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# Black Soldier Fly (BSF) Used as Poultry Feed and its Nutritive Value Analysis: A Review of Article

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**Abstract:**
Poultry creates direct and indirect employment opportunity to people. We know that every farm owner wants that "lesser investment, greater profit ". More than 50% of total cost of poultry rearing has to pay in feedstuff. Among all feed ingredients protein sources are higher in price, and not only is that protein the vital element for growth and production. But this high price can't bear by this small scale farmer. For this reason, Nowadays scientists are try to replace the protein source via the use of black soldier fly in their ration. In this review paper we discussed about the beneficial effect of using Black soldier fly larvae, oil or powder that are shown in the research paper of scientists . From our analysis we can show in this era a large number of peoples are involved in poultry they replaced their ration formulation with Black soldier fly as a source of protein and meet up the demand of protein requirement. Black soldier fly larva, powder, oil directly affect poultry performance growth, and production. In case of broiler chicken these replacements increase their FCR rate and in case of laying chicken quality and quantity of eggs also increases. Apart of all scientists are shown that for cultivation of black soldier fly, people can use poultry manure, sheep- goat faces thus wastage management are also occurred . Rearing method and investment on Black soldier fly than other protein ingredients is quite less. We may hope to have a world in which people arebelieved and practice that substation of protein source.

