

Fatty Acid Composition in Larva, Pupa, Adult and Prey of Mud-Dauber Wasp, *Sceliphron destillatorium* (Hymenoptera: Sphecidae)

Çamur Yuva Yapan Yaban Arısı, *Sceliphron destillatorium* (Hymenoptera: Sphecidae)'un Larva, Pupa, Ergin ve Avlarının Yağ Asidi Kompozisyonu

Research Article

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ABSTRACT

Fatty acid composition of larvae, pupae, and adults of the mud-dauber wasp, *Sceliphron destillatorium* Illiger 1807, as well as spiders obtained from its nests was investigated for the first time. All samples were obtained from mud nests of the wasp collected from the field. Adults of this insect feed on nectar of flowers but their larvae feed on spiders. Totally 15 fatty acids were identified and quantified by GC-FID in analyzed samples. The highest of all fatty acids is oleic acid which was found as: 43.87%, 42.43%, 48.69%, and 43.88% in larvae, pupae, adult, and the spiders respectively. Fatty acid compositions in larvae, pupae, and spiders were found close to each other. Alpha linolenic acid was determined in larva, pupa, and spider but not in adults, so it seems to be essential fatty acid for this wasp species. The data obtained are usable to reveal the relationship between fatty acid composition and nutrition or physiological events in insects.

Key Words

Sceliphron destillatorium, fatty acids, Sphecidae, Hymenoptera.

ÖZ

Çamur yuva yapan yaban arısı *Sceliphron destillatorium* türünün larva, pupa ve erginleri ile yuvalarından alınan örümceklerin yağ asit kompozisyonu ilk kez incelenmiştir. Numuneler araziden toplanan yabanarısı yuvalarından elde edilmiştir. Bu böceğin erginleri çiçekli bitkilerin nektarı ile larvaları ise örümceklerle beslenmiştir. İncelenen örneklerde toplam 15 yağ asidi tanımlanmış ve miktarları GC-FID ile ölçülmüştür. Bu yağ asitleri arasında en yüksek miktarda olan oleik asit larva, pupa, ergin ve örümcekte sırasıyla şu şekilde bulunmuştur: %43.87, %42.43, %48.69 ve %43.88. Larva, pupa ve örümceklerde yağ asidi kompozisyonu birbirine oldukça yakın bulunmuştur. Alfa linolenik asit larva pupa ve örümcekte tespit edilmiş ancak erginlerde bulunamamıştır, bu nedenle bu böcek türü için temel görünmektedir. Elde edilen veriler böceklerde yağ asit kompozisyonunun beslenme veya fizyolojik olaylarla ilişkilerini belirlemek için kullanılabilir.

Anahtar Kelimeler

Sceliphron destillatorium, yağ asitleri, Sphecidae, Hymenoptera.

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INTRODUCTION

Fatty acids play an important role in insect life such as supplying energy, constructing body components as well as transforming to other physiologically important compounds [1-5]. Nutrition, metabolism, reproduction and many other factors affect fatty acid composition, so that the same insect species may have different fatty acid composition through its development [5-6]. In addition to dietary lipids some carbohydrates are also converted into fatty acids and triglycerides for long-term energy requirements [1,8]. Fatty acid requirement may differ among insects and their developmental stages. Linoleic and linolenic acids are thought to be essential for insects as in most of the animals (Gilbert and Chino, 1974; Canavoso et al., 2001). But de novo synthesis of linoleic acid has been shown in many of the insect species [4,8-12].

S. destillatorium is a solitary wasp belonging to the Sphecidae family (Insecta: Hymenoptera). Members of this species live in temperate regions all over the World which construct mud nests and so are commonly known as "mud-dauber wasps". Most people are familiar to these large and conspicuous wasps since they frequently locate their nests close to human habitations. Adult wasps feed on nectar of various flowers but they paralyze spiders and carry them to the nest to provision for their larvae [13]. During development larvae eat spiders provisioned by their mother, thus contribute to the preservation of ecological balance in the nature.

