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Investigation of the Nutritional Constituents of the Wild Silk Moth *Epiphora Bauhiniae* (Guerin Meneville) Lepidoptera: Saturniidae in Sudan

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***Abstract*— The elementary information , on the nutritional constituents, of the wild silk moth *E.bauhiniae* (pupa) was investigated , where as the nutrient contents, of diapauses pupae of *E.bauhiniae* was determined, in the laboratory of the Gazira University, Faculty of Agricultural Sciences, Department of Crop Protection. The protein, phosphorous, Calcium, Magnesium, Chromium, fat and ash were examined in the pupal tissue of *E.bauhiniae*. The study revealed that nutrients components of pupae tissue, under laboratory conditions were found as follows: Protein (11.037%), Fat (27%), Phosphorous (0.3165%), Calcium (0.08%), Magnesium (0.372%), Chromium (0.9968%), and ash (1%). The nutrients expressed or elicited by the study in pupal tissue are essential nutrients, for human health which reflect that the insect has contained highly nutritious components and energy content, enough to be candidate source of human diet or as a significant food security item in Sudan. For the justification that , it has wide range of distribution in Sudan i.e. it was found in Gedarif, Sinnar, Blue Nile, White Nile, South Kassala, South Gazira, Kordofan and Darfur. Consequently this insect has a good potential, for being use in community based projects, and can be inured to be cultured, for food production (pupal meal base diets). This will back the efforts towards enhancing food security and henceforth to lessen and enucleate the poverty, in different regions of the Sudan however, to endure with the expected large-scale food crisis. This study claimed to be the first report on nutritional value of *E.bauhiniae* pupae in the Sudan.**

***Index Terms*— Nutritional constituents, Wild silk moth *E.bauhiniae* (pupa), Protein, Phosphorous, Calcium, Magnesium, Chromium, Fat and ash, Food security**

I. INTRODUCTION

Little is known about how to trap the full potential of insects as a food crop, predominantly the edible insect species which are gathered in forests. Over the past decade, recognition by forest managers of the role of Non-Wood Forest Products (NWFPs) in food security has grown considerably. However, they tend to be much less aware of the food potential of edible insects. Several investigations have shown that, in addition to their fundamental contribution for pollen dissemination, insects may contribute significantly to livelihoods in both rural and urban areas De Foliart,GENER and Stack *et al* [1,2,3]. F AO [4] notes that, insects are also important NWFPs. That poor people gather particularly women and children. Insects are a popular food in many cultures all over the world, be it as an occasional delicacy or as a replacement food in times of shortages, droughts, floods or war. The global consumption of meal will grow 173 percent by 2050 as the result of the explosive growth of 209 percent in developing countries FAO [5] the European Union [EU] will spend € 3 million to research to potential of insects as alternative source of protein. The Food Standard Agency [FSA] stated that, while insects have not traditionally been used for food in the United Kingdom or elsewhere in the EU, it is estimated that about 7.5 billion peoples across the world have diets that routinely included insects. In China yellow meal worm [*Tenebrio molitor*] were used where 280 tons produce annually to feed poultry, fish, frogs, birds, turtles, scorpions, centipedes and snakes. Also used for animal feed and additive protein in a powder form to be used in human food FAO [6]

Lepidoptera is an order of all silk worms Maras,S.,M., [7]. Mulberry silk worm *Bombyx mori* (L) is a member of the family *Bombycidae*. However *Saturniidae* is a largest silk worm family under which *Epiphora bauhiniae* was found and known in south and central Africa, pupated in a silken cocoon, and hosted on *Ziziphus spina Christi* Billoehlke [8]. The leaves of *Ziziphus* trees are used for rearing silk worm (Tasar) for commercial uses in tropical region Vogt K [9] *E.bauhiniae* knowns as emperor moth Gashe,B.,A.MpuchanemS.,F [10]. It is called in Sudan umkhiwait and Nasaga, it has a wide range of distribution, and hosted on *Ziziphus spina Christi*. *E. bauhiniae* has high potential, in egg production and pupation in Sudan, during the rainy season and feed only on one plant (monophagous inset) Eltayeb *et al* [11]. *E bahiniae* easy to be reared in door, consume a commercial amount of food, with high survivability Eltayeb *et al* [12].

