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Edible Insects As An Alternate Source of Complete Nutrition

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ABSTRACT

Insects can be easily employed in our diets to make up for severe protein and vitamin deficiencies in the population. In this study, two insect species, namely Silkworm (Bombyx mori) pupae (SP) and Black Soldier Fly (Hermetia illucens) (BSF), were considered for the experimentation. This work aims to produce insect meals from the two samples and evaluate their physicochemical, nutritional, and sensory qualities. The mean values of crude protein, crude fiber, ether extract, total ash, and total moisture on a dry matter basis (%) were found as 8.44(SP), 8.70(BSF), 57.44(SP), 42.8(BSF), 38.3(SP), 35.3(BSF), 0.25(SP), 9.4(BSF), 4.01(SP), 12.1(BSF) respectively. Proximate analysis was done as per methods of AOAC, 2000. Amino acid profiling was conducted after extraction and pre-column treatment using a ZORBAX Eclipse AAA column with gradient elution. Vitamin analysis was carried out using High-Performance Liquid Chromatography and was expressed in µg/g.

Keywords: *Entomophagy, Proximate analysis, protein, sensory, amino acid profiling, vitamins.*

I. INTRODUCTION

In its fifth article, the Universal Declaration of Human Rights states that food may be a basic right of everyone living around the globe. Humans are most likely distinctive in this they'll doubtless be able to avail a large number of agricultural resources. However, Humans over all these years have been able to exclusively cultivate only limited plants and animal sources for his daily nutrition as an addition to the nutrient pool. Moreover, there is a drastic loss of diversity in the food and agricultural practices worldwide due to an unprecedented unfolding of western culture due to globalization. This trend is predicted to have a hugely detrimental effect on consumers' health due to the ingredients market skewing towards the economic profits instead of consumer health guidelines (Johns and Eyzaguirre 2006). With each passing second, the world's population is constantly increasing, so it needs agricultural resources. Enhancements in food cultivation are brought to us by extensive agricultural practices, artificial selection, and by the event of genetically changed organisms. In its most common sense, the rapid agricultural enhancement will lead to loss of ecology, and animal welfare will be under threat.

It is a very common practice to include worms and other creepy crawlies in many humans' daily diets worldwide. This practice is termed as Entomophagy. Insects have been since time immemorial been regarded as a wonderous source of nutrition for humans, including protein and fiber. For example, 85% of the required daily intake of proteins and nearly 100% of the advised amount of daily vitamins for humans can come from just 100 g of crickets. It is known that the nutrition provided by insects is comparable to meat sources, except for pork due to its extremely high ether extract content. Taking into consideration that insects have a drastically great reproducibility, have an exponential feed conversion efficiency, less requirement of space, the fact that they are omnivorous help in an increase in their nutritional value, Entomophagy is the only option the world has right now to answer limited food resources and food security issues, they may also be prevalent as regular meat alternatives, especially to meat products and fish.

II. MATERIALS AND METHODS

A. Procurement of samples:

Samples of Silkworm pupae *(Bombyx mori)* and *(Hermetia illucens)* were obtained from reliable vendors in Villupuram and Bangalore.

B. Drying of test samples:

The chosen insect samples were dried in a tray drier following a low-temperature long time (LTLT) method (i.e., 39-40°C for 6 hours) to protect all nutritional factors sample from getting denatured. Followed by grinding the dried samples into a coarse powder (i.e., insect meal) using a tabletop mixer grinder at a speed of about 15,000 RPM. All analytical procedures were carried out using this insect meal powder.

C. Proximate analysis

Proximate analysis was done as per methods of AOAC, 2000. The crude protein, moisture content, crude carbohydrate, crude fiber, crude fat, and ash content were evaluated. Results were published per 100g of dry matter.

