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The Chemical Composition, Fatty Acid and Amino Acid Profiles and Mineral Content of Black Soldier Fly (*Hermetia illucens* L.) Larvae Reared on Restaurant Waste

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Abstract

BLACK SOLDIER FLY (BSF, *Hermetiaillucens* L.) larvae are among the most productive species because of their nutritional advantages and minimal environmental effect. They are not regarded as pests and can be reared and harvested without specialized infrastructure. Additionally, depending on the substrate they consume, they can transform organic waste into beneficial biomass, such as proteins, lipids, and chitin, with varied compositions. In this study, larvae were raised on restaurant waste, which included fried food (such as chicken, meat, and fish), potato peels, carrot scraps, rice, and bread remnants. Larvae samples were frozen and dried for proximate analysis, where protein content, lipid content, moisture content, flavonoids, phytic acids, amino and fatty acid profiles, mineral content, and microbiological properties of BSFL were evaluated. According to the results, the dry base BSF biomass included 33.90% crude protein, 45.37% fat, 0.95% phytic acids, and 12.43% fiber. In addition to the total flavonoids reaching 892.4 ppm, the moisture content reached 66.00%. The amino acids that are essential present in the highest concentrations were phenylalanine, leucine, and lysine, whereas glutamic acid and alanine were considered non-essential amino acids. Lauric acid was identified as the main saturated fatty acid and oleic acid as the most prevalent unsaturated fatty acid. Sodium (Na) was the most abundant mineral in BSF larvae (40%). This study emphasizes the importance of this insect as an alternative protein source, in addition to its utilization as a substitute for protein-rich feedstuff in chicken feed production.

Keywords: Black soldier fly, Restaurant waste. Chemical Composition, Amino acids, Fatty acids, Mineral content.

Introduction

The black soldier fly (BSF), *Hermetiaillucens*, is a common and ubiquitous fly species that belongs to the *Stratiomyidae* family. Due to its capacity to recycle organic waste, the BSF has received increasing attention since the late 20th century [1]. According to [2], a adult female lays 200–600 eggs at a time. These eggs hatch in approximately four days and are typically laid on surfaces above or adjacent to decomposing materials, such as compost or manure . Although newly hatched larvae are 1.0 mm long, they can grow to a length of 25 mm and weigh between 0.10 and 0.22 g by the end of the larval stage. According to [3], larvae can adapt to diets with varying nutrient content by consuming a variety of organic materials. The duration of the larval stage varies from 18 to 36 days, depending on the kind of food that is given to the larvae [4]. The prepupal (post-feeding) phase lasts roughly seven days [5].The larval stage may last for months due to low temperatures or a lack of food [3]. The pupal stage lasts between one to two weeks [6]. According to [7], adults may survive for 47–73 days if provided with food and water, such as sugar in captivity or nectar in the environment. On the other hand, when given water, they can survive for eight to ten days on fat reserves that were accumulated during their larval

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stage [6]. Like red worms, black soldier fly larvae (BSFL) are bio-degraders that aid in the breakdown of organic substrates and replenishment of soil nutrients. Because of their ravenous appetites, larvae may be utilized to convert agricultural waste and household food scraps into fertilizer. Additionally, BSFL are used as a replacement protein source in aquaculture, feed for animal and pet meals [8]. Adult Black soldier flies are only able to swallow liquids, like nectar from flowers, because their spongy mouthparts are much smaller than those of house flies; however, they don't usually feed. As a result, adult black soldier flies do not transmit diseases, in contrast to houseflies, which repeat meals and digestive enzymes [9].

There are few records of human consumption of BSFL. In 2013, an Austrian designer created a farm for breeding insect that facilitate people to produce edible flies at their home. The larvae are said to have a very unique flavor [10]. Although BSFL's potential is a highly nutritious, sustainable food source, there are still several hurdles should be overcome before regarding BSFL as a safe food source for humans..The safety aspects of BSFL as food are still little known, as BSFL has only ever been utilized for animal feed. It has been demonstrated that all edible insect species have high microbial content; of particular concern are pathogenic bacteria such *Escherichia coli*, *Staphylococcus aureus* and *Bacillus cereus* [11]. Studies have demonstrated that BSFL may considerably lower *Salmonella* spp. and *Enterobacteriaceae* colonies in a range of feed sources when used exclusively for human consumption. This is that BSFL naturally breaks down and has a variety of defense mechanisms against the microbial load in their diet. Some bacterial species (including *Salmonella* spp. and *E. coli*) from the feed cannot survive because of their high pH (9.3).Enzymatic reactions in the gut, and gut bacteria that compete with them [12]. The presence of heavy metals is another contaminant of concern. According to studies, BSFL accumulates some heavy metals from their diet; heavy metals including cadmium, mercury, lead and copper are especially dangerous due to the serious health risks they pose when consumed [13]. To reduce health hazards to humans, it is essential to know the risks of heavy metals associated with the garbage that the larvae are supposed to eat. Considering that the concentration of heavy metals for larval health is also crucial, as some heavy metals can hinder the development. of BSFL by producing disturbance in their gut microbiota [14]. So far, the European Union (EU) only has guidelines for the safety of usage mealworms for human food; the rules restrict the usage of BSFL as human food [15].

