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Opinion

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Sericulture `Waste' Silkworm Pupae as Alternate Source for Animal Protein

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One of the major problems, the world facing today, is to feed the ever galloping population, which has already crossed 7 billion mark. Though, the agricultural community is working hard, to combat these bottleneck drawbacks, more than 1/3 of the world population goes to sleep without having a food. When one talks about the food, biomolecules such as carbohydrate, proteins and lipids have to be considered. Agriculturists concentrate mainly to provide carbohydrates in the form of wheat, paddy and other staple food and lipid and proteins to a lesser extent. Source of plant as well animal protein is limited Hence millions of people are facing the problem of deficiency of proteins in particular in their food [Udani, 1979]. Commercially available protein supplements are beyond the reach of not only poor people but also middle class people category as well. By and large plant protein is made available from dicotyledonous plants such as lentils, grams, peanut while fish happen to be is major source of animal protein, which could be affordable by poor and middle class category also population. If one looks for alternate source for animal protein in particular, silkworm pupa, which is presently considered as waste material in the process of silk reeling, seem to be promising source for animal protein [Finke, 2002].

Sericulture is an agro-based rural cottage industry, where the `biological machine' silkworm converts plant protein such as Morin into animal protein such as silk. This is one of a few industries where money flows from rich to poor. Although there are several commercial species of silkworms such as Tasar, Muga, Eri, Anaphe silks available, it is the mulberry silkworm *Bombyx mori* available, is the most widely reared and used apart from being intensively studied. Silk was first produced in China as early as the Neolithic period [Vainkar, 2004]. Today, China followed by India is the world leader in silk production accounting about 60% of total world's silk production. According to Confucian text, the discovery of silk production dates to about 2700 BC, although archaeological records point to silk cultivation as early as the Yangshao period (5000-3000 BC) [Barber, 1992].

Silk is a continuous protein fiber produced by the silkworm during their larval-pupal metamorphosis, where it forms its cocoon [Cook, 1968]. Though `silk fibres' are also produced by some spiders belonging to Fl: Arachnidae [Cook, 1968, Robson, 1985] as they cannot be commercially produced or spun unlike silkworms. Silk fibre is a mix of mainly two proteins viz., yellow colored, brittle, no-elastic sericin, which is also known as `silk gum' having antibacterial activities along with some other minor component such as waxes, fats, pigments etc., and fibroin, the main silk fiber.

The silk is obtained by placing the silk cocoons in hot water, by which the `silk gum' gets dissolved and core fiber fibroin gets exposed and is reeled Once silk is extracted, the pupae inside the cocoon comes in contact with hot water and gets killed. Generally these pupae are discarded as waste. Silkworm pupae are the by-product after the silk-thread has been wound-off from the cocoon and can serve as a feedstuff. However, as the people became aware of the nutritive value of the silkworm pupae they started utilizing them as food since last couple of decades. Today, in Assam, India, they are boiled for extracting silk and the boiled pupae are eaten directly with salt or fried with chili pepper or herbs as a snack or dish.

In Korea, pupae are boiled and seasoned to make a popular snack food known as *Beondegi*. In China, street vendors sell roasted silkworm pupae. In Japan, silkworms are usually served as a *Tsukudani* i.e., boiled in a sweet-sour sauce made with soy sauce and sugar. In Vietnam, this is known as *con nhong*. Silkworms have also been proposed for cultivation by astronauts as space food on long-term missions [Choi, 2009].

Silkworm pupae contains α-glucosidase inhibitor. The percentages of total protein and lipid contents by dry weight were 55.6 and 32.2%, respectively. Silkworm pupae protein had high levels of essential amino acids such as valine, methionine and phenylalanine [Tomotake., *et al.* 2010]. The contents of essential amino acids in silkworm pupae protein satisfied the FAO/WHO/UNU suggested requirements in 2007. In addition, they also possessed n-3 fatty acids, especially α-linolenic acid (36.3%), as a major component. The 50% ethanol extract of silkworm pupae contained 1-deoxynojirimycin (DNJ), which is a potent α-glucosidase inhibitor [Kumar., *et al*. 2011]. These results suggest that silkworm pupae are a new source of high quality protein, lipid, and α-glucosidase inhibitor. The silkworm pupae is rich source of undeoiled and deoiled dry matter, Organic matter, Crude protein, Crude fat, Ash, Crude fibre, N-free extract etc., [Table-1]