D. Mineral Composition Analysis

Mineral composition analysis for the samples was done using NOVA 400 atomic absorption spectrometer. The specifications were as follows:

a) 213.9 nm, 0.5 nm, 4.0 mA (zinc)

b) 422.7 nm, 1.2 nm, 4.0 mA (calcium)

c) 324.8 nm, 1.2 nm, 3.0 mA (copper)

d) 589.0 nm, 0.8 nm, 3.0 mA (sodium)

e) 248.3 m, 0.2 nm, 6.0 mA (iron)

f) 766.5 nm, 0.8 nm, 4.0 mA (potassium)

E. Amino Acid composition

Amino acid composition analysis was conducted after extraction and pre-column treatment of the samples using a ZORBAX Eclipse AAA column of dimensions 150mm*4.6mm (L*I.D) with gradient elution. Mobile phase consisted of two eluents; eluent A- 40mM Phosphate buffer (pH- 7.8) and eluent B- Methanol/Acetonitrile/water (45/45/10). The flow rate was maintained at a constant of 2.0 millilitre/min; the temperature was maintained at 40℃. Diode array detectors were used for the analysis (Shun Watanabe et al.,2011).

F. Vitamin content analysis

Vitamin analysis was carried out using High-Performance Liquid Chromatography and was expressed in µg/g. Flow rates and elution methods were followed for both fat-soluble and water-soluble vitamins according to protocols, as mentioned by (Rokayya Sami et al., 2014).

G. Sensory Evaluation:

Sensory evaluation was conducted for the produced insect meal samples on a 5 point hedonic scale. The panel consisted of people from different age groups and genders to obtain a wholesome analysis for the study.

III. RESULTS AND DISCUSSION

The following results were obtained on the investigation of the insect meal samples.

A. Proximate Analysis:

The mean values according to the proximate analysis of total moisture, crude protein, ether extract, crude fiber, total ash on a dry matter basis (%) were found to be 8.44(SP), 8.70(BSF), 57.44(SP), 42.8(BSF), 38.3(SP), 35.3(BSF), 0.25(SP), 9.4(BSF), 4.01(SP), 12.1(BSF) respectively. Detailed results are shown in Table 1

Table 1: Proximate analysis

PARAMETERS	SILKWORM PUPAE (% dry matter)	BLACK SOLDIER FLY LARVAE (% dry matter)
Crude Protein	57.44	42.8
Crude Fibre	0.25	9.4
Ether Extract	38.3	35.3
Total Ash	4.01	12.1
NFE	--	--
% Moisture	8.44	8.70

B. Mineral content analysis:

Produced insect meal sample SP showed the following Ca-8.4, K-3.5, Na-0.6, Mg-3.7, Fe-0.32, Mn-0.02, Zn-0.22, and Cu-0.01 g/kg respectively, and sample BSF showed the following Ca-75.6, K-6.9, Na-1.3, Mg-3.9, Fe-1.37, Mn-0.24, Zn-0.11 and Cu-0.01 g/kg respectively. Detailed results are shown in Table 2

Table 2: Mineral analysis

Mineral Name	SP (g/Kg)	BSF (g/Kg)
Ca	8.4	75.6
K	3.5	6.9
Na	0.6	1.3
Mg	3.7	3.9
Fe	0.32	1.37
Mn	0.02	0.24
Zn	0.22	0.11
Cu	0.01	0.01

C. Amino acid content:

Produced insect meal sample SP showed the following Aspartic acid-91.27, Threonine-39.5, Serine-37.5, Glutamicacid-95.22, Glycine-36.1, Alanine-39.02, Cysteine-

14.6, Valine-47.3, Methionine-34.4, Isoleucine-34, Leucine-62.18, Tyrosine-56.26,Phenylalanine-46.09, Lysine-61.38, Histidine-27, Arginine-47.07, Proline-70.1, Tryptophan-15.08 mg/g of protein respectively.

While BSF showed Aspartic acid-68, Threonine-23.1, Serine- 19.3, Glutamicacid-68.1, Glycine-33.7, Alanine-48, Cysteine-0.6, Valine-51.3, Methionine-13.1, Isoleucine-31.8, Leucine-49.3, Tyrosine-43.2,Phenylalanine-32.5, Lysine-41.2, Histidine-18.7, Arginine-35, Proline-41.2, Tryptophan-3.1 mg/g of protein respectively. Detailed results shown in table 3.

