketing of insects. This will gain momentum when insect are processed into different forms and Entomoceuticals.
3. Maas production may create uncertain situation in invasion new pest to the agriculture crop if any candling and production error happened.
4. Insect can be cultivated only in controlled environment so automation only the viable solution to cultivate in mass this makes mass production capital intensive.
5. Over harvesting of wild insects will affect ecosystem of earth as happening in Nepal regions.
6. Food safety and standard norms have to be established throughout the country and it must be location specific.

Conclusion

This means that crickets are twice as efficient in converting feed to meat as chicken, at least four times more efficient than pigs, and 12 times more efficient than cattle. This is likely because insects are cold-blooded and do not require feed to maintain body temperature. Global warming potential of insects is less compared with conventional animal protein sources. Land and water required to rare insects is less compared with convention animal protein sources. Vertical usage of land can be adopted in raring of insects which not possible for other conventional protein sources. In further insects can replace other conventional animal protein sources. They are sustainable and alternative sources of protein.

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