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Original Research Article

Black Soldier Fly Larvae as Alternative to Conventional Animal Feed: An Islamic and Science Perspective

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Abstract: The black soldier fly (BSF), *Hermetia illucens* Linnaeus, is a worthwhile insect genus whose larvae have shown promise for sustainable animal feed because of their economical and premium protein. Concerns arise among Muslims about whether the usage of black soldier fly larvae (BSFL) as animal feed is permissible by Shariah because *hasyarat* (insect) consumption, excluding grasshoppers, is forbidden based on the majority of Islamic scholars. This study examined the Halal status of animals fed with BSFL, investigated the benefits of BSFL in industrial farming, and analyzed the *Maqasid al-Shariah* view on the usage of BSFL as animal feed. Library research and document analysis were applied as qualitative methods. The study shows that BSFL has approximately a dry matter of 40% protein and 30% fat, no significant upshot in egg odour produced by hens fed with BSFL, and the whole nutritional exchange of fish meal with BSFL has no negative effects on the physicochemical merit of Atlantic salmon. The study concludes that if animals fed with BSFL are not affected in terms of the odour, colour, and taste of *najs* (impurity), then the animals are not categorized as *Jallalah* (contaminated) animals. Hence, the usage of BSFL as animal feed is permissible (Halal) and is classified as *Tahsiniyyat* (luxuries) based on *Maqasid al-Shariah*.

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1. Introduction

In today's world, the unique strategy of bio-waste conversion and sustainable animal feed employing black soldier fly larvae (BSFL) has been raging within the industrial agriculture. *Hermetia illucens* L., the black soldier fly (BSF), belongs to the dipteran family *Stratiomyidae* (Dortmans *et al.*, 2017). Turning organic waste quicker than worms used in worm castings is one of the skills obtained by BSFL (Rindhe *et al.*, 2019).

Furthermore, because it is high in essential amino acids, minerals, and vitamins, BSFL is a promising alternative to fish meal (FM) (Tippayadara *et al.*, 2021). Al-Nawawi (n.d.) mentioned in his book, *al-Majmu' Syarh al-Muhadhdhab*, that the consumption of *hasyarat* (insect) is prohibited as it falls under the category of disgusting (*khabaith*) things (except for the insect which Islam had permitted, such as the grasshopper), as Allah the Almighty says in the al-Quran: "*Those who follow the Messenger, the unlettered prophet, whom they find written in what they have of the Torah and the Gospel, who enjoins upon them what is right and forbids them what is wrong and makes lawful for them the good things and prohibits for them the evil*" (al-Quran, 7: 157). Moreover, the BSFL diet is rich in protein content and amino acids, as well as low amounts of crude fat and dry matter (Al-Qazzaz *et al.*, 2016), and the whole nutritional exchange of fish meal with BSFL has no negative effects on the physicochemical merit of Atlantic salmon (Bruni *et al.*, 2019). This study aims to examine the Halal status of animals fed with BSFL, investigate the benefits of BSFL in industrial farming, and analyze the *Maqasid al-Shariah* view on the usage of BSFL as animal feed. Library research and document analysis were applied as qualitative methods. This study concludes that if animals fed with BSFL are not affected in terms of the odour, colour, and taste of *najs* (impurity), then the animals are not categorized as *Jallalah* (contaminated) animals. Hence, the usage of BSFL as animal feed is permissible (Halal) and is classified as *Tahsiniyyat* (luxuries) based on *Maqasid al-Shariah*.

2. Materials and Methods

Firstly, the data were collected using library research from both antecedent and contemporary evidences from scientists, Muslim jurists, and some other researchers from Shariah and science backgrounds. Secondly, document analysis was applied as the data analysis method, wherein it consists of analyzing various types of documents including books, academic journal articles, as well as industry and institutional reports (Morgan, 2022). In this study, the researchers utilized various text and photograph sources from scientists about the life cycle of black soldier fly (BSF), physicochemical properties of Atlantic salmon that were fed with black soldier fly larvae (BSFL), and the protein contents of a BSFL diet. The researchers

utilized a *fatwa* (legal ruling given by a qualified jurist) from the Indonesian Ulama Council (MUI) concerning the usage of BSFL as animal feed. The researchers collected and analyzed data from Qur'anic text, scientific reports, books, academic journal articles, *fatwa*, and the Malaysian Standard MS 2208:2009 Animal Feeding Stuffs - Code of Practice. The results have been displayed in figure models.