**Keywords:** Black Soldier Fly, Nutritive value, Amino acid, growth performance

## 1. Introduction:

Increasing population of human beings, changing dietary patterns, and increasing rivalry between food and feed production highlight the urgent need for the exploration of new sustainable food production chains. The poultry industry has been more popular with others,having superior environmental and economic benefits which require innovation and refinement along the value chain to increase further sustainability(Ahmed et al.,2022). The global food production system is facing challenges due to the ever-growing population in the world. According to the Food and Agriculture Organizations of the United Nations (FAO), with the exponential growth of the global population, it is expected to reach the threshold of 9 billion people by 2050 (FAO,2018) This will result in a greater need for food, especially for animal protein sources such as cattle,poultry and fish. In addition, the FAO has foreseen that global meat production and consumption will double by 2050 compared to 2000 (Migietta et al.,2024)Insects such as Hermetia illucens, commonly known as black soldier fly (BSF) can be a promising alternative protein-rich food due to its high protein content as compared to livestock (Boccazzi et al.,2017)] Black soldier fly larvae (BSFL) is regarded as a great potential in the feed sector whereby insect-meal could substitute in part fish-meal and soybean-meal as a protein source in the animal and aquaculture feed industry (Nguyen et al.,2015)]The BSFL can consume a wide range of biowaste, such as fruits and vegetable waste,kitchen waste, abattoir waste and animal manure, which will directly affect the nutritional value of the black soldier fly pupae (BSFP).(Miglietta et al.,2015). Nutritive value of black soldier fly higher that other protein source. For example, soybean meal as a protein source is one of the most frequently used ingredients in feed formulations for poultry. However, in recent years,the high price of this ingredient has become a serious issue for the economic sustainability of poultry production, particularly in developing countries . In short, the rapid decrease of areas suitable for agricultural production present a serious global challenge , which is different from anything we have faced before. These new challenges require revolutionary solutions to cope adequately in the pursuit to find the way towards sustainability of global food production (Makker et al.,2014) as much as possible. However, the competition for food and fuel at the same time for the same resources may exacerbate the situation. Under these conditions, the investigation for alternative feed resources is a must (Nguyen et al.,2015)].There is a growing amount of literature and experts that recognize that using insect meals in feed formulation could be a novel way to improve feed and food security (Makker et al.,2014) Nowadays the demand of this substitutional protein is higher because of its Nutritive value. The black soldier fly have 50% protein on their dry matterprotein.Protein is a vital nutrient for poultry and all other classes of animals. In virtue of its amino acid constituents,protein plays a significant role in growth, egg production, immunity, adaptation to the environment, and in many other biological functions.The rationing of feeds for protein should, therefore, be manipulated in such a way that ‘optimal’ rather than ‘maximum’performance is achieved without too much feed expenditure. The best way to explain this point is by a practical example of alayer feed with 16% or 17% protein. In corn-soybean diets, this difference can be created by adding 3% more of soybean containing 44% crude protein.(Tschirner et al.,2015).Furthermore, BSF larvae could Be used for recycling of various agricultural by-products Like coffee pulp (Lardé, 1990), manure (Newton et al., 2005) and palm kernel meal (Hem et al., 2008) or organic waste materials like market waste, municipal organic waste or Dewatered faecal sludge (Diener et al., 2011). However,Tomberlin et al.,(2002) observe that the development and various life-history traits of BSF are highly depend on the growing substrates used. The increase of annual organic wastes generated worldwide has become a major problem for many countries since the mismanagement could bring about negative effects on the environment besides,being costly for an innocuous disposal. Recently, insect larvae have been investigated to valorize organic wastes. This entomoremediation approach is rising from the ability of the Insect larvae to convertorganic wastes into its biomass via assimilation process as catapulted by the natural demand to complete its lifecycle. Among the insect species, black soldier fly or Hermetia illucens iswidely researched since the larvae can grow in various environments while being saprophagous in nature. Even though black soldier fly larvae (BSFL) can ingest various decay materials, some organic wastes such as sewage sludge or lignocellulosic wastes such as waste coconut endosperm are destitute of decent nutrients that could retard the BSFL growth. Hence, blending with nutrient-rich low-cost substrates such as palm kernel expeller, soybean curd residue, etc. Is employed to fortify the nutritional contents oflarval feeding substrates prior to administering to the BSFL. Alternatively, microbial fermentation can be adopted to breakdown the lignocellulosic wastes, exuding essential nutrients for growing BSFL. Upon reaching maturity, the BSFL can be harvested to serve as the protein and lipid feedstock. The larval protein can be made into insect meal for farmed animals, whilst the lipid source could be extracted andtransesterified into larval biodiesel to cushion the global energy demands..(Ratchaprapa et al.,2020).Biodiesel is a renewable and environmentally friendly liquid fuel.However, the feedstock, predominantly crop oil, is a limited and expensive food resource which prevents large scale application of biodiesel. Development of non-food feedstocks are therefore,needed to fully utilize biodiesel's potential. In this study, the larvae of a high fat containing insect, blacksoldier fly (Hermetia illucens) (BSFL), was evaluated for biodiesel production. Specifically, the BSFL was grown on organic wastes for 10 days and used for crude fat extraction by petroleum ether. The extracted crude fat was then converted into biodiesel by acid-catalyzed (1% $H2SO4$) esterification and alkaline-catalyzed (0.8% NaOH) transesterification, resulting in 35.5 g, 57.8 g and 91.4 g of biodiesel being produced from 1000 BSFL growing on 1 kg of cattle manure, pig manure and chicken manure, respectively. The major ester components of the resulting biodiesel were lauric acid methyl ester (35.5%), oleinic acid methyl ester (23.6%) and palmitic acid methyl ester (14.8%). Fuel properties of the BSFL fat-based biodiesel, such as density (885 kg/m3), viscosity (5.8 mm2/s), ester content (97.2%), flashpoint (123 °C), and cetane number (53) were comparable to those of rapeseed-oil-based biodiesel (Li et al.,2011). Due to the high protein and fat content,Wang and Shelomi (2017) suggested the use the BSFL could be used as a human food, but mainly saw the potential use as a feed for animals. Therefore, BSFL composting systems can be used to convert various waste streams into larval biomass, with the potential use as a feed product for animals. Even though the BSF in many aspects is distinctly different from conventional agricultural animals, it is still considered as a production animal in the legislation of the European Union (Čičková et al., 2015).Black soldier fly (Hermetia illucens) larvae have the potential to replace commercial poultry feed in the diet of poultry.BSFL reported as the high protein content compared to other insects protein, not only this it's also contain the higher amount of amino acid and fatty acid.

**Review**

**2.1 General information about Black Soldier Fly :**

The black soldier fly (BSF), Hermetia illucens Linnaeus, is a large Stratiomyidae fly (13-20 mm size) found worldwide. Naturally, the BSF can be found all over South America and Asia, but is native to Colombia. They are generally considered a beneficial insect and non-pest. The adult fly does not have mouthparts, stingers, or digestive organs; thus, they do not bite or sting and do not feed during its short lifespan. They feed only as larvae and are, therefore, not associated with disease transmission. BSF larvae (BSFL) are voracious eaters of a wide range of organic wastes, decomposing and returning nutrients to the soil. Additionally, BSFL is an alternative protein source for aquaculture, pet food, livestock feed, and human nutrition. Rapid growth in the global human population and urbanization have led to increasing demands for food production and organic waste management. As the needs for nutritious food continue to rise, it is critical to ensure current and future food security, reduce waste generation, and promote sustainable farming that includes residue reuse and waste valorization. The use of the Black soldier fly (BSF), Hermetia illucens L., an emerging green technology, represents an enormous potential in waste management. BSF can remarkably reduce a wide variety of wastes and concurrently offer valuable animal or human feed and oil with high nutrient composition. They are able to survive and adapt to a wide array of environmental temperatures (McCallan, 1974). These flies fall under the Stratiomyidae family and, in the wild, are commonly found in habitats suitable for larval development such as marshlands and generally damp places with animal waste, rotten fruit or any decaying organic matter (Li et al., 2011). The adult fly does not eat or look for food and thus does not enter areas where people live (Sheppard et al., 1994). It is also believed that the BSF larvae are able to consume and digest organic waste at a faster and more efficient rate than the housefly larvae (Kim et al., 2011).