It is crucial that further study be done to fully comprehend the dangers that are unique to BSFL raised on a range of foods that can raise issues in a food application. Consumer acceptability of BSFL is also influenced by its safety, thus before completely promoting its use, it is essential to look at the larvae from a food safety standpoint. Furthermore, because of the possible toxins the larvae may gather throughout the waste reduction process, BSFL's capacity for recycling organic matter is both one of its greatest benefits and one of the main issues when it comes to using it as a food source.

Therefore, it is now advised that BSFL be raised on clean "waste" in order to reduce some of the dangers that have been mentioned, such as heavy metal absorption and microbial contamination [16] Effective management of kitchen waste, especially in restaurants is crucial because its effects on the environment, include emissions of greenhouse gases and consumption of resources during food production. Therefore, the purpose of this research was to detect if BSFL grown on the kitchen waste containing meat are considered safe for use; by determining the characteristics of amino acids, fatty acids and mineral content of BSFL. Nutrient analysis to these larvae will provide important guidance for their users in various fields.

Material and Methods

Black soldier fly rearing

Housing adult of black soldier fly

In this study, the adult BSF (5Kg) were kept in an outside wooden cage with a mesh frame (1.8×1.8×1.8 m diameter) maintained at 28±5°C to promote mating and with good access to sunshine. Water was provided to flies to extend their lifespan. To encourage adult females to deposit eggs, cardboard with corrugations was placed inside the cage. The eggs then hatched and converted into neonatal BSFL [17]. Adults mated at about two days of age, laid eggs at about four days of age [6], and stayed alive for an average of 8-14 days [18].

Substrate preparation and larval feeding

The restaurant waste was a mixture of fried food waste (chicken, meat, and fish), potato peels, carrot scraps, cooked grains such as rice, and bakery scraps obtained from local restaurants in Qalyubia *Governorate*. The waste was selected based on its availability, Considering its possible application in a massive -scale industrial BSFL production in the future. Plastic containers measuring 23×15 cm were utilized to contain waste. Randomly, the containers were arranged in a wooden frame in a room. A quantity of neonatal BSFL was carefully placed on top of the waste. The temperature and relative humidity were kept at 28±2°C and 65±5%, respectively, during the rearing phase. To provide a moisture content 65–70%, distilled water was sprayed on the waste. every week the waste was replaced with new one .The larvae were harvested after they reached the larval phase by sieving them from feed and frass and fasting for 6 hrs. After that, the larvae were cleaned with tap water, scarified by freezing, dried for 48 hours at 60°C in an oven, ground with a lab blender, and kept in a refrigerator at -20°C for further analyses (Figure 1).

Proximate composition

Moisture content

BSFL's moisture content was evaluated in duplicate under AOAC method 14004[19],in an oven set to 105°C for 24 hours.

Fat content

The Total amount of crude fat in BSFL was calculated using a Soxhlet apparatus using the non-polar solvent *n*-hexane following AOAC method 14006 [19].

Crude protein determination

Nitrogen (N) content in BSFL was calculated using the method 7015, AOAC[19]. The crude protein (CP) of these samples was estimated by multiplying the N content by 6.25.

Ash content

Ash content was estimated by burning organic components of identified weight of dried and homogenized samples of BSFL using a furnace set at 550°C as stated in method 14009, AOAC[19].