3. Results and Discussions

3.1. Black Soldier Fly (BSF) Life Cycle

The egg initiates the BSF life cycle while simultaneously signalling the end of the previous life phase: a fly laying a cluster of eggs, in which the female lays a package of 400 to 800 eggs close to decaying organic debris, into a tiny, dry, sheltered cavity (Dortmans *et al.*, 2017). Approximately one kg of household food waste may be consumed by a colony of 2000 larvae daily (Rindhe *et al.*, 2019). BSFL are strong, resilient organisms with the capacity to expand their life cycle under adverse circumstances, and the larval phase is the only phase in which the BSF feeds (Dortmans *et al.*, 2017). Georgescu *et al.* (2020) discovered that the prepupal phase lasted about 21 days for all weight categories, and when the larvae transit into a prepupa, it reinstates its mouthpart with a hook-shaped structure and changes colour from dark brown to charcoal grey (Dortmans *et al.*, 2017).

The pupation phase follows; it begins when the prepupa notices a suitable place and becomes immobile and rigid, and it is preferable when the environmental conditions stay warm, dry, and shaded (Dortmans *et al.*, 2017). During this stage, the insects are neither moving nor eating for at least eight days (Da Silva & Hesselberg, 2019). The pupation takes approximately two to three weeks and finishes when the fly emerges from its pupa shell, where it takes the fly less than five minutes to break apart the area of the pupa that used to be the head section, crawl out, dry, and then spread its wings and fly off (Dortmans *et al.*, 2017). The adult does not ruin crops, contaminate the environment, spread illness, or invade houses or outlets, but rather lives away from humans, maturing, and mating predominantly (Liu *et al.*, 2019). The adult lives for approximately a week and eats on nothing but water or stays in a humid area to keep hydrated, and it will look for a mate, copulate, and deposit eggs (Dortmans *et al.*, 2017), and the females die shortly after ovipositing (Da Silva & Hesselberg, 2019).

3.2. Black Soldier Fly (BSF) for Organic Waste Treatment: A Green Technology for Sustainable Future

Black soldier fly larvae (BSFL) and house fly larvae (HFL) had the average waste reduction rates of 96.05 % and 94.22% respectively (Dzepe *et al.*, 2021). Nyakeri *et al.* (2019) found a bioconversion rate of 22.30% in human manure, while Joly (2018) found a bioconversion rate of 20.73 % in kitchen waste. The values differ based on the type of waste stream handled and the amount of water content in it (Dzepe *et al.*, 2021). Gligorescu *et al.* (2020) observed that during the 14 months of pilot scale production, 190 kg of dry matter from food waste was bioconverted into about 79 kg of dry matter BSFL.