Table 3: Amino acid analysis

Amino Acids	SP (mg/g)	BSF (mg/g)
Aspartic acid	91.27	68
Threonine	39.5	23.1
Serine	37.5	19.3
Glutamic acid	95.22	68.1
Glycine	36.1	33.7
Alanine	39.02	48
Cysteine	14.6	0.6
Valine	47.3	51.3
Methionine	34.4	13.1
Isoleucine	34	31.8
Leucine	62.18	49.3
Tyrosine	56.26	43.2
Phenylalanine	46.09	32.5
Lysine	61.38	41.2
Histidine	27	18.7
Arginine	47.07	35
Proline	70.1	41.2
Tryptophan	15.08	3.1

D. Vitamin analysis:

Produced insect meal sample SP showed the following Vitamin A-0.505, Vitamin B1-0.21, Vitamin B2-5.19, Vitamin B5-10.58, Vitamin B6-0.195, Vitamin B12-0.52, Vitamin D3-10.9, Vitamin E-9.65, Niacin-11.88, Carotene-6.5, Folic Acid-187.91, and Free Biotin-0.12 µg/100g respectively.

While BSF showed Vitamin A-1.75, Vitamin B1-0.62, Vitamin B2-4.25, Vitamin B5-19.4, Vitamin B6-2.06, Vitamin B12-2.72, Vitamin D3-13.04, Vitamin E-9.26, Niacin-55.02, Carotene-5.9, Folic Acid-273.96, and Free Biotin-0.97 µg/100g respectively, detailed results are shown in Table 4.

Table 4: vitamin analysis

Vitamin Name	SP (µg/100g)	BSF (µg/100g)
Vitamin A	0.505	1.75
Vitamin B1	0.21	0.62
Vitamin B2	5.19	4.25
Vitamin B5	10.58	19.4
Vitamin B6	0.195	2.06
Vitamin B12	0.52	2.72
Vitamin D3	10.9	13.04
Vitamin E	9.65	9.26
Niacin	11.88	55.02
Carotene	6.5	5.9
Folic Acid	187.91	273.96
Free Biotin	0.12	0.97

E. Sensory analysis:

Produced insect meal had a reasonable favor score on a 5 point hedonic scale. The score ranged from moderately acceptable to highly acceptable among the panel. The flavor was close to the taste of toasted nuts with a mild bitter after taste. It was seen that panel members of the age group 20-25 were highly accepting of the product and seemed to like it more, whereas the older age groups were not very convinced. This may result from a predefined mindset and an apprehension against trying new food among the older people used to traditional cuisine. Detailed results are shown in Tables 5 and 6.

Table 5: Sensory chart for SP:

RATING SCALE	Appearance	Taste/ Flavor	Texture/ Consistency	Smell/ aroma	Overall acceptability
5. Like extremely	✔		✔		
4. Like slightly		✔			✔
3. Neither like nor dislike				✔	
2. Dislike slightly					
1. Dislike extremely					

Table 6: Sensory chart for BSF:

RATING SCALE	Appearance	Taste/ Flavour	Texture/ Consistency	Smell/ aroma	Overall acceptability
5. Like extremely	✔		✔		
4. Like slightly		✔		✔	✔
3. Neither like nor dislike					
2. Dislike slightly					
1. Dislike extremely					

IV. CONCLUSION

In summary, the produced insect meal showed great promise as an alternate source of stable macro and micronutrients. Socially, products like this could help eradicate hunger and malnutrition among the underprivileged in most developing nations. This holds many potentials to emerge as a trend in the superfood business in years to come. Lower costs for the rearing of insects can prove beneficial to manufacturers and lead to high employability in the rural and urban sectors. The only setback in this novel study is the acceptance of such a product among the masses. In a country like India, insects are not a very common sight in the daily diet; hence, the mindset changes. The population must become more and more accepting of new and emerging technological advancements.

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