Determination of fatty acid composition of an insect's larva, pupa, adult, and the food material in its natural habitat will provide more accurate data to reveal the relationships between its chemical constituents and physiological or metabolic events. Most of the previous studies have dealt with laboratory-reared insects. To our knowledge, there has been no study on the wasp *S. destillatorium*. Therefore, in this study it is aimed to analyze fatty acid composition of larva, pupa, adult, and prey of the species as well as to determine its essential fatty acids.

MATERIALS and METHODS

Collection of Samples

15 mud nests of *S. destillatorium* were collected from their natural habitats, such as under balconies, attics, and barns, from Samsun (Çarşamba and Terme) and Amasya (Taşova) provinces between June-July 2014. Nests were brought to the laboratory in sterile plastic bags. Larvae, pupae, paralyzed spiders, and emerging adults were taken from the mud nests in laboratory. Nine samples for each group (larva, pupa, spider, adult) were separated in threes for further analysis. Adult wasps were fed with sugar and water for ten days prior to extraction. Whole bodies of samples were used for extraction and fatty acid analyses.

Extraction Procedure

Larva, pupa, spider, and adult wasp samples were placed in distinct tubes. Before analysis, each sample was disintegrated under liquid nitrogen. After removing nitrogen, crude oil was obtained from disintegrating parts with light petroleum ether (b.p. 40-60°C) in a Soxhlet. The solvent was removed using rotary evaporator. The extracted oil was used for fatty acids analysis. The oils were saponified by the usual procedure according to the Standard IUPAC methods [14]. Fatty acids were esterified using official methods [15].

GC Procedure for Fatty Acids

Gas chromatographic (GC) analyses were performed using a Perkin Elmer Clarus 500 Series GC system, in split mode, 50:1, equipped with a flame ionization detector (FID) equipped TR-FAME apolar capillary column (30 m x 0.25 mm and 0.25 m ID). Helium (0.5 mL/min) was used as carrier gas. The injector temperature was set at 250°C and the FID was operated at 260°C. An initial column oven temperature of 100°C was elevated to 220°C at a rate of 2°C/min and held for 0 min. Identification of fatty acid components was accomplished based on comparison of their retention times with those of authentic standards (Supelco 37 Comp. Fatty acid Mix, 18919). The relative peak area percentages of compounds were calculated based on the FID data.

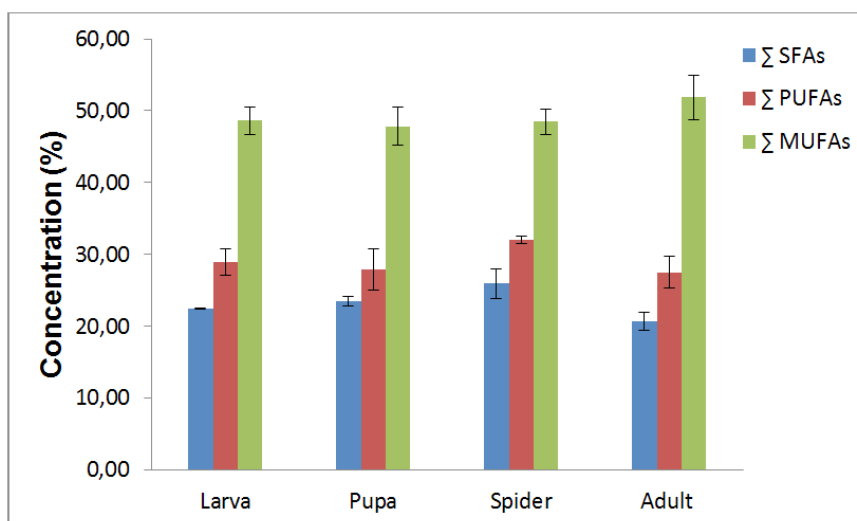


Figure 1. Saturated (SFA) and Unsaturated (MUFA, PUFA) fatty acid concentrations in larva, pupa, adult, and prey (spider) of *S. destillatorium*.