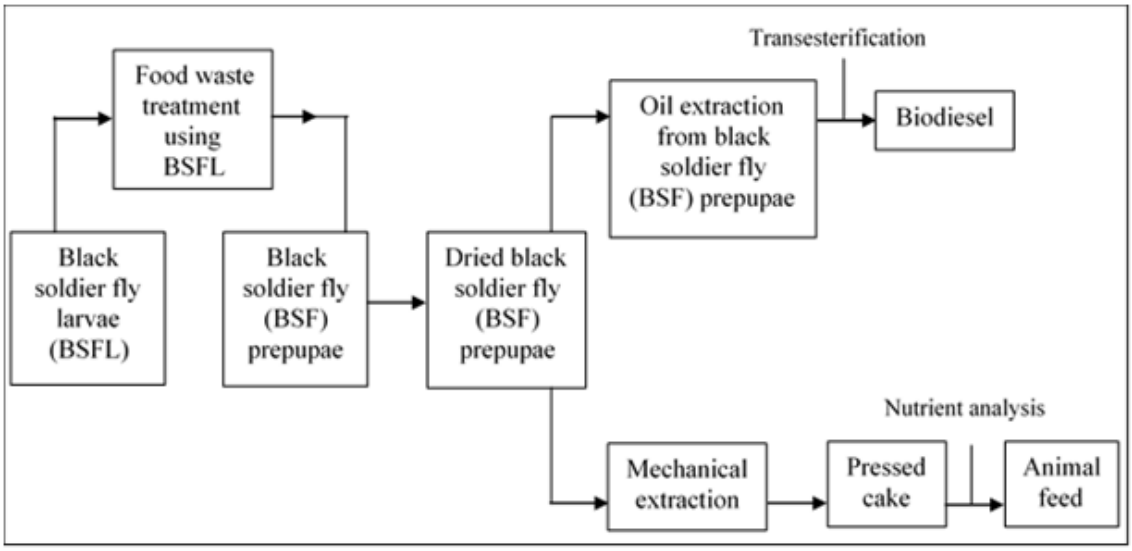

Figure 1. The process of treating food waste with black soldier fly larvae (BSFL) and producing animal feed and biodiesel from black soldier fly (BSF) (*Hermetia illucens* L.) (Kim *et al.*, 2021).

Utilising their strong mouth parts and powerful digestive enzymes, BSFL successfully degrade organic wastes (Cho *et al.*, 2020; Pastor *et al*., 2015). When treating waste of animal origin, feeding waste to larvae has been found to deactivate illness-transmitting bacteria, such as *Salmonella* spp. (Rindhe *et al.*, 2019). Fruits and vegetables are ideal substrates for BSFL, and BSFL fed with a variety of fruits and vegetables had the highest larval survival rate, pupa mass, adult emergence rate, and protein composition when compared to BSFL that were only given a single fruit or vegetable (Jucker *et al.*, 2017). The survival rates of BSFL when fed with food waste, fruits and vegetables, and poultry feed were 87%, 90%, and 93%, respectively; meanwhile, the survival rate of BSFL fed with digested sludge was as low as 39% (Lalander *et al.*, 2019). Figure 1 depicts the process of treating food waste with BSFL and producing animal feed and biodiesel from BSF (*Hermetia illucens* L.).

3.3. Fatwa Concerning Black Soldier Fly Larvae (BSFL)

As of now, there is only one *fatwa* pertaining to the usage of black soldier fly larvae (BSFL) as animal feed, wherein the Indonesian Ulama Council (MUI) had convened on 15th of May 2019 and had agreed that the larva of black soldier fly (*Hermetia illucens*) is categorized as *hasyarat* (insect) species. MUI had agreed that the consumption of *hasyarat* (insect) is impermissible, thus black soldier fly larvae (BSFL) is impermissible for human consumption, nonetheless cultivating black soldier fly larvae (BSFL) for their benefits, for instance as animal feed, is permissible (lawful) (Indonesian Ulama Council, 2019).

3.4. The Usage of Black Soldier Fly Larvae (BSFL) in Industry: A Sustainable Source for Animal Feed from Islamic and Science Perspectives

The high cost of fish meal prompted an exploration of an alternate protein feed; in the meantime, insects are a natural food supply for poultry, and BSFL have been discovered to be plentiful in most regions of Malaysia (Al-Qazzaz *et al.*, 2016). In BSFL, no trace of aflatoxin, as well as three vitamins (i.e. Gamma tocopherol, Alpha tocopherol and Provitamin D3) and eleven fatty acids were detected (Shumo *et al.*, 2019).