Some insects are important source of food, for human being ,where as the insects were cultured for food production, the larvae of *Tenebrio molitor* (meal worm) a commonly cultured insect are collected for food as reported by Frye and Calvert [13].

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Plant and Pandey [14] affirmed that protein was higher during pupal stage than larval stage in *Antheraea mylitta* (Dru.). Also Gashe and Mpuchane [10] emphasized that emperor moths produce edible moth larvae. Emperor moth caterpillars are widely consumed in South Africa, the most well known emperor moth is *Imbrasia bellina* the mopane worm, large quantities are harvested annually and some time exported to other countries Paual Vantomme *et al* [15]. A canning factory was set up in South Africa some years ago Website Iziko Museum [16]. The macronutrient contents of immediate pre-metamorphosis larvae of *Bombyx mori* was studied by Frye and Calvert [13], the protein, fat, calcium, and phosphorous and gross energy contents were compared to, and found to exceed those of another cultured insects. Plant and Pandey [14] studied variation in different biochemical parameters in the fat body of the *Antheraea mylitta* (Tasar silkworm) during larval and pupal stage and they found that the level of the total free amino acids ranged from 14.6 mg to 1.03g / 100g fresh body, while that of the total proteins ranged from 0.20 to 8.6 %, and the highest level of RNA are observed in diapauses pupae. Silkworm pupae consider as by-product of silkworm product FAO [6].

Pupae used as animal food or human diet. In China nowadays recognized new food source, in India, Eri silkworm pupae [*Samia recini*] were considered a delicacy. In both cases, their high protein content and well balanced amino acids are much value Longvah *et al* [17]. V.G.Halliyal [18]. stated that pupa oil manufactured from pupa stored for long period of time is found to be inodorous with high acid value V.G.Halliyal [18]. Silk worm rearing industry, generates considerable amount, of silkworm pupae as an inevitable byproduct ,which is about 75% to 80% of the green pupa Anon [19]. Silkworm pupae produced provide a valuable oil for many industrial products, such as paints, varnishes, pharmaceuticals, soaps, candles and plastics or bio fuels FAO [6]. Silkworm production was about 500 000 tons in 2010. Main silkworm producers are China, India, Uzbekistan, Thailand and Vietnam FAO [6]. Silkworm pupae was found to be useful economical protein rich feed and reduced production cost, when meat replaced by pupae Reddy *et al* [20]. Eri silworm reported as a source of edible oil, with high content of a tinolenic acid and of significant nutritional value Thingnganing *et al* [21]. Chinese Medicine Health reported on silkworm pupae nutritional value Adimin [22] at 2=37a fresh pupae 51% protein [crude], fatty acid 29% ,vitamin A, B, D. Pupae content of more than **50%** protein ,for higher than the general food. Also full range of essential amino acids in proteins, consist of 18% amino acids. The amino acid is about two times that of eggs yolk, ten times that of milk. Eight kinds of essential amino acids nutritionally balanced right proportional in line with FAO/WHO; requirements are very suitable for the need of human body is equality insect proteins. Pupae contain Potassium, Calcium, and Magnesium, iron, copper, manganese, zinc, phosphorus, selenium and other trace elements. Vitamin, A, B, B, E carotene essential human .It is rich unsaturated fatty acids important for cell growth of infants ,enhance cell viability ,improve blood circulation ,enhance memory and thinking ability promote digestion and absorption of fat soluble vitamins.

In Islamic jurisprudence, and ordinance the insect was mentioned in some prophet's statement (Hadeeth) i.e. locust was mentioned by Seydna Mohamed peace and blessing upon him (PBUH) in prophet ś statement that locust stated as one of the two excused carrions not illicit to be eaten by Muslims without any contestable tenet or creed, for this reason locust has been eaten by Muslims without slaughter treatment like other animals, but only kill it and cook it. Tree locusts (sary ellil) were captured in different areas or regions in Sudan for food, such as Gedarif State (Sug Salamet Elbi), where as one sack of dry locust (*Anacridium melanorod melanord*) insect valued three hundred pounds this season, which exceed the cost of Dura, millet and even gum Arabic in that area. The people also use the insect as traditional medicine against some diseases e.g. diabetics, constipation and other some enteric diseases. There are larvae used by Sudanese people as food, this larva called locally Dood Mani, which usually live on the leaves of *Balanites aegyptiaca*, it is an edible larva in Blue Nile (Engasana areas) where the people collect them for food. We observed the larvae of this insect were captured by women of Engasana tribe, collected them (final instars) killed by crushed their heads, on the fire wood and placed them directly on fire, transferred to bowl or dish salted and ate them.

