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EVALUATING THE BIOLOGICAL CONVERSION OF PADDY HUSK TO HOUSE FLY, *MUSCA DOMESTICA* L (DIPTERA: MUSCIDAE) PUPA POWDER: A STUDY OF HOUSE FLY AS ANIMAL FEED

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ABSTRACT

The sector of livestock and aquaculture are growing rapidly in order to meet the incremental demand of essential protein for the world's population. However, the supply of plant-based animal feed was limited by resources such as land and water. The opportunity for insect as the substitute to animal feed is tremendous; nonetheless, little attention was taken in Malaysia. In this study, low value bio-waste, paddy husks, which were in pellet form were prior ground and dried, then fed to larva of common house fly, *Musca domestica* L (Diptera: Muscidae).

House fly pupae were collected, dried and ground into powder for analysis. Weight-conversion and nutrition value were studied by applying standard AOAC and FAO methods. The paddy husk to pupa weight conversion was 4.10%, in other words, 41g housefly pupae powder could obtained from 1kg of paddy husk. For the nutritional analysis, house fly pupae powder consists of 68.90% crude protein, which was significantly higher that the paddy husk (15.65% crude protein, <0.001). This study indicating a significant conversion of a low value material to highly protein contained animal feed and this transformation was crucial in providing an alternative solution for animal feed.

Keywords: Paddy husk, *Musca domestica* L pupae, bio-conversion

ABSTRAK

Sektor ternakan dan akuakultur semakin berkembang pesat untuk menampung tuntutan keperluan protein masyarakat global. Namunbegitu, bekalan makanan tumbuhan untuk haiwan terhad dengan sumber-sumber alam seperti tanah dan air. Peluang untuk serangga diganti sebagai makanan haiwan adalah tinggi tetapi kurang mendapat perhatian di Malaysia. Oleh sebab itu, kajian ini melibatkan penggunaan pellet sekam padi yang kering, dan merupakan bahan buangan biologi digunakan sebagai makanan untuk larva lalat rumah, *Musca domestica* L (Diptera: Muscidae). Pupa lalat rumah dikumpul, dikering dan dihancurkan menjadi serbuk untuk tujuan analisis. Nilai penukaran berat dan nutrisi dikaji dengan menggunakan kaedah AOAC dan FAO. Nilai penukaran berat sekam padi kepada pupa adalahsebanyak 4.10% dimana, 41g serbuk pupa lalat rumah boleh diperoleh daripada 1 kg sekam padi. Analisis nutirisi membuktikan serbuk pupa lalat rumah memiliki 68.90% protein mentah yang lebih tinggi berbanding sekam padi (15.65% protein mentah, <0.001). Kajian ini membuktikan penukaran bahan kurang bernilai dengan kadar protein yang tinggi sebagai sumber makanan haiwan adalah penting dan transformasi ini penting sebagai alternatif sumber makanan haiwan.

Kata kunci: sekam padi, pupa *Musca domestica* L, penukaran biologi.

INTRODUCTION

Food security has received much attention in recent years due to the limited resources. The world's population is expected to grow about 35 percent, from 7 billion currently, to 9 billion by 2050. However, to feed that population, crop productions mainly for the animal-feed, have to increase in double. The reason for the unparalleled growth is because of the developing countries will be grown prosperous enough to consume more meat (Tilman, 2002). One of the solutions that able to solve the problem of plant-based animal feed supply, while simultaneously reducing the environmental pollution is insect, which can be processed into animal-feed (van Huis et al., 2013). The common housefly (*Musca domestica* L) is very nourishing, especially in protein content (Veldkamp et al., 2012). It is potentially processed into animal-feed and substituted the typical materials such as soybean and corn, which have exhausted and polluted the clean water and soil. Nevertheless, the information about the bio-conversion of bio-waste to housefly weight and the nutritional conversion statutes is little in Malaysia. Therefore, the bio-weight (gram) conversion of a common bio-waste in Malaysia, paddy husk, to housefly pupae was studied in this experiment.

MATERIALS AND METHODS

Rearing of insect

The WHO/VCRU strain of the house fly was used in the laboratory testing. The populations are reared at 25 ± 3°C and 67 ± 5% relative humidity with an 8:16 hour (light: dark) photoperiod in Lab 312 at the School of Biological Sciences of University Science Malaysia. Fresh eggs were collected by using a Petri dish that filled with a thin layer of moist paddy husk powder. Red-brownish pupae (1-2 days after pupa formation) were collected for the testing.