**2.2 Life cycle of Black Soldier Fly :**

The Black Soldier Fly undergoes a complete life cycle comprising of four live stages: egg/embryo, larva, pupa/imago and adult (Li et al., 2011). Eggs hatch into larvae within 3-4 days of being laid (Diclaro and Kaufman, 2009). Under the right conditions of food, relative humidity and temperature, larvae mature into prepupa in about two weeks. Prepupa, given the right conditions take two weeks to change into pupa in a process called pupation and characterized by development of an embryo within the puparium (casing), stiffness of the body, followed by immobility. Prepupae change into pupa when they find a dry medium to burrow in. In the dry medium, pupa go into a sleeping mode for a duration of at least two weeks during which time, the embryo further develops within their exoskeletal casing. When fully developed, the casing breaks up at the tip to release an adult fly in a process called emergence (Sheppard et al.,2002). Freshly emerged adult flies have undeveloped, folded wings which gradually unfold within 2-3 hours and also have slightly larger, softer and greenish coloured bodies compared to one day old adults. Adults have a lifespan of 5-12 days during which time they mate and lay eggs (Diclaro and Kaufman, 2009). Eggs are laid in masses of 500-1200 eggs depending on the fertility level of the female, which in turn is dependent on the diet and rearing conditions at the larval stage (Tomberlin et al., 2005). The lifecycle of a Black Soldier Fly from egg to adult is estimated to last about 44-45 days under optimum rearing conditions but under unsuitable rearing conditions, the period can stretch up to six months (Popa and Green, 2012). The longest part of the lifecycle is spent at the larval and pupal stages (Figure 1) (Popa and Green, 2012). In addition, the larval stage determines and influences the longevity of other stages and the productivity of the adult stage (Holmes et al., 2012)

**2.3 Nutritive value of Black Soldier Fly :**

Body composition of BSF larvae varies among substrates not only in protein content (ranging from 37 to 63% dry matter; DM) but also fat content, which has the most variation (ranging from 7 to 39% DM). Although BSF larvae on average contain both a high protein and fat content (Zheng et al., 2012), body composition of the larvae depends on the quality and quantity of food ingested (Nguyen et al.,2015). Dry matter content of fresh larvae is between 20 and 44% (Nguyen et al., 2015) and depends on both diet and larval stage (Rachmawati et al., 2010). Others have found protein contents that range from 35% crude protein (Haasbroek, 2016) to 44% protein (Surendra et al., 2016) for dried full-fat BSF larvae. BSF larvae have been found to contain 58-72% saturated fatty acids and 19-40% mono- and poly-unsaturated fatty acids of total fat content (Makkar et al.,2014) containing high levels of lauric, palmitic and oleic acid (Surendra et al., 2016). Black soldier fly larvae in various stages (adult, larval and pupal forms) are naturally consumed by wild bird and free-range poultry (Biasato et al., 2018a). Birds including chickens have a low taste bud number and thus low taste acuity compared to mammals (Liu et al., 2011). Chickens have different sensitivities to the bitter taste (Woods et al., 2019). Cullere et al. (2016) made a feed-choice test in quails and observed that the birds preferred the diet including H. illucens meal compared to Commercial poultry ration. In particular studies, Black soldier fly larvae are fed to poultry in the form of meal. But according to Moula et al. (2017), feeding life larvae may be more adequate than after processing. They should be processed to make them safe for use in poultry diets. Live larvae can also be difficult for handling and incompatible with automated feeding systems and can act as vectors in the transmission of infectious and viral diseases (Khusro et al., 2012). Live larvae also may be difficult to mix with ingredients in the diet, so processed insects can be easier to handle (Al-Qazzaz et al., 2016). Johnson & Boyce (1990) revealed that increasing amount of larvae meal added in the diet improved survival and growth rate of chickens. Mortality of quails was not affected by the inclusion of 10% dried H. illucens larvae (Woods et al., 2019). Correspondingly, the results obtained by Kareem et al. (2018) showed that excreta Enterobacteriaceae count was lower in birds fed with larvae meal supplemented diets than the control.