Determination of phytic acid

Phytic acid was measured in BSF using the method explained in [20]. Phytic acid was isolated from roughly 0.5 g of sample using 0.2 M HCl for 3 hrs., then centrifugation at 500 *g* for Half an hour. 0.5 mL of the extract was added to 1 mL of ferric ammonium sulfate solution (0.2 g of $NH_4Fe(SO_4)_2 \cdot 12H_2O$ in 100 mL 2 M HCl and made up to 1000 mL), boiling water bath is used for incubation for half an hour after that using an ice water bath to room temperature to cool it. Then 2 mL of 2,2-bipyridine solution (1% w/v, in distilled water) was mixed into the mixture after the cooling. The absorbance was immediately determined at 519 nm and a calibration curve was used to evaluate phytic acid concentration in samples. The calibration was established using solutions created by diluting the stock solution (1.3 mg mL^{-1} phytic acid) with 0.2 M HCl within the range of 0.1 to 1.0 mg mL^{-1}.

Flavonoid content

According to [21], a colorimetric method using aluminum chloride ($AlCl_3$) was used to assess total flavonoids. Two grams of the defatted powder were extracted using petroleum ether that was mixed with ethanol (95%) , and the extract's volume was adjusted to 50 mL. Five milliliters of the extract were poured into a test tube, and 5 mL of 0.1 M $AlCl_3$ reagent was added. A spectrophotometer was used to measure the absorbance of the reaction mixture at a wavelength of 445 nm against blank sample. The standard used was quercetin. Different amounts of quercetin ranging from 5 to 300 µg were poured individually into test tube and then evaporated to dryness in a hot water bath (40-50°C). The content of flavonoids was represented as mg of quercetin equivalent (QE) per g of dry weight.

Mineral content determination

The mineral composition of the larvae was established by using ICP-MS (iCAP, Thermo, Germany); Approved reference materials (Merck, Germany) were applied . Qtegra software was used to compute The mean and Relative standard deviations [22].

Fatty acid profile analysis

In accordance with the AOAC 2000 standard, the gas chromatography (GC) technique was used to analyze the profiles of saturated and unsaturated fatty acids. First, *n*-hexane solvent was used to create a standard solution with a single concentration. The sample was placed in a 20 mL screw-cap vial after being weighed to equal 50 mg of fat. Methyl tertiary butyl ether was then introduced. After adding the transesterification solution, the vortex flask was shut off for 10 seconds. The flask was opened, hexane and neutralizing solution were added, and then centrifuged. A 2 mL vial containing the organic phase was introduced into the GC flame ionization detector (FID). Conditions for instrument measurement included split injection mode, 1 µL injection volume, 240˚C injection temperature, DB FastFAME capillary column, helium carrier gas, 50-230˚C temperature gradient oven program, 240˚C detector temperature, 30 mL/min water flow, and 300 mL/min air flow.

The C4-C24 chains, which are identified by comparing the retention times of each fatty acid component in the sample with the retention times of each standard fatty acid component, served as the peak plot of the sample measurement data when interpreting the results.

Amino acid analysis

According to the procedure of [23], amino acid analysis was performed using an LC3000 amino acid analyzer manufactured by the Eppendorf-Biotronik Germany in the following mothod: 6.0 N HCl was introduced into a hydrolysis tube containing 20 mg of defatted BSFL. For 24 hrs, the hydrolysis tube was heated to 110˚C, once hydrolyzed, cool in an ice bath.

The insoluble components in the solution were precipitated by centrifugation. To remove any residual acid, it was evaporated at about 40 C in a rotary evaporator; the supernatant was dissolved in around 1 mL of distilled water, and then filtered again. Diluting buffer (1-2 mL) was used to dissolve all samples. Samples with a total volume of 20 μL were introduced into the amino acid analyzer.

Microbiological analysis

Twenty-five g of BSFL were flushed with distilled water for 5 min, followed by sieving them and grinding larvae in a mortar containing sodium citrate to form a suspension. Serial dilutions (ten-fold) were made by adding 1 g of the suspension to 9 mL of saline solution. One mL from each tube was then poured into Petri dishes containing different types of media, according to the types of bacteria, mold, and yeast. For the cultivation of yeast and mold, peptone dextrose agar (PDA) was used. MacConkey agar was used for the cultivation of E. coli and Staphylococcus aureus. To cultivate Salmonella and Shigella, Salmonella-Shigella (SS) agar was used. Nutrient agar was used for the total count. Then incubated bacteria plates at 37˚C for 48 hrs. the bacteria plates were incubated at 37˚C for 48 hours and the yeast and mold plates at 28˚C for 72 hrs., and then the growth of bacteria, yeast, and mold was observed and determined the colony forming unit (CFU) .