Weight-conversation study

The conversion study was a modified version of Cickova et al. (2012), which has converted organic manures into house fly pupa. Paddy husk pellets were prior ground and dried in an oven at 105 ºC to remove and at the same time studied the moisture content. Next, 20 housefly eggs were placed on 20 gram of dried paddy husk powder in a 50 ml container and 10 ml of distilled water has sprayed on the powder in order to create a moist environment for the larva. After around 1 week, the upper layer of the husk powder was drier than the bottom part, and pupation would be occurred at the upper layer. The pupa were collected, dried and ground into powder for mass and nutritional study. The remain of paddy husks were again been dried, ground and the weight loss was measured by an electrical balance. Later, the remain was wetted and introducing again the house fly eggs, the pupa were collected and re-drying again the remains for its weight loss. The procedures were repeated until significant or no pupa has been generated.

Nutrition analysis

The paddy husk and housefly pupae powder were analyzed by standard proximate analysis (AOAC, 2000) with slight modification. For moisture, approximately 2.00 g of the samples were weighted in an electrical balance before and after drying in an oven. The moisture was indicated by the differences of mass and it was converted into percentages. The dried samples were projected into protein analysis by using the Kjeldahl method, which prior digested approximately 0.10 g sample with concentrated sulfuric acid and catalyst in a Kjeldahl flask. The products were later cooled down at room temperature and sodium hydroxide was added into the flask. The flask was subjected to the distillation connection unit and the distillate was mixed with the boric acid and a few drops of methyl red. The distillate mixture was titrated with 0.40% hydrochloric acid and calculates the protein in percentage. Determination of lipid content was performed following Soxtec method described by AOAC (2000). Food samples were weighted approximately 0.20 g and the solvent petroleum ether was used for the extraction. First, the mixture was homogenized by using ultrasonic homogenizer and filtered by the Buchner funnel. The filtrate was transferred to a separating funnel and shaken with 20ml of distilled water. The mixture was allowed to settle down overnight and the ether part was removed and dried in the oven at 60°C for 8 hours. The residue weight was the lipid and was expressed in the percentage. For the ash content, dry ashing method was used to determine the content. The samples were put in a pre-weighted ceramic cup and incinerated in a furnace.

The inorganic material was cooled and weighed, and the ash content was expressed in percentage. The total carbohydrate content in the samples was calculated by difference method. The food's constituents (protein, fat, water, ash) were determined individually, summed and subtracted from the total weight of the food. This is referred as the total carbohydrate by difference and it should be clear that carbohydrate estimated in this method included fibers (Nanteil, 1999).

Statistical analysis

The weight conversion was calculated by divided the average pupa weight to the average weight loss of paddy husk. The nutritional contents were expressed in percentage and the value will be prior transformed by arcsine transformation and compared their variances by one-way ANOVA in SPSS 17.0. The tests were evaluated at a significance level of $\alpha = 0.001$.

RESULTS AND DISCUSSION

Pupae was preferred as the stages in this study because of its higher biomass content, in contrast to the adult (El Boushy, 1991) as the biomass of housefly is reducing when growing from larva to adult, this mainly due to the formation of chitinous exoskeleton (Papp, 1974). The percentage of weight-conversion, initial paddy husk's weight, larval survival rate and total housefly pupae weight were presented in Table 1.A total of 0.51g of housefly pupae powder was formed from an average of 12.66 g paddy husk, this showed as much as 4.10±0.08% weight conversion. The result was parallel to Cickova et al. (2012), which processed pig manures to housefly pupae and the conversion rate was 7.43% in maximum. Moreover, Sheppard et al. (1999) also demonstrated the uses of common housefly and black soldier fly in the turning of manures to nutrition feedstuff for poultry and the conversion percentage was 8.0% in maximum. As suggested by Papp (1974) the conversion of waste to housefly pupae may max in 10%. The lower percentage in this study might due to the different testing feed for the house fly and the mishandling of paddy husk and pupae powder, as the light-weight powder could be blow by air current.

For the nutritional evaluation, three essential classes (Protein, Carbohydrate and Fat) were compared. As can be seen in Table 2 and Figure 1, house fly pupae powder consist of significantly higher protein content (68.90±1.05%, $p < 0.001$) than paddy husk (15.65±0.72%). In contrast, paddy husk was having significantly higher amounts of carbohydrate (53.83%, including the fiber) compared to house fly pupae (9.61±0.69%). For the fat content, both paddy husk and house fly pupae contained not significantly content. The low protein content of paddy husk also reviewed in the research of Chumpawadee et al (2007) that apply paddy husk as the feed for ruminant. Also, the crude protein of housefly pupae in this research was agreed to the researches of Calvert & Martin (1969), Sheppard et al. (1999) and van Huis et al. (2013), which had also analysis protein content of housefly pupae and the result was in the range of 45-68%. The survival rate (73.00±5.63) for the present study is parallel as the research of Cickova et al. (2012) that processed the organic matter for housefly culture. The remaining weight of paddy husk was consisting an average of 5.95±1.24g was mostly composed of inorganic matter and difficult digested fiber, as suggested byCickova et al. (2012).