**2.3.1 Chemical analysis of Black Soldier Fly :** The proximate composition in this study shows that BSFM contains 43.17% protein and 31.08% lipid, previous studies that reported that the prepupae of black soldier fly contained approximately 40% protein and 30% fat Newton et al., 2005) .The crude protein content of larvae in our study ranged between 30 and 46%. These values are within the range of crude protein values for BSF larvae reported in the literature (Liland et al., 2017; Spranghers et al., 2017; Meneguz et al., 2018).
https://1drv.ms/w/s!AjCDdUcNOTiYgiXybxdeH4L-n8_O
Table 1: Proximate analysis of BSF from different article

**2.3.2 Amino acid content of Black Soldier Fly :**The amino acids (AA) composition of BSF is rich in methionine and lysine (9.05 and 22.3 g/kg DM, respectively) ( Oonincx et al.,2015) and is reported to be similar or even superior than that of soybean ( Veldkamp et al., 2012)However, nowadays knowledge about the suitability of the use of BSF as poultry feed ingredient is scarce and little-to-date.

Table -2: Amino acid content of Black Soldier Fly (%)
https://1drv.ms/w/s!AjCDdUcNOTiYginAL7tBuX5yeOvd

**2.3.3 Fatty acid percentage of Black Soldier Fly:**

Compared with other insects, the black soldier fly commonly contains a higher amount of fat (up to approximately 40%) and is rich in saturated fatty acids (SFA), especially palmitic acid (C16:0) and lauric acid (C12:0), the latter of which is known for its antimicrobial activity against Gram positive bacteria .(Muller et al., 2015, Caligiani et al., 2019,Rabani et al., 2019).It also has higher contents of oleic acid (C18:1n-9), palmitic acid (C16:0) and linoleic acid (C18:2n-6) in its body compared to other insects ( Caligiani et al., 2019) However, the fat content and fatty acid composition of the larvae dramatically vary (ether extracts from 5% to 40% dry matter) with the rearing substrates.

**2.4. Effect On poultry ration as protein source :**

Black soldier fly larvae have high nutritive value, not only in crude protein but, also for fats,minerals, and vitamins (Khusro et al., 2012). BSFL can be utilised as a feed ingredient in various animal's diets, and has been researched extensively in fish but not as vastly in poultry and other animals (Sealey et al., 2011). Fly larvae, in general, has been tested as a potential renewable protein source for poultry

(Awoniyi et al., 2003). The nutrient requirements of a poultry depend on its species, age and type of production. Broiler performance (based on nutrient utilisation) is reported as being influenced by one things which is crude protein of a diet (Zaman et al., 2008). The amino acid requirements differ for every animal species and even vary within species due to different physiological stages and needs (McDonald et al., 2002). Methionine is known to be the first limiting amino acid for poultry, followed by lysine, and adequate supply of these two amino acids will support optimised protein utilisation (Schutte & de Jong, 2004). In the ideal amino acid profile for broilers, all essential amino acids are expressed as a percentage of lysine, because the essential amino acids relative to lysine are unaffected regardless of genetics, dietary and environmental factors (Schutte & de Jong, 2004). BSFL also have sufficient content of copper, iron, magnesium, phosphorus, and zinc for requirements of domestic birds (Barker et al., 1998).

**2.4.1 Black soldier fly meet up the protein requirement of Poultry :**

BSF are possibly the most widely studied and the earliest referenced paper for their use as protein source in poultry feed. (Hale et al.,2014) In case of Broiler starter (20 to 23 percent protein) 0 to 2 weeks Pullet starter (20 to 22 percent protein) 2 to 6 weeks.Pullet grower (16 to 18 percent protein) 6 to 12. Birds almost reach the desired weight. Starter and grower feeds must contain a coccidiostat.Broiler finisher withdrawal (15 to 18 percent protein) or supplemented scratch grains (10 percent protein). This feed should be fed for 7 to 10 days before slaughter, because it contains no medication or a medication requiring no withdrawal time. These feeds also are high in energy and low in protein, so they will produce excessively fat birds when used longer than 2 weeks.A complete broiler grower diet containing 18 to 20 percent protein should be available free-choice at all times. Above all Dietary Black soldier fly larvae has positively influenced the growth performance of the birds in the present trial up(Gajana et al.,2018)In case of laying hen, Research indicates that light breed hens require at least 17 grams of well-balanced protein per day. Using of black soldier fly in ration to meet up this requirement and experiment shows that its give the required amount protein.(Dabbou et al.,2018)