BSFL had a greater manganese, iron, zinc, copper, calcium, and phosphorus compound in comparison to that in other insect larvae that were discovered, and a greater calcium compound than fish meal (Makkar *et al.*, 2014). In addition, 54 village chickens of the Arabian strain at nine months old were utilized for the experiment, which comprised a baseline diet supplemented with BSFL, and remarkably, the greatest hen day egg production was when the hens' meals included BSFL at 50 g/kg (Al-Qazzaz *et al.*, 2016). Aside from that, the dietary treatment influenced egg yolk colour, with eggs laid by hens fed BSFL at 50 g/kg being significantly brighter than those fed the basal diet and BSFL at 10 g/kg, which could be because BSFL contain carotene or xanthophyllous pigments required for egg colouration development (Al-Qazzaz *et al.*, 2016). Bruni *et al.* (2019) observed that replacing fish meal in salmon diets with BSFL had no effect on colour, pH, or texture of the flesh. Cullere *et al.* (2018) discovered that when comparing the flavour and meat quality of livestock given conventional and BSFL diet, the distinction in the flavour, odour, and texture was not statistically significant. Substituting BSFL for fish meal, either partially or completely, does not damage the physical, chemical, or volatile content of Atlantic salmon flesh (*Salmo salar* L.) (Bruni *et al.*, 2019).

Furthermore, there is no significant distinction observed by the trained panel, with the exception of salmon fed with BSFL meal as a total replacement of fish meal, resulting in a

softer texture when raw and a noticeable rancid odour when baked compared to salmon fed with the control fish meal (Belghit *et al.*, 2019). It is also discovered that 0%, 33%, 66%, and 100% of fish meal substitutedwith BSFL meal appeared acceptable with 83%, 78%, 73%, and 78% of consumers saying they will consume the fish again for the respective BSFL-based dietary treatment (Bruni *et al.*, 2019).

The Code of Practice on Good Animal Feeding of the Codex Alimentarius Commission describes feed as "animal feedstuffs, ingredients, additives, and supplements given to the animals" (Codex Alimentarius Commission, 2008), whereas Malaysian Standard MS 2208:2009 Animal Feeding Stuffs - Code of Practice defines animal feed as "any single or multiple materials whether processed, semi-processed or raw, which is intended to be fed to animals" (Department of Standards Malaysia, 2009). One of the nine essential criteria for Halal land animals as food, according to the Malaysian Standard MS 1500:2019, is the source of Halal animal feed (Department of Standards Malaysia, 2019).

Basically, animals that are fed filth (*najs*) are referred to as *Jallalah* (contaminated) animals (Qal'ahji, 1996). *Jallalah* (contaminated) is described as an animal that has consumed filth (*najs*) or impurity and because of this eating habit, it produces an unpleasant odour, which is considered as the reason for the prohibition of consumption (Jamaludin *et al.*, 2014). On the other hand, if animals are fed filthy (*najs*) things inconsistently, they are not referred to as *Jallalah* (contaminated) animals (Jamaludin *et al.*, 2014) because it did not cause any unpleasant change in the egg or meat of the animals. Al-Nawawi (n.d.) mentioned in his book, *al-Majmu' Syarh al-Muhadhdhab*, that the consumption of *hasyarat* (insect) is prohibited as it falls under the category of disgusting (*khabaith*) thing (except for the insect which Islam had permitted, such as the grasshopper), as Allah the Almighty says: *"Those who follow the Messenger, the unlettered prophet, whom they find written in what they have of the Torah and the Gospel, who enjoins upon them what is right and forbids them what is wrong and makes lawful for them the good things and prohibits for them the evil"*, (al-Quran, 7: 157). As long as there is no sign of impurity (*najs*), in terms of the odour, colour, and taste of the egg or meat of the livestock, where Shariah forbids, when giving BSFL to the livestock as feed, then the livestock is not categorized as *Jallalah* (contaminated) animal.