CFU/mL= number of colonies × dilution factor / volume of culture plate.

Results

Proximate composition

The nutritional compositions of black soldier fly larvae (BSFL) are presented in Table (1). The moisture contents, lipids, content of crude protein, fiber, and phytic acid were 66.00%, 45.37%, 33.90%, 12.43%, and 00.95%, respectively. The flavonoid content of BSFL was estimated in quercetin equivalent (QE) mg/g (ppm). To evaluate the total flavonoids The linear equation of the quercetin standard curve was used. The total flavonoid content of the BSFL was 892.2ppm(QE).

Minerals content of black soldier fly larvae cake

Mineral content of the pressed cake of BSFL. Our research is one of the few that has addressed the mineral composition of cake of the BSFL. Table (2) and Figure (2) showed the range of values and average mineral composition concentration for all BSFL cake established by chemical reference methods (ICP-MS). Macro-minerals such as K, Ca, Mg, and Na were demonstrated in high concentration (184.103, 81.520, 59.578, and 369.327 mg/kg DW, respectively). Cr and other micro-minerals such as Co, Cu, Fe, Mn, and Zn were found in trace and high concentration (3.090, 0.112, 4.583, 83.578, 26.342 and 3.282 mg/kg DW, respectively). Of the overall element ratio, sodium represents 40%, followed by potassium 20%, iron 9%, and calcium 9%.

Amino acid composition

Dietary protein should be regarded as a source of amino acids as separate nutrients. Table (3) and Figure (3) show the composition of amino acid (AA) of black solider fly larvae.

The essential amino acids at the highest content were phenylalanine (2.60 mg 100 mg^{-1}), leucine (2.11 mg 100 mg^{-1}), and lysine (2.08 mg 100 mg^{-1}); and other (nonessential) AA glutamine acid, alanine, aspartic acid and proline (3.09, 2.74, 2.39, and 2.09 mg 100 mg^{-1}, respectively). 43.17%. was the average percentage of indispensable amino acid.

Fatty acid composition

Results in Table (4) showed the presence of eleven fatty acids recognized in the crude fat of black soldier fly larvae. Saturated fatty acids were predominant (63.08%), while unsaturated fatty acids were (35.01%). The major saturated fatty acid was Lauric acid, constituting 37.08% of the total detectable fatty acids, after palmitic acid (17.25%). the main unsaturated fatty acid was Oleic acid, constituting 18.35% of the total detectable fatty acids, followed by linoleic acid (12.29%).

Microbiological analysis

Escherichia coli is considered an indicator organisms, they are usually inspected in foods to evaluate potential of hygiene of food . In black soldier fly larvae raised on waste of food, the levels of *E. coli* and *Staphylococcus* sp. were within the acceptable ranges of $2X10^2$ and 5x10 log cfu/g, respectively.

There was no interaction between *Shigella* and *Salmonella* species. No colonies were seen in any of the cake samples of black soldier fly larvae. All samples of black soldier fly larval cakes reared on waste of food had yeast and Mold levels of $8x10^2$ log cfu/g “Specific limits can vary, but generally, yeast and mold counts should be kept as low as possible, typically below 10^3cfu/g”(Table 5).

Discussion

The nutritional importance of insects investigated being focused on their protein and fat content, has been mentioned in numerous studies. BSFL meal's high content of protein and fat that supports its potential for use in animal feed [24]. Insects' diet [25], and their developmental stage [26], can have an impact on the chemical composition of insect meals. The results indicate that lipids constitute the largest quantity of dry matter in BSFL. The abundance of protein suggests that BSFL meals might be a valuable source of amino acids. There are significant amounts of essential micronutrients identified in insects, such as Fe, Ca, P, Zn, and vitamin E, which also have a significant value [27]. Moreover, unwanted materials may be accumulated in BSFL, such as harmful metals, so, it is important to monitor it during production. There are greater abundance of minerals in the prepupal stage than in the mature larval stages, such as P and Ca. For example,