**2.4.2 Increasing the growth rate and feed conversation ratio**

A positive performance impact of dietary inclusion of insect meal has also been observed in other research studies in broilers, with increases in body weight, body weight gain, and feed conversion ratio (FCR). (Gajana et al.,2018).Based on the results of this study, up to 20%, full-fat BSFL can be safely used in balanced broiler diet formulations without compromising broiler performance or health, and an inclusion level of 15% to 20% impacted immunologic parameters. The use of BSFL in broiler diets at that level improved growth performance parameters potentially due to the reduced energy demands of the immune system. Research conducted on commercial farms and in disease challenge models is highly warranted to validate the current results for economic relevance ( Benzertiha et al.,2019).For broiler producers, an FCR of 1.6 means that their chickens gain 1 kilogram of weight for every 1.6 kilograms of feed consumed. The lower the FCR, the more efficient animals are at converting feed into food.(Farooq et al.,2019)

**2.4.3 Increasing egg quality andlaying performance**:

Providing ad libitum dried larvae on the outdoor range found a reduction in egg weight, shell weight, shell thickness, and yolk color compared to -control hens and found no differences between treatments in the ranging behavior of the hens In comparison, , found an increase in egg weight and egg shell thickness in a group fed dried whole BSF larvae compared to the control. A new area of interest is providing live larvae to laying hens, in order to further promote foraging behaviors and avoid abnormal behaviors such as feather pecking. Indeed, in a study of older laying hens, from 67 to 78 wk of age, the feather condition of live-larvae-fed hens was better than that of the control hens which were provided a commercial diet Furthermore, larvae provided throughout the day seemed to facilitate the expression of natural feed searching behavior without affecting feed conversion, body weight gain or egg parameters (Kawasaki et al., 2019)(Star et al.,2019)

**2.4.4 Effect on carcass characteristics:**

Most of the studies did not find significant differences in carcass traits of young chickens when fly larvae or pupae replaced soybean meal. T. Molitor meal inclusion did not affect the carcass traits of experimental groups in the trial of Bovera et al. (2016) or Biasato et al. (2016, 2018a). Altmann et al. (2018) detected heavier carcass in chickens fed with diet where 50% of the soy-based protein was substituted by H. Illucens larval meal than in control group, probably because of H. Illucens larvae meal diet was substantially higher in crude protein and ether extract and chickens fed with this diet had higher final live weight. When poultry ration was replaced by larvae meal broiler diets, the dressing out percentage was affected (Awoniyi et al., 2003). In agreement, Cullere et al. (2016) fed broiler quails on 0, 10, and 15% inclusion levels of H. Illucens meal and did find a difference between the conventional and insect-based diet on dressing out percentage. Hwangbo et al. (2009) observed higher dressing percentages for broilers fed house fly meal included at levels from 5% to 20%. The results of the percentage of the main valuable parts in poultry fed insect meals are ambiguous. Awonyi et al. (2011) showed no effect of replacement fishmeal by larvae meal on muscle yield. Cullere et al. (2016), Onsongo et al. (2018) and Kareem et al. (2018) did not observe the effect of H. Illucens meal inclusion on breast meat percentage in quails or chickens, respectively. However, when poultry ration diet was partially replaced with insect meals, it resulted in higher breast and thigh muscle weights (Hwangbo et al., 2009) or higher breast meat percentage (Pieterse et al., 2014)

**2.4.5 Ensure the high quality meat :**

Meat quality can be described by chemical composition, physical meat characteristics (pH value, colour, tenderness) or sensory value. The chemical composition of meat can be influenced by the crude protein and energetic concentrations in the diet, whereas the impact of the crude protein source is still unclear (Özek et al., 2003). Regarding the change of protein in the diet, Pieterse et al. (2019) and Bovera et al. (2016) found that when the soybean meal was completely replaced by T. Molitor meal as a crude protein source, it did not affect the proximate composition of meat. Pieterse et al. (2019) showed that the inclusion of H. Illucens meal in the broiler chicken diet did not influence moisture, crude protein, fat and ash content of cooked meat. It seems that H. Illucens meals used in broiler chickens have the potential to produce meat with comparable chemical traits compared to those fed diets containing traditional feed ingredients (Pieterse et al., 2019). From physical meat properties, the pH value is important for the detection of meat defects like PSE (pale, soft, exudative meat) if the pH value measured 15 minutes post mortem is lower than 5.6. Cullere et al. (2016) obtained that quails fed H. Illucens at 10 or 15% had a pH value of around 5.67, that is slightly lower than in control group fed soy-based diet. On the other hand, according to the study of Bovera et al. (2016), poultry fed with insect meals had higher pH value.