In Sudan also some people eat an insect called Umsumaim, collect them, and cook in span without oil (In Gedarif and Sinnar state). Sayed [23] stated that the protein and amino acids are important nutrients for human health and are found in meat. Vitamin B is easy to be absorbed and has ability to improve or activate the sexual and copulation power beside promote the level of fertilization or acts as prolific agent. While the minerals such as zinc, magnesium, calcium, potassium, these are good materials lead to increase excretion of Testosterone and Androgen for both male and female.
Gibreil and Idris [24] conducted feeding trial, to investigate the feeding value of locust meal, in broiler production, under Sudanese conditions, they found that locust meal is deficient in lysine and therefore, cannot be used as sole protein supplement, in sorghum based broiler diet and it can be used as a base for production, of commercial protein supplements. The chemical analysis, of the locust meals used in their study, revealed a higher value of crude protein (89%). in terms of poultry nutrition, locust meal values, meta boilable energy, crude fiber and fat apparently had advantage over that of the super concentrate.

The chromium is the best mineral, for production of insulin from spleen, and organizes the level of sugar concentration in the blood. Mader and Syliva [25] stated that the four major classes of nutrients are Protein, Carbohydrates, Lipids, Vitamins and minerals. Proteins, Carbohydrates and Lipids are all utilized by body as a source of energy Carbohydrates, Fats and Proteins all contribute to human energy needs. The amount of energy released, upon full oxidation of one gram of each of these showed 4.1 calories for Carbohydrate, 9.3 calories for fat

and 4.1 calories for protein. Carbohydrates supply about 40% of energy need; fats supply about 45% and Protein supplies about 15% for the average American.

Among poorer people, either in this country or other countries, carbohydrates may supply as much as 80% of energy needs. Vitamins are organic compounds (other than Carbohydrates, Lipids, and Proteins) that the body is unable to produce and therefore must be present in the diet. In addition to vitamins, various minerals are also required by the body. Minerals are divided into Macro minerals that are needed in only microgram amounts per day and the trace element that are needed in only microgram amounts per day. The macro minerals, Sodium Magnesium, Phosphorus, Chlorine, Potassium, and Calcium serve as Component of tissues and teeth and also for nerve conduction and muscle contraction.

Food rich in Proteins include meat, fish, poultry cheese, nuts, milk, egg and cereals. Various legumes such as beans and peas also contain lessen amount of Protein. Flowing digesting of protein amino acids entre the blood and transported to the tissues. Some protein sources, which include those available from animals' sources are complete proteins, they contain adequate amount of the tissues and promoting normal growth and development. Other protein sources, such as those from plant sources are incomplete protein and are not able to maintain body tissues and growth. Fats are present only eggs, milk, nuts and a variety of vegetable oils. Fats from an animal origin tend to have saturated fatty acids and those from plants tend to have unsaturated fatty acids. An increase in the amount of fats in the diet can greatly increase the number of calories consumed.

This study aimed to add another diet or nutriment, containing essential nutrients, to maintain human health, so the objective of the study is to test, the hypothesis that, the pupae stage of the wild silk moth *E.bauhiniae* in Sudan has contained highly nutrient components, suitable for human diet and can be contributed in food security in Sudan.

II. MATERIALS AND METHODS

The study was conducted in the area of Sennar State, Central Sudan, which lies between Latitude 12°.5, 14°.7 and longitude 32°.80-35°.42 N. Many experiments were conducted in the laboratory, determined nutrient contents of pupae (diapause) of the wild silk moth *Epiphora bauhiniaee* (Guerin Meneville).
In nutritional experiment, 45 healthy cocoons of *E.bauhiniae* were collected, from the culture in Singa area, in the period of January 2009 (Fig. 1).

Figure 1. Cocoons of *E.bauhiniae* collected for nutritional Experiment.