Unde-oiled De-oiled				
	Mean	**Variation**	**Mean**	**Variation**
Dry matter	88.9	68.5 -95.1	91.9	90.4-98.5
Organic matter	89.6	87.9-91.8	91.8	84.2 -88.8
Crude protein	55.1	49.4-60.9	72.8	44.5-77.6
Crude fat	23.2	14.2-30.3	2.0	0.7-7.0
Ash	3.8	2.2-7.5	5.6	4.4-9.1
Crude fiber	5.5	4.9-8.8.	6.2	4.6-9.8
N-free extract	6.4	5.5-10.8	7.3	6.7-9.8

(Source: Hertrampf and Piedad-Pascual (2000))

Table 1: *Chemical composition of silkworm pupae meal (% in dry matter) (Nehring, (1955) Friede, (1977) Zaher and Mazid (1993) and Hossain (1991).*

The mean crude protein content of silkworm pupae meal has widely varied crude protein contents. The mean Crude protein mean content of fat extracted silkworm pupae meal is higher (72.8%) than that of the fat containing meal (55.1%). Several important amino acids such as lysine, methionine, arginine, histidine and threonine are also present in a limited quantity. The protein of silkworm pupae meal is not of high value [Friede, 1977] based on the EAA-Index (essential amino acid) and the biological value (BW) (51.6%) [Steger and Piatkowski, 1959]. Apart from the above essentials, the silkworm pupae meal fat has a lecithin content of 2.12% [Steger and Piatkowski, 1959].

Silkworm pupae also contains saturated fatty acids (20.7%), unsaturated fatty acids such as Palmitic acid (20.7%), Oleic acid (70.1%), Linoleic acid (14.0%), Linolenic acid (9.1%), Other fatty acids amounting to 24.6%, of which, Linolenic acid: accounts for 14.0% and other fatty acids are present at 8.4% [Hertrampf and Piedad-Pascual, 2000] An essential amino acid, or indispensable amino acid, is an amino acid that cannot be synthesized *de novo* (from scratch) by the organism, and thus must be supplied in its diet. Among nine amino acids humans cannot synthesize phenylalanine, valine, threonine, tryptophan, methionine, leucine, isoleucine, lysine and histidine. However, the silkworm pupae contains several of the essential aminoacids such as Arginine, Histidine, Isoleucine Leucine, Lysine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan and Valine in considerable amount [Table-2].

	Mean	Variation
Arginine	6.0	3.6 - 7.8
Histidine	3.3	3.2-3.3
Isoleucine Leucine and Lysine	7.8	7.5-8.0
Lysine	6.1	2.5-10.1
Methionine	1.9	1.8-1.9
Phenylalanine	2.5	1.8-3.2
Threonine	4.6	3.6-5.6
Tryptophan	1.1	0.6-1.5
Valine	4.7	----

(Source: Hertrampf and Piedad-Pascual (2000)).

Table 2: *Essential amino acid profile of silkworm pupae meal (Steger and Piatkowski (1959) Koyama., et al. (1961) Lakshminarayana and Thirumala (1971), and New (1987).*

The crude fiber of silkworm pupae meal is mostly chitin which is hardly utilized by animals [Friede, 1977]. Information on the mineral and vitamin content of silkworm pupae meal is shown in Table-3. Based on the above it is possible to utilize the one of the `wastes' of sericulture industry viz. silkworm pupae, which is generally discarded or at the most used as fish or poultry feed, for human consumption to reduce the load of providing animal protein to humans.

Minerals	Vitamin (mg per 100g)
Calcium 0.63%	Vitamin E 1000
Phosphate 1.25%	Vitamin B1 15
Sodium 0.03%	Vitamin B2 80.0
Potassium 1.07%	Vitamin B12 0.5

(Source: Hertrampf and Piedad-Pascual (2000)).

Table 3: *Mineral and vitamin contents of silkworm pupae meal.*

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