In contrast, Pieterse et al. (2019) showed that no treatment differences were found regarding to the initial and ultimate pH of the thigh muscles. Despite this, the addition of H. Illucens meals did not lead to negative changes in pH values that could indicate meat defects. Nutrition can also affect meat colour, as it is the main sources of pigments in poultry life. Consumers consider meat colour an important quality clue at the point of purchase (Fletcher, 1999). Secci et al. (2018) have recently found that 1 kg of H. Illucens larval meal contained around 42 g of total tocopherols and 2 mg of total carotenoids. The pigments in animal feeding are derived from all the ingredients utilized for the formulation. No significant treatment differences for colour were observed regarding the colour characteristics of the broiler breast muscle (Fletcher, 1999). Secci et al. (2018) did not find any differences in meat colour parameters between barbary partridge fed with soybean meal H. Illucens meals or vegetable oils. Another meat quality parameter important for the consumer is meat tenderness, which was not affected by the introduction of larvae meals in the diet (Bovera et al., 2016; Pieterse et al., 2019). Water holding capacity of meat can be described by the drip loss or cooking loss when the meat is heat-treated. Drip loss was the lowest for the larvae-fed samples compared to those with soybean (Pieterse et al., 2014). However, when meat was heat-treated poultry fed with insect meals had higher cooking losses (Bovera et al., 2016). In another study, no significant treatment differences were found for thaw loss and cooking loss (Pieterse et al., 2019). Broilers are monogastric animals, any variation in the chemical composition of the feeds could potentially influence (positively or negatively) the sensory profile of the meat (Pieterse et al., 2019). According to the study of Hwangbo et al. (2009), the organoleptic characteristics of broiler meat were not affected by Black soldier fly larvae meals in the diet. Likewise, the sensory test of Onsongo et al. (2018) suggests that inclusion of H. Illucens meal in broiler diets does not affect consumer preference for broiler chicken breast meat consumption because the black soldier fly larvae meals inclusion did not change the taste and aroma of the meat as well as in study of Pieterse et al. (2019). On the other hand, fresh chicken breast filets score had the most intensive flavour in H. Illucens fed group (Altmann et al., 2018). The larvae-fed meat samples scored significantly higher for sustained juiciness compared to the soy and fish meal-fed samples and it also provides an indication that broilers fed larvae meal could have juicier meat (Pieterse et al., 2014). Therefore, it can be concluded that the substitution of commercial poultry feed containing protein with black soldier fly larvae meals expressed very modest or no changes in the meat quality for many of the meat quality

### 2.5. Ecological benefit of using Black Soldier Fly

Indirectly,Black Soldiers Fly plays vital role to maintain the ecological balance of environment. There are several ways through we can use black soldier fly as the weapon which help to modarate the wastage and convert wastage into organic compounds.

#### 2.5.1 Black Soldier Fly composting

In earlier studies (e.g. Sheppard et al., 2002), BSFL was mainly reared on manure from various animals. Lately though, a wide variety of substrates has been tried out for the BSFL; examples include restaurant waste, fish offal, cow manure, biogas digestate, brewery by-products, sewer sludge and human faeces (Lalander et al., 2019; Meneguz et al., 2018b; Spranghers et al., 2017; St-Hilaire et al., 2007a). There is a consensus in the literature, that the growth and feed conversion of the BSFL, as well as nutritional composition, are affected by the substrate that the larvae are reared on. For example, in the study by Lalander et al. (2019) BSFL reared on abattoir waste took 12 days to reach the prepupal stage, while it took up to 40 days when the larvae were reared on digested sewage sludge. Also, in the same study, the prepupae reached a weight of 250 mg when the larvae were reared on abattoir waste, while it was as low as 70 mg when reared on digested sewage sludge. In the study by Lalander et al. (2019) it was observed that the amount of volatile solids and protein of the substrate had a large impact on the size and development time of the larvae. The impact of the protein content of the substrate has also been investigated in other studies. Pimentel et al. (2017) observed morphological changes in the fat body of the BSFL, as well as starvation response in the gene expression, when the larvae were reared on substrates poor in nitrogen. While the protein and volatile solids content in the substrate appears as important for the larval development, the BSFL has been observed to withstand wide variations in substrate pH. In the study by Meneguz et al. (2018a) no significant differences were found in final larval weight, mortality or development time between larvae reared on substrates with pH-values between 4.0-9.5. Additionally, during the trial, the pH-value changed to 9, independent of the initial pH. It also seems like the BSFL are able to reduce pathogens in the rearing substrate. In a study by Lalander et al. (2015), a 7 log reduction of Salmonella spp. Was observed during the BSF composting trial. In addition to the substrate quality, factors such as temperature and relative humidity also affects the development of the larvae (Tomberlin & Cammack, 2017). BSF mating and oviposition has been observed at temperatures of 24-40°C and at relative humidity between 30-90% (Sheppard et al., 2002). The temperature usually used for the fly larvae composting step is 27-29°C at a relative humidity of 60-70% (e.g. Meneguz et al., 2018b; Spranghers et al., 2017). Another factor which has been observed to affect the larval development is the feeding system. Meneguz et al. (2018a) found that when larvae were given the substrate in one batch, the prepupae developed faster, but when given the same amount of substrate spread over the whole feeding period, the larvae grew bigger.