Conventional classifications of *Maqasid al-Shariah* split them into three divergent hierarchies, which are necessities (*Daruriyyat*), needs (*Hajiyyat*), and luxuries (*Tahsiniyyat*), where necessities (*Daruriyyat*) are further categorized into what conserve one's faith, soul, mind, lineage, and wealth (Auda, 2008), and if the stage of necessities (*Daruriyyat*) is not

being conserved, the safety of human both in the world and hereafter will be jeopardized, while needs (*Hajiyyat*) were considered less crucial for human life, but if it is not being conserved, it will not bring a safety menace, instead human will encounter some hardships (Al-Arif, 2020), whereas luxuries (*Tahsiniyyat*), are beautifying purposes (Auda, 2008) and to choose what is pertinent along with the best practice and culture, in which it will neither jeopardize nor imperil the existence of any, or give rise to hardships if it is not being preserved (La Jamaa, 2011). Al-Raysuni (1995) describes *Maqasid al-Shariah* as the intents earmarked by Shariah to secure public interest (*maslahah*) or welfare of mankind.

Additionally, it has been reported that BSFL have approximately 40% protein and 30% fat (Barragan-Fonseca *et al*., 2017) and earned a substantial scrutiny for the treatment of food waste (Kim *et al.*, 2021), and hence these are in line with the concept of *maslahah* (interest) designated within the scope of *Maqasid al-Shariah*. Future research may also focus on other approaches, particularly on laboratory works to establish a thorough clarification pertaining to the points of debates. Figure 2 depicts the usage of BSFL as animal feed in industrial farming from Islamic and science perspectives.

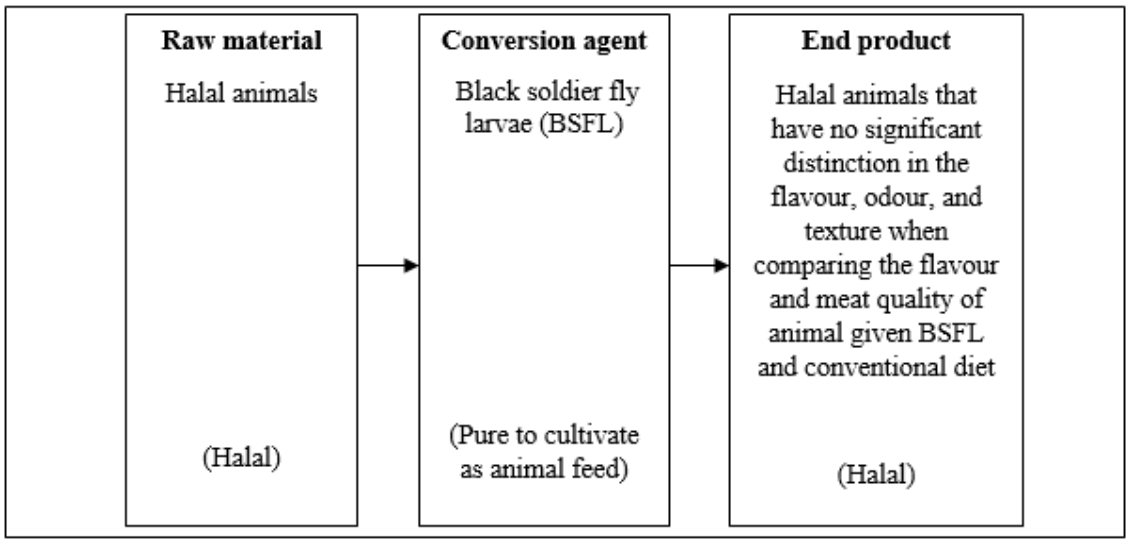

Figure 2. The usage of black soldier fly larvae (BSFL) as animal feed in industrial farming from Islamic and science perspectives.

4. Conclusions

Study shows that BSFL have approximately a dry matter of 40% protein and 30% fat, no significant upshot in egg odour produced by hens fed with BSFL, and the whole nutritional exchange of fish meal with BSFL has no negative effects on physicochemical merit of Atlantic salmon. This study concludes that if animals fed with BSFL are not affected in terms

of the odour, colour, and taste of *najs* (impurity), then the animals are not categorized as *Jallalah* (contaminated) animals, hence the usage of BSFL as animal feed is permissible (Halal) and is classified as *Tahsiniyyat* (luxuries) based on *Maqasid al-Shariah*.

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