Statistical Analysis

The means of three groups were compared through Duncan's Multiple-Range Test after all data were subjected to analysis of variance (Anova). Two group means were compared Paired-Samples T Test using SPSS statistical package (Norusis, 2002).

RESULTS

Totally 15 fatty acids were identified and quantified in analyzed samples, of which oleic and linoleic acids comprise over 60% (Figure 1). In adult insects total saturated fatty acid (SFA) concentration is lower but monounsaturated fatty acid (MUFA) concentration is higher than larva, pupa, and the spider, prey. The high MUFA level in adults is most probably due to high oleic acid level. Nevertheless, the difference between adults and others in terms of SFA and MUFA is not statistically significant (Table 1).

Polyunsaturated fatty acid (PUFA) concentration was found highest in spider but lowest in adults and the difference between them is significant statistically. It was slightly different between larva, pupa, and spider which is not significant statistically.

Palmitic acid has the highest concentration among SFA in larva, pupa, adult, and spiders. Palmitic and stearic acid concentrations in spider are higher from that of larva and pupa but the

differences are not significant statistically. These fatty acid concentrations are the lowest in adults and its difference from the prey is significant statistically (Table 1). Most probably larva obtained palmitic acid from its prey, spider, which is then transferred to the pupa. Adults should have synthesized it de novo, since they were fed only with sugar and water. Stearic acid is known to be synthesized from palmitic acid by means of chain elongation [16,17].

The amount of oleic acid was the highest in adult and its difference from larva, pupa, and the prey is statistically significant. Its content in larva, pupa, and prey was close to each other. Palmitoleic and linoleic acid concentrations are close to each other in larva, pupa, and spider but are low in adults and the difference is statistically significant.

Alpha linolenic acid was determined in larva, pupa, and spider but not in adults, so it is essential for *S. destillatorium*.

Gamma linolenic and eicosatrioneic acids were not identified in larva, pupa, and prey however the former was 5.23% and the latter was 4.97% in adults. Therefore these fatty acids seem to be non-essential for this species.

Table 1. Fatty acid composition (%) of *S. destillatorium* larva, pupa, adult and prey (spider).

| Fatty acids | Developmental Stages and Prey of <i>Sceliphron destillatorium</i> | | | |
|--------------------------|---|-----------------|----------------|----------------|
| | Larva | Pupa | Adult | Spider |
| C12:0 Lauric | 0.13 ± 0.06 ab | 0.4 ± 0.07 b | ND | 0.28 ± 0.14 ab |
| C14:0 Myristic | 0.85 ± 0.03 b | 1.31 ± 0.11c | 0.57 ± 0.06 ab | 1.03 ± 0.06 bc |
| C16:0 Palmitic | 14.59 ± 0.36 a | 13.60 ± 0.22 ba | 10.59 ± 0.97 b | 16.61 ± 1.44 a |
| C17:0 Heptadecanoic* | 0.40 ± 0.04 a | 0.53 ± 0.02 b | ND | ND |
| C18:0 Stearic | 6.36 ± 0.38 a | 6.47 ± 0.22 a | 4.47 ± 0.01 b | 7.23 ± 0.17 a |
| C20:0 Arachidic | 0.19 ± 0.19 | 0.84 ± 0.08 | 1.02 ± 0.51 | 0.77 ± 0.13 |
| C21:0 Heneicosanoic | 0.11 ± 0.05 a | 0.13 ± 0.06 a | 2.81 ± 0.36 b | ND |
| C22:0 Behenic* | ND | ND | 0.84 ± 0.42 a | ND |
| Σ SFAs | 22.45 ± 0.08 | 23.44 ± 0.70 | 20.63 ± 2.10 | 25.93 ± 1.23 |
| C16:1 Palmitoleic | 3.80 ± 0.59 a | 3.48 ± 0.19 a | 1.15 ± 0.05 b | 3.69 ± 0.83 a |
| C18:1n9c Oleic | 43.87 ± 1.19 b | 42.43 ± 3.15 b | 48.69 ± 1.69 a | 43.88 ± 3.55 b |
| C22:1n9 Erucic | 0.92 ± 0.15 b | 1.94 ± 0.28 a | 1.69 ± 0.12 a | 0.91 ± 0.10 b |
| Σ MUFAs | 48.60 ± 1.88 b | 47.85 ± 2.69 b | 51.89 ± 1.82 a | 48.45 ± 3.10 b |
| C18:2n6c Linoleic | 21.20 ± 0.41 a | 22.22 ± 1.68 a | 15.73 ± 0.53 b | 19.26 ± 2.32 a |
| C18:3n3 Alpha Linolenic | 6.18 ± 1.18 | 3.99 ± 0.55 | ND | 4.10 ± 1.30 |
| C18:3n6 Gamma Linolenic | ND | ND | 5.23 ± 0.02 b | 0.17 ± 0.08 a |
| C20:3n3 Eicosatrienoic* | ND | ND | 4.97 ± 0.30 a | ND |
| C20:5n3 Eicosapentaenoic | 1.38 ± 0.30 | 2.61 ± 0.52 | 1.54 ± 0.03 | 1.77 ± 0.27 |
| Σ PUFAs | 28.95 ± 1.81 ab | 27.92 ± 2.89 ab | 27.47 ± 0.49 b | 31.97 ± 2.20 a |