Data demonstrated that in the early prepupa phase, the amount of P was almost twice that of mature larvae. In contrast,, at 14th day of growth the mature larval stage showed high concentration of some other minerals, including Na, Fe, and Zn [26]. The amino acid content of the BSF varies throughout its life cycle, such as lysine. According to data from a recent experimental investigation every growth phase of the BSF life cycle has a wide variety of synthesized essential amino acids. additionally, the amino acid level in the BSF appears to be correlated with its protein content as in the early stages of larval development showed the highest level of amino acid content, then gradually declined until the larval maturity, followed by a steady phase of amino acid content at a late stage of the BSF life cycles as in pre-pupal and pupal stages [26]. Generally, insects contain high concentrations of these essential amino acids [28], and possess a better amino acid profile in comparison to soya bean meal and most popular conventional protein sources [29]. Ileal amino acid digestibility and amino acid profiles are considered the primary indicators of protein quality in chicken feedstuffs. Nowadays, protein from plant sources is used to design poultry diets. The mainstay of diets across the world is cereal protein. Furthermore, lysine, threonine and methionine are the three most limiting necessary amino acids in poultry diets based on cereals. The essential amino acid content of BSFL meal is generally valuable that of corn gluten meal (60%). However, leucine and lysine are represented as the majority of essential amino acids in BSFL meals [30]. As far as non-essential amino acids, the protein content in BSFL exhibited greater amounts of alanine, proline, and tyrosine in comparison to soybean meal and fish meal protein [31]. lauric acid (dodecanoic acid, C12:0) is the major fatty acid in BSF. The concentration of lauric acid elevated gradually from the larval stage and maximized during the pupa stage.

BSF demonstrated a sufficiently high level of essential fatty acids throughout their life cycle. Such as linoleic (C18:2) and alpha-linolenic acid (C18:3). BSF contains an adequate amount of oleic acid (C18:1) with average 10.3-15.9%, depending on the composition of feed [32]. Furthermore, on the 4th day of larval development a maximum concentration of oleic acid 36.4% was observed [26]. Recent research demonstrated that the possibility of utilization BSF fats as alternative to soybean oil in rabbit diets with no effect on consumer acceptance. Furthermore, the Data demonstrated that the meat of the rabbits that fed the diets including insect fat was less susceptible to oxidation [33]. The microbiological load of BSFL is influenced by the diet . However, it has been proposed that the situation is more complicated and that a variety of variables may impact the final microbial load of BSFL.

Among these include feed, the way the BSFL is raised, the total amount of handling, its interactions with other microbial populations, and its parents' origins [34]. in the BSFL samples (frozen and blanched) or in the feed not found Both Salmonella and *Listeria monocytogenes* in them) [35].Conversely, numerous studies indicate that Black Soldier Fly larvae (BSFL) possess antimicrobial properties and can effectively reduce pathogenic fungi and bacteria, including *Salmonella*, *Staphylococcus aureus*, and *E. coli*, in their substrate [36]. BSFL also produce natural antibiotics, such as defensin-like peptide 4 (DLP4), which is an antibacterial peptide secreted by fungi. This peptide has the potential to alter harmful microorganisms in food waste and reduce the abundance of *Escherichia coli* O157:H7 and *Salmonella enterica*. [37]. The moisture content of Black Soldier Fly larvae (BSFL) is a crucial factor influencing both its shelf life and processing characteristics. High moisture levels pose challenges in BSF production; however, studies have indicated that optimizing moisture levels can enhance survival rates and increase biomass yields [38]. According to [39], Moisture content of BSF was 4.4 – 8.4% The difference in moisture content from study to another depend on age harvesting, medium rearing, and technology processing.

Another parameter that was relatively high in Black Soldier Fly larvae (BSFL) is ash content, which reflects the presence of inorganic minerals. BSFL are rich in minerals; calcium (Ca)is the most abundant . Copper (Cu). Iron (Fe). Magnesium (Mg). Manganese (Mn). Phosphorus (P) Potassium (K). Sodium (Na). Zinc (Zn). However, in addition to the accumulation of the above minerals, some toxic and harmful elements (such as Ba, Hg and Mo) will also bioaccumulate in BSFL which will pose a challenge to the safety of feed and food production [40]. BSFL contained a higher calcium content compared to fishmeal [37].

Conclusion

We could conclude that since the high protein and fat content and quality of black soldier fly (BSF) larvae, they present a promising a viable substitute protein source for animal feeds. In the future, we aim to address the challenges related to poultry feed and soybean production by substituting plant protein with insect protein sourced from BSF larvae. This will involve conducting experiments on poultry nutrition using insect protein as a replacement for soybean protein. The evaluation will focus on meat quality, feed conversion efficiency, and overall weight of poultry.