**2.5.2 Wastage management throughharvesting of BSF**

Black soldier flies (Hermetia illucens) play a significant role in recycling many forms of organic waste and other accumulated nutrients in the environment. The larvae of black soldier flies able to broken down various organic matter including food waste in ecosystem . This Species also recorded as an agricultural-waste consumer such as coffee pulp palm kernel meal and rice straw waste or organic waste materials like market waste, municipal organic waste or dewatered faecal sludge . Larvae of black soldier flies also consume livestock manure such as chicken manure pigmanure, and dairy manure. In digestion process, this larvae assimilate nutrients of the organic matter. Through this process, black soldier fly larva cuts down the amount of organic waste, so indirectly decline the pollution potential. More than half of the nutrients contained in feed are excreted as manure. The black soldier fly consume and convert residual manure proteins and other nutrients into their valuable biomass, which is a high quality animal protein feedstuff The larvae and prepupae of black soldier fly have a high protein and fat content that can be used to support growth a lot of livestock such as blue tilapia fish and pigs . The environmental impact of animal husbandry could decline significantly if black soldier fly larvae are used in order to eliminate livestock manure and reused as livestock feed. Organic matter as growing substrate greatly affects the development of black soldier fly and various biological traits. The present study focused on analyzing the influence of horse and sheep manure substrates toward nutrient composition and growth performance of black soldier fly larvae and to quantify the suitability of horse and sheep manure as feed for black soldier fly larvae.

### 2.5.3 Reduction of pollution and sanitation of the environment

BSFL feeding activity reduces the amount of organic waste dumped in open streets and water points by at least 50-60% (Diener et al., 2011), resident nutrients such as nitrogen content by 71%, phosphorus and potassium by 52% each, amount of greenhouse gases that is generated from the waste through anaerobic respiration such as Carbon di oxide, Sulfur dioxide, methane, ammonia and other noxious gases (Van Huis et al., 2013). The larvae also treat organic leachates that pollute marine and terrestrial environments (Popa and Green, 2012), and clean up oil and grease pollutions that may cause aquatic suffocations by feeding on the spilled oil (Zheng et al., 2013). The inclusion of BSFL in pit latrines and sewerage sites to feed on, decompose and reduce the faecal matter content can help prolong the lifespan of these facilities and therefore contribute to the improvement of sanitation by lessening open defeacation (Banks et al., 2014).

## 2.6 Cost effectiveness of BSF

Feed cost can form up to 70% of the total cost of poultry production. Animal protein sources are preferred over plant protein sources because animal proteins contain a good balance of essential amino acids and an excellent content of vitamins (Saima et al., 2008). Fish meal is a high-quality Protein source used mainly in black soldier flypotentially low-costnutrient-rich alternative protein source, that is similar or superior in protein quality to FMand plant sources The processed larvae of this insect is rich in nutrients such ascrude protein content (38.5–62.7%) with well-balanced amino acids profile, good qualityfatty acids (14.0–39.2%) and micronutrients such as iron and zinc. However,the nutritional status of these insects might vary depending on the species, developmentalstage, and rearing substrates Several studies on the use of BSF larvae meal (BSFLM)in commercial feeds have largely focused on broiler, pig and fish ) rather thanlayers. In literature, few studies on chicken layers have largely focused from the point ofegg laying both for non-defatted BSFLM or defatted BSFLM based feeds. Also,chick, pullet, and layer birds, each has its own specific nutritional requirements, which must be considered when formulating their feed . The studies described illustrated differences in body weight only at the onset of egg production because it is a major factorinfluencing the efficiency of egg production. Although, laying hen are not raised formeat, the lack of information on the growth of the visceral organs could have a detrimental impact on egg productivity. For example, the weights of some visceral organs have been shown to be affected by dietary treatment. Also, during feed restriction or change, the physical development of birds usually gives priority to the development of the internal organs, which are capable of recovering more quickly than other parts of the body. According to Obeng et al. Changes of internal organs in growing birds could improver hinder the utilization rate of energy, protein, amino acids, and other nutrients required to enhance .