The values are shown as mean ± SD. Different superscript letters within a line differ significantly (Duncan, p 0.01).

*Analyzed by t-test (p 0.01). ND: Not detected.

SFAs, saturated fatty acids; UFAs, unsaturated fatty acids; and PUFAs, polyunsaturated fatty acids.

DISCUSSION

It has been demonstrated that Stearoyl Coenzyme Desaturase (SCD) catalyzes the biosynthesis of monounsaturated fatty acids (MUFAs, i.e. palmitoleic acid, C16:1n-7; oleic acid, C18:1n-9) from saturated fatty acids (SFA, i.e. palmitic acid, C16:0; stearic acid, C18:0) that are either synthesized de novo or derived from the diet [18,19]. The results of our study suggest that larva and pupa have acquired palmitoleic and linoleic acids from the prey but they were biosynthesized in adults from palmitic and stearic acids. Although linoleic acid is stated to be essential for many insects [20,21] it seems not essential for *S. destillatorium* and most probably was synthesized from dietary carbohydrates in adults. Visser et al. [22] has reported lipogenesis in adult insects belonging to Apoidea based on morphological and molecular data.

Shimizu et al. [23] stated that linoleic acid is converted to arachidonic acid, a precursor of prostaglandins and other physiologically important eicosanoids by chain extension and desaturation in the endoplasmic reticulum in many animals. The reason for low level of linoleic acid concentration in adults in our study is probably due its conversion to eicosatrienoic acid. Delta-6 and $\Delta 5$ desaturases are required for the synthesis of polyunsaturated fatty acids (PUFAs). $\Delta 6$ desaturation of essential fatty acids, linoleic acid (18:2n-6) and α -linolenic acid (18:3n-3), is the first and rate limiting step in the biosynthesis of n-6 and n-3 polyunsaturated fatty acids (PUFAs). The products of these reactions, γ -linolenic acid (18:3n-6) is elongated to dihomo- γ -linolenic acid (20:3n-6). The fatty acid is then substrate of a $\Delta 5$ desaturase that generates arachidonic acid (20:4n-6) which is further elongated to 22:4n-6 and finally to its respective product, 24:4n-6 [24].

In general fatty acid composition of larva, pupa, and spiders in their nest was found quite similar in this study, indicating that it is closely related to nutrition. According to our results, alpha linolenic acid is thought to be the only essential fatty acid for *S. destillatorium*. However further studies are needed for its preciseness.

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