The cocoons were stored in a pot and sent to Gazira University, Faculty of Agricultural Sciences Department of Crop Protection laboratory, where they were studied used Gel filtration chromatography and segmentation equilibrium analysis, observation of nutrients component, of pupal tissue under laboratory conditions were examines, protein, fat, calcium, phosphorous, copper, magnesium, chromium and vitamin B to be designated on tissue of pupae of *E.bauhiniae*. The following methods were used in the Laboratory, determined each element.

Fat percentage

Extraction of oil was done used Soxhlet apparatus by the following steps: five grams of fresh pupa were twisted in a distillation paper and weighed, this called thimble which was placed in the extractive column. Funnel or a flask was weighed and data were recorded. An extractive solvent Hexane was added to the extract, the calculation of oil percentage was done, used the following steps: Thimble was transferred from oil extractive column and dried to 105 ° C in an oven (Plate 2) before placed in a discater and weighed. Percentage of oil was determined used the following formula:
Fat % = Weight of thimble before extraction (WTB) minus weight of thimble after extraction (WTA) over weight of original specimen (SPW) multiply by hundred. i. e.

$$\text{Fat \%} = \frac{\text{WTB} - \text{WTA} \times 100}{\text{SPW}}$$

used flask method also:

$$\text{Fat \%} = \frac{\text{Weight of flask (FW) + oil (O) – Flask weight (FW)}}{\text{Weight of specimen}}$$

And data were recorded.

Figure 2. An oven used in experiment

***Ash** Percentage*

Here we used Furnace apparatus, where five grams of fresh pupa was weighed and placed in a crucible which had taken its empty weight before. The sample was burned to 550 ℃ in furnace and apparatus for three hours at which the complete burning was finished and cooling was held before calculation of ash percentage in which the following formula was used:

Ash % = Weight of crucible and specimen before burning (WA) minus weight of crucible and specimen (SPW) multiply by hundred.

i.e.

$$\text{Ash \%} = \frac{WA - WB \times 100}{SPW}$$

Data were recorded.

Protein Percentage

One of fresh pupa was taken, added to one gram of digestive tablets compose of copper sulphate and potassium sulphate. Twenty five ml of sulphuric acid (conc.) was added in the funnel of kjeldahal apparatus (Fig. 3), the temperature was adjusted to 100 ° C for two hours, then the mixture was cooled and completed to 100 ml used distill water. Uric acid (2%) concentration was prepared in addition to saturate NaoH (40%).

Figure 3. Kjeldahal apparatus used for protein digestion

Distillation

In distillation apparatus (distillatory) which was completed a digestive apparatus. Five ml of the digestive specimen was added to 10 ml of recent prepared NaOH. Twenty five ml of boric acid was found in flask (75 ml capacity) was left till ammonia (NH_3) was distillated and observation was done for the color change. The color was changed from red to greenish black. When volume, reach 50 ml (1%) concentration by Sahaha. The calculation of protein percentage was obtained used the following equation:

$$\text{Protein \%} = \frac{\text{Volume of displaced acid} \times 0.0014 \times 6.25 \times 100}{\text{Original Volume of Specimen}}$$

6.25 = Windly constant.
Data were recorded.

The elements calcium (ca), magnesium (mg) and phosphorous (P) were determined in the laboratory as following:

$$\text{Calcium Percentage} = \frac{\text{mg / L} \times \text{molecular weight} \times 50\text{ml} \times 100}{106 \times \text{volume of specimen}}$$

$$\text{Magnesium (mg) \%} = \frac{\text{mg / L} \times \text{molecular weight} \times 50\text{ml} \times 100}{106 \times \text{volume of specimen}}$$

$$\text{Phosphorus (p) \%} = \frac{\text{mg / L} \times \text{molecular weight} \times 50\text{ml} \times 100}{106 \times \text{volume of specimen}}$$

Data were recorded.
Chromium (Cr) was determined in the pupa used Automatically Absorption apparatus, and data were recorded.

III. RESULTS AND DISCUSSION

The results of the study revealed that the wild silk moth *E.bauhiniae ś* paupae were contained highly nutritious component (Table 1) that expressed in the pupal tissue (Fig. 4 and Fig. 5). This in agreement with Longvah *et al* and Thingnganing *et al* [17,21].

Figure 4. Live Pupa of *E.bauhinia***e.**

Figure 5. Pupae of *E.bauhiniae* (fried) with high Nutritional value.