## 2.7 Challenges in the use of Black soldier fly larvae as a food and feed resource

Operations for the production of BSF have been faced with different challenges which mostly relate to the use of the larvae as feed rather than as an agent of waste management (Mutafaela, 2015). To start with, Black Soldier Fly production requires a warm environment. This requirement has proved difficult and energy consuming to sustain in the temperate climates and during winter periods (Holmes et al., 2012). Use of greenhouses to ensure continued production during the cold seasons within the tropics and equatorial climates has made the enterprise expensive (Holmes et al., 2012). The duration of the life cycle ranges between several weeks to several months depending on temperatures, quality and quantity of the diet. This makes prediction of production a challenge (Veldkamp et al., 2012). The continued lack of legal framework and specific legislations on the use of BSF discourages investment in the sector (Leek, 2017). For example within the European Union (EU), strict sanitary regulations, a lack of guidelines on the mass rearing of insects, lack of clarity on which insect types are authorized for the market, and prohibition of some common types of substrates for insect production have also hindered progress in the acceptance and establishment of the insect market (van Huis et al., 2013). This is in contrast to countries in Africa where there is virtually no restriction on the kind of substrates used (Leek, 2017). Issues of feed quality due to the potential of BSF to bio-accumulate toxins and heavy metals from pesticides, chemical fertilizers, herbicides and other chemicals sprayed on production substrates and genetic engineering technologies presents another challenge (Diener et al., 2009). High sodium levels in processed food stuffs have also proved problematic. Most of these accumulate in ecosystems and in larva, and at higher concentrations may be toxic both to the larvae and the consuming animals along the food chain (van Huis et al., 2013). This therefore limits the potential sources of suitable substrates. Another concern involves acceptance and perception of insects. This is perhaps because society associates them with houseflies which are a known health risk. This is the basis for the EU restrictions on the use of insects as feed ingredients of animals destined for human consumption (Leek, 2017). The generalization is affecting even harmless flies like BSF and is largely due to lack of awareness. Lack of collaboration among experts in the field to make necessary explanations to the naïve public and create awareness on potential of insects as a food and feed resource has contributed to poor acceptance and persistence of the wrong perceptions (Smith and Barnes, 2015). However the perceived benefits of insects such as sustainable production, lowered dependence on imported protein sources and lower environmental impact are mitigating for improved change of attitude towards broad acceptance and are considered more important than the perceived risks such as microbiological contamination, chemical residues in the food chain and lower consumer acceptance of poultry products (Verbeke, 2015). Healthy risks from a variety of pathogens, parasites and diseases are a major challenge in BSF production systems (Leek, 2017). Knowledge of disease and health management in intensive insect rearing is still limited and population crashes sometimes involving the whole colony do occur (Leek, 2017). For instance in Georgia, a parastoid wasp of the Trichopria genus has been reported to infect 21-32% of Black Soldier Fly pupae (Mutafaela, 2015). Current mitigation measures involve minimizing the health risks by ensuring bio-security in a breeding colony, use of very ‘clean’ substrates and separate housing of the different stages of the breeding stock to avoid cross infection between the different stages (Leek, 2017). In addition, predators such as rats, mongooses and lizards do feed on larva and adults and can therefore significantly contribute to diminishing of populations and returns. At current prices, BSF is at par with fishmeal which over recent years has all but disappeared from most livestock diets. However with increase in campaigns to increase adoption of insect rearing technologies, supply is expected to rise and with it, reduction of price (Rumpold and Schlüter, 2013).

## Conclusion

This modern era facing the food and feed crisis, and this problems being greater day by day.For this reason every poultry farmers wants to more profit at lowest possible cost.In case of poultry ration formulation, the most expensive feed ingredients is protein source. BSF would be the best solution to make ration at lowest possible cost because of it nutritive value. BSF plays multiple rule in poultry production, economically farmers will get their target production and benefit if they used it as alternative source of protein. BSF contain higher amount of essential amino acid, saturated and unsaturated fatty acid which is very important for poultry's growth, production and maintenance.Not only this BSF also plays a vital role in wastage management and indirectly maintain the ecological balance of our environment..Except a few limitation, BSF is the best alternative source of protein for poultry with higher amount of protein and other essential nutrients.

**Abbreviation**

BSF = Black soldier Fly, DM= Dry Matter, CP = Crude Protein, CFT = Crude Fiber, EE = Ether Extract, Ca = Calcium, P = Phosphorus

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