Paddy husk composed of 21.33% of paddy weight and it was usually waste material from the milling process in Malaysia (Hashim et al., 1996). Malaysia produced around 2.5 billion kg of paddy in 2010 (Department of Agriculture Malaysia, 2014), this indicated 0.5 billion kg of paddy husk may be generated. According to this study, the weight-conversion was 4.10%; these paddy husks might turn into approximately 20.5 million kg of house fly pupae, which will be large resources for animal-feed. In additional, the route for the animal feed production had been largely influenced by the green revolution in 1940s, in which synthetic fertilizer had been invented (Figure 2). Nevertheless, the chemicals that used as the fertilizer contained heavy metal that will pollute the environment then organic waste or biosolid were considered a more sustainable approach as fertilizer for crop plantation (EPA, 1994). By using house fly as bio-converter, bio-wastes such as paddy husk and biosolid could be transformed into higher value animal feed with fewer trophic levels, and thus reducing energy wasting.

CONCLUSIONS

In this study, low value paddy husk was converted to high protein content house fly pupae and the weight-conversion had been studied. Although other aspect (animal digestibility or availability) have to consider before the house fly pupa processed as animal feed, nevertheless, the biodegradation ability of house fly larva to bio-waste for examples manures, compost and agriculture waste will soon grow and become a trend for the solution for animal feed shortage and waste management.

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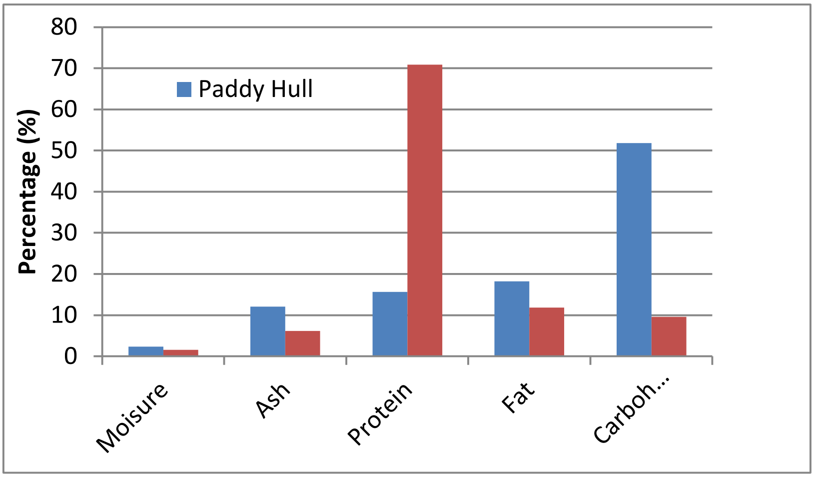

Figure 1. Comparison Nutrition Content between Paddy Husk and Housefly Pupae Powder.

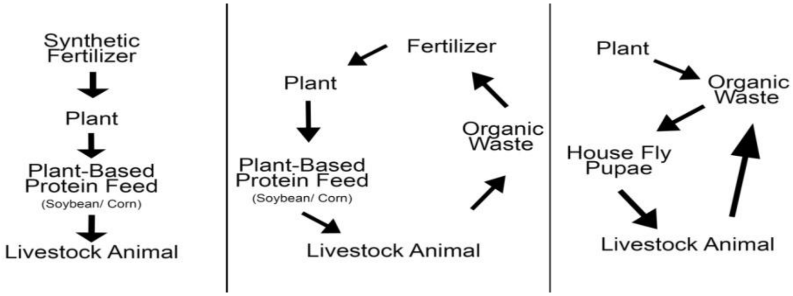

Figure 2. Left: Green revolution that bloom the crop production for animal feed, Middle: Sustainable route to produce animal feed (EPA, 1994), Right: A suggested sustainable route that used house flies pupae as a bio-converter.

Table 1. The mean value of the remaining weight of paddy husk, percentage of weight-conversion and total pupa weight generated.

Initial weight (gram)	Mean values for Remain weight (gram) ± S.E.	Mean percentage of weight-conversion (%)± S.E.*	Larval survival rate (%)± S.E. **	Total Housefly pupa weight (gram)
20	7.34±0.17	4.10±0.08	73.00±5.63	0.52

n=5,

S.E. Standard error

*The mean value was based on 18 times of the bio - conversion

**Percentage of larval survival rate was based on the larvae hatch (total eggs=360)

Table 2. Nutrition content of paddy husk and housefly pupae powder

	Content±S.E. (%)				
	Moisture	Ash	Protein	Fat	Carbohydrate (Including fiber)
Paddy husk	2.31±0.33	12.05±0.33	15.65±0.72	16.22± 1.63ns	53.83±0.78**
Housefly pupa powder	1.54±0.20	6.15±0.26	68.90±1.05**	13.80± 0.65ns	9.61±0.69

n=5, **significant level at P < 0.001

S.E. Standard error

ns not significant