Where the most abundant nutrient was found to be fat (27%) and protein (11.2 %) followed by ash (1%), chromium see Calibration curve below (Fig. 6) mg (0.327%), phosphorous (0.3165 %) and calcium (0.08 %).

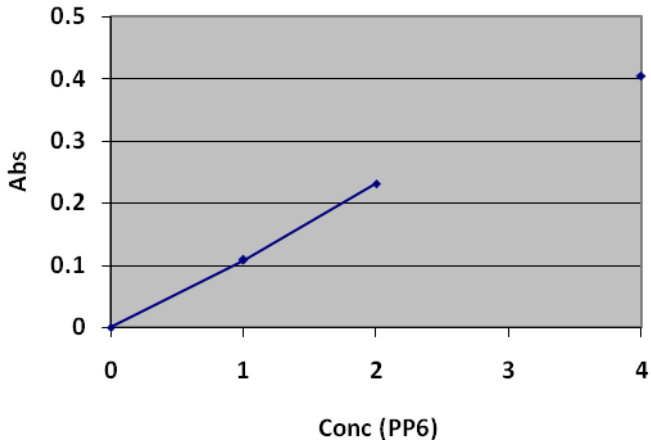
Table 1

Nutrient contents found in pupae tissues *Epiphora bauhinae*

Elements	Weight (mg)	Percentage (%)
Protein	1000.00	11.3700
Fat	5000.00	27.000
Phosphorous	12.66	0.4165
Calcium	4.00	0.0800
Magnesium	13.00	0.3720
Ash	5000.00	1.0000
Chromium	-	0.9968

The result confirmed that these nutrients are expressed in pupal stage of E.bauhiniae. These nutrients discovery from pupal stage of E.bauhiniae are important nutritious items or agents for human health and they would be a source specialized for production of protein. This result is in line with Banjjo *et al* [26] and in agreement with the result of Plant and Pandey [14] on insect *Antheraea mylitta* for producing protein and also agreed with the report of Gashe and Mpuchane [10] on emperor moth as a source of food (edible moth larvae). Plant and Pandey [14] also stated that protein is higher during pupal stage. Beside FAO [6] reported on Eri silkworm pupae that coincide with this result and coincided with that reported on edible insects in China by FAO [5] and withThingnganing et al, Longvah et al and GENE [21,17,2]. [22] reported about the need of human body, where the pupae of insect present quantitative protein, calcium, magnesium, phosphorus and fat which are important for cell growth beside other human health as stated by Anon, Sayed and Mader [19, 23, 25].This reflect the important of *E.bauhiniae* as indigenous insect that can be reared, for food production to contribute for both animal and human health.

The most essential nutrients, for human health, that stated by Sayed and Mader [23,25] were presented in pupal tissue of *E.bauhiniae*, according to this result, which can be candidate *E.bauhiniae* in Sudan, as a source of protein, that can be fed from silk moth pupal meal diets. This result is the first report describing an insect nutrient of *E.bauhiniae* in Sudan, in which there was no difference found, between this insect and other cultured insects, in term of nutrient contents and it will pave the way, for more investigation, perhaps investments, for producing nutriments (food) for local and export use.



Abs = 0.102186 conc. + 0.0067, r =0.9968

Figure 6. Calibration curve shows present of chromium (cr) in pupal tissue of *E.bauhiniae* silks moth

IV. CONCLUSIONS

Result of this study, confirmed the importance of the wild silk moth *E.bauhiniae* as a wild silk moth, for rearing, to produce food, as the result proved that, it has contained in pupal stage, essential nutrients component, which has a good contribution, of nutrients as silk moth pupal meal based diet indispensable for human health. This make it an important insect, for nutrient production, beside silk production in Sudan i.e. two revenues from the same source is possible, which will create new income for the farmers in the rural areas, perhaps to national income. The nutrient contents level, obtained generally are in agreement, with those reported by different authors investigating different insects, from several parts of the world. The outcome of this study authenticates the reality that insects are undoubtedly a good source of protein and other nutrients, particularly during the period of drought and hard times.

The nutritional and economic value, of edible insects is often ignored; efforts should be made to promote their collection and commercialization, given the benefits to the environment and human health. Research is considered necessary to ensure

further reliable supplies, through development of cost-effectively, workable methods of mass-rearing, edible species and development of more and better management programs for effectively harvesting wild populations.

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