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Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical of approval

This study follows the ethics guidelines of Genetic Engineering and Biotechnology Research Institute, University of Sadat City, Egypt (ethics approval number; 49/11/2023).

TABLE 1. Chemical composition of black soldier fly larvae

Component	Value (ppm)
Moisture[&]	66.00
Fat[#]	45.37
Crude protein[#]	33.90
Fiber[#]	12.43
Phytic acid[#]	00.95
Total flavonoids[@]	892.4

[&]*% (wet basis),* [#]*% (g/100 g dry basis),* [@]*ppm (dry basis)*

TABLE 2. Minor and major elements of black solider fly larvae (mg kg^{-1} dry weight)

#	Element	Average concentration (mg kg^{-1})
1.	^{7}Li	0.149
2.	^{11}B	6.717
3.	^{23}Na	369.327
4.	^{24}Mg	59.578
5.	^{27}AI	66.031
6.	^{39}K	184.103
7.	^{44}Ca	81.520
8.	^{48}Ti	25.271
9.	^{52}Cr	3.090
10.	^{55}Mn	26.342
11.	^{57}Fe	83.578
12.	^{59}Co	0.112
13.	^{60}Ni	1.367
14.	^{63}Cu	4.583
15.	^{66}Zn	3.282
16.	^{71}Ga	0.179
17.	^{75}As	1.575
18.	^{77}Se	6.758
19.	^{88}Sr	3.524
20.	^{107}Ag	2.748
21.	^{111}Cd	0.145
22.	^{115}In	0.178
23.	^{137}Ba	0.456
24.	^{202}Hg	0.094
25.	^{208}Pb	1.055
26.	^{209}Bi	0.347

TABLE 3. Amino acid composition of black solider fly larvae

Amino acid	% (mg/100 mg dry weight)
Alanine	2.74
Arginine	1.13
Aspartic acid	2.39
Threonine	1.34
Serine	1.14
Glutamic acid	3.09
Glycine	1.52
Valine	1.85
Isoleucine	1.40
Leucine	2.11
Tyrosine	1.79
Phenylalanine	2.60
Histidine	0.69
Lysine	2.08
Proline	2.09

TABLE 4. Fatty acid profile of black soldier fly larvae

	Fatty acid (%)
Saturated fatty acids	
Lauric (dodecanoic acid)	37.08
Myristic	06.49
Palmitic	17.25
Stearic	02.12
Arachidic	00.06
Behenic acid	00.09
Unsaturated fatty acids	
Oleic	18.35
Linoleic	12.29
Linolenic	01.31
Palmitoleic	03.02

The oil content was 45.375%

TABLE 5. Microbiological properties of black soldier fly larvae

Microorganisms	Log CFU#/g	Acceptable microbial count
Total count	**$4.4x10^4$**	*should not exceed 6.69 Log $_{10}$cfu/g (approximately 5 million cfu/g)*
Coliformsbacteria (*E. coli*)	**$2X10^2$**	*Should not exceed 2.69 log $_{10}$cfu/g (approximately 500 cfu/g)*
Staphylococcus	**5x10**	should not exceed 10^2cfu/g (100 cfu/g) in ready-to-eat foods)
***Salmonella*spp**	**ND&**	*Should be absent in 25 g of the sample*
***Shighella*spp**	**ND&**	*Should be absent in 25 g of the sample*
Yeast and molds	**$8x10^2$**	*Specific limits can vary, but generally, yeast and mold counts should be kept as low as possible, typically below 10^3cfu/g (1,000 cfu/g) for many food products*

 # Colony forming unit, & not detected

Fig. 1. Stages of the process of using restaurant waste to produce a pressed cake from black soldier fly larvae. A. black soldier fly larvae, B. plastic trays containing kitchen waste for feeding larvae, C. dried black soldier fly larvae and D. Pressed cake of black soldier fly larvae

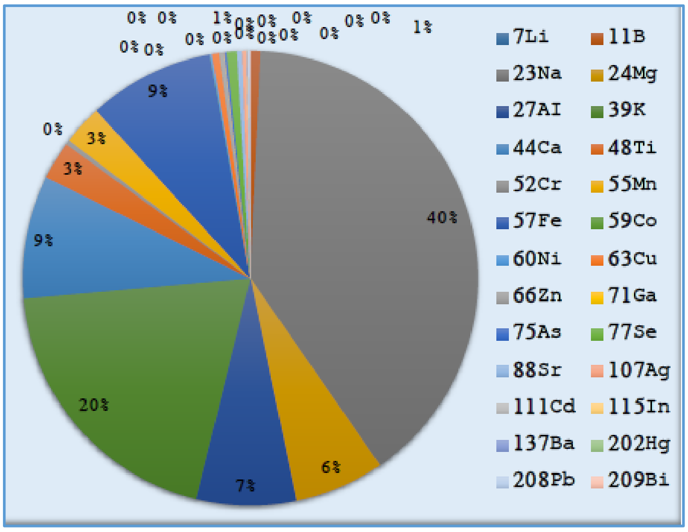

Fig. 2. Minor and major elements of black solider fly larvae (mg kg^{-1} dry weight)

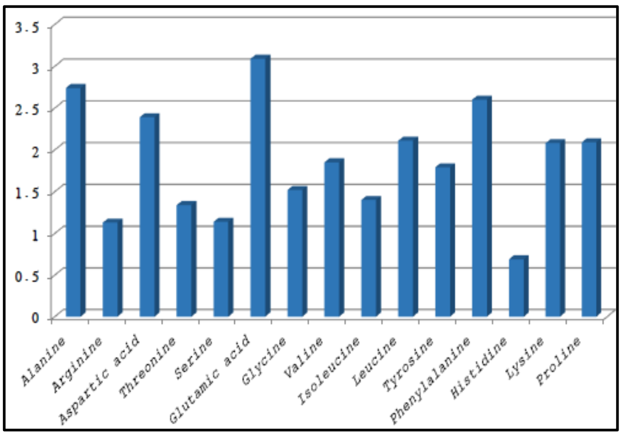

Fig. 3. Amino acid composition of black solider fly larvae

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التركيب الكيميائي والأحماض الدهنية والأحماض الأمينية والمحتوى المعدني ليرقات ذبابة الجندي الأسود المربا علي نفايات المطاعم

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الملخص

تعد يرقات ذبابة الجندي الأسود من بين الأنواع الأكثر نشاطًا في الإنتاج نظرًا لتأثيرها البيئي المنخفض وفوائدها الغذائية. يمكن زراعتها وحصادها بدون مرافق مخصصة ولا تعتبر آفات. علاوة على ذلك، يمكنها تحويل النفايات العضوية إلى كتلة حيوية قيمة، بما في ذلك البروتينات والدهون والكيتين، مع إختلاف التركيبة إعتمادًا على الركيزة التي تتغذى عليها. وفي هذه الدراسة، تمت تربية اليرقات على مخلفات المطاعم، والتي شملت بقايا الطعام المقلية (مثل الدجاج واللحوم والأسماك)، وقشور البطاطس، وبقايا الجزر، والأرز، وبقايا الخبز. تم تجفيف عينات اليرقات للتحليل الكيمائي، الذي قام بتقييم نسبة البروتين، ونسبة الدهون، ومحتوى الرطوبة، والفلافونويد، والأحماض الأمينية، والأحماض الدهنية، والمحتوى المعدني، والخصائص الميكروبيولوجي لـليرقات.وفق للنتائج، تضمنت الكتلة الحيوية الجافة ليرقات ذبابة الجندي الأسود 33.90 % بروتين خام، و45.37% دهون، و0.95% أحماض فيتيك و12.43% ألياف. بالإضافة إلى إجمالي الفلافونويدات الذي بلغ 892.4 جزء في المليون، بلغ محتوى الرطوبة 66.00%. كانت الأحماض الأمينية الأساسية الموجودة بأعلى تركيز ات هيفينيلألانين، وليوسين، وليسين، إلى جانب أحماض أمينية غير أساسية مثل حمض الجلوتاميك والألانين. وقد وُجد أن حمض الأوليككان أكثر الأحماض الدهنية غير المشبعة شيوعًا، بينما كان حمض الوريقة والحمض الدهني المشبع الرئيسي. كانالصوديوم (Na) أكثر المعا دن وفرة في اليرقات (40%). يؤكد هذا البحث على أهمية هذه الحشرة كمصدر بروتين مستدام، بالإضافة إلى أهمية إستخدامها كبديل للأعلاف الغنية بالبروتين كتصنيع أعلاف الدواجن.

الكلمات الدالة: ذبابه الجندي الاسود، التحليل الكيمائي، الأحماض الأمينية ، الأحماض الدهنيه ، العناصر المعدنية.