THERMOGRAVIMETRIC ANALYSIS OF BLACK SOLDIER FLY LARVAE FLOUR

Quethelen Elizabeth Araujo Garcez Rodrigues[1], Lilian Dena dos Santos[2], Marcel Jefferson Gonçalves[1], Carolina Krebs de Souza[1], Vanderleia Botton[1], Jaci Carlo Schramm Câmara Bastos[1], Marcela Kotsuka da Silva[1]

[1] *Chemical engineering Laboratory, Regional University of Blumenau, Blumenau - Santa Catarina – Brazil*
[2] *Zootechnics Laboratory, Federal Unversity of Parana, Maringá, Paraná - Brazil*
* *Corresponding author's email address: que.96@hotmail.com*

ABSTRACT

The study addresses the growing scarcity and unsustainability of animal protein, highlighting the need to seek ecologically viable and economically accessible alternatives. Insects, such as black soldier fly larvae, emerge as a promising solution due to their ability to convert organic waste into nutritious food. However, processing insect flour, especially at high temperatures, can affect its sensory properties. This study aimed to analyze the thermal stability of black soldier fly larvae flour through thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC), providing valuable insights for its application in sustainable foods. Understanding the thermal properties of insect-based ingredients can help optimize their processing methods, contributing to a more sustainable and resilient food system in the future.

Keywords: Black Soldier Fly. Protein. Thermal stability.

1 INTRODUCTION

Animal protein is becoming increasingly inaccessible in developing countries [1]. Additionally, there is a scenario of growing global demand for protein sources, which are produced on arable land and require large amounts of energy and water for their production, making them unsustainable [2].

In light of this, it is necessary to investigate food ingredients that do not compete with human consumption, require less land and resources during production, and promote sustainability [3]. Insects have been considered as ingredients in animal diets, mainly as a protein source, because they are already part of the natural diet of many species and are rich in amino acids, fatty acids, vitamins, and minerals. Additionally, they do not require arable land or large amounts of energy and water for their production [3,4].

In Brazil, the Ministry of Agriculture, Livestock and Supply (MAPA) authorized the use of certain insect species as raw materials in animal feed (Ordinance No. 359 of July 9, 2021), stimulating the development of research to generate standardized products with better characteristics from edible insect flour. Among these species is the black soldier fly (Hermetia illucens (L. 1758)) (Diptera: Stratiomyidae), which is widely distributed around the world, both in tropical regions and temperate areas, and is present in rural, urban, and forest areas [5]. Its larvae have high nutritional potential [6].

The use of insects in food is a response to this need, as larvae can efficiently convert organic waste into nutrient-rich food [7]. However, processing insect flour at high temperatures can negatively affect its sensory characteristics [8]. Therefore, this study aims to analyze the thermal stability of black soldier fly larvae flour.

2 MATERIAL & METHODS

For the thermal stability analysis of BSFL, thermogravimetric analysis (TGA) was conducted using a Perkin Elmer TGA 4000 instrument. The samples were weighed in alumina crucibles and subjected to a heating ramp from 30 to 500°C at a rate of 10°C min-1. An inert atmosphere was ensured with nitrogen at a flow rate of 20 mL min-1. Data acquisition and processing were performed using Pyris 6 software (version 13.3).

To characterize the thermal behavior of the particles, differential scanning calorimetry (DSC) was employed using a Perkin Elmer DSC 6000 instrument equipped with a liquid nitrogen cooling system. BSFL was weighed on a five-decimal-place analytical balance onto suitable aluminum supports. After weighing, the supports were sealed and subjected to heating from 30 to 250°C at 10°C min-1, cooling from 250 to -50°C at 5°C min-1, and heating from -50 to 250°C at 5°C min-1. Pyris 6 software (version 13.3) was used for data control and acquisition.

3 RESULTS & DISCUSSION

The results of the TGA analysis of black soldier fly larvae flour are presented in Figure 1. The first decomposition stage, observed in the temperature range of 50 to 100°C, is attributed to the evaporation of water and other volatile substances [1,9] The second stage, between 150 and 300°C, corresponds to the weight loss related to the decomposition or degradation of proteins and carbohydrates [1,9]. Finally, the third stage, in the range of 450 to 500°C, is associated with the decomposition of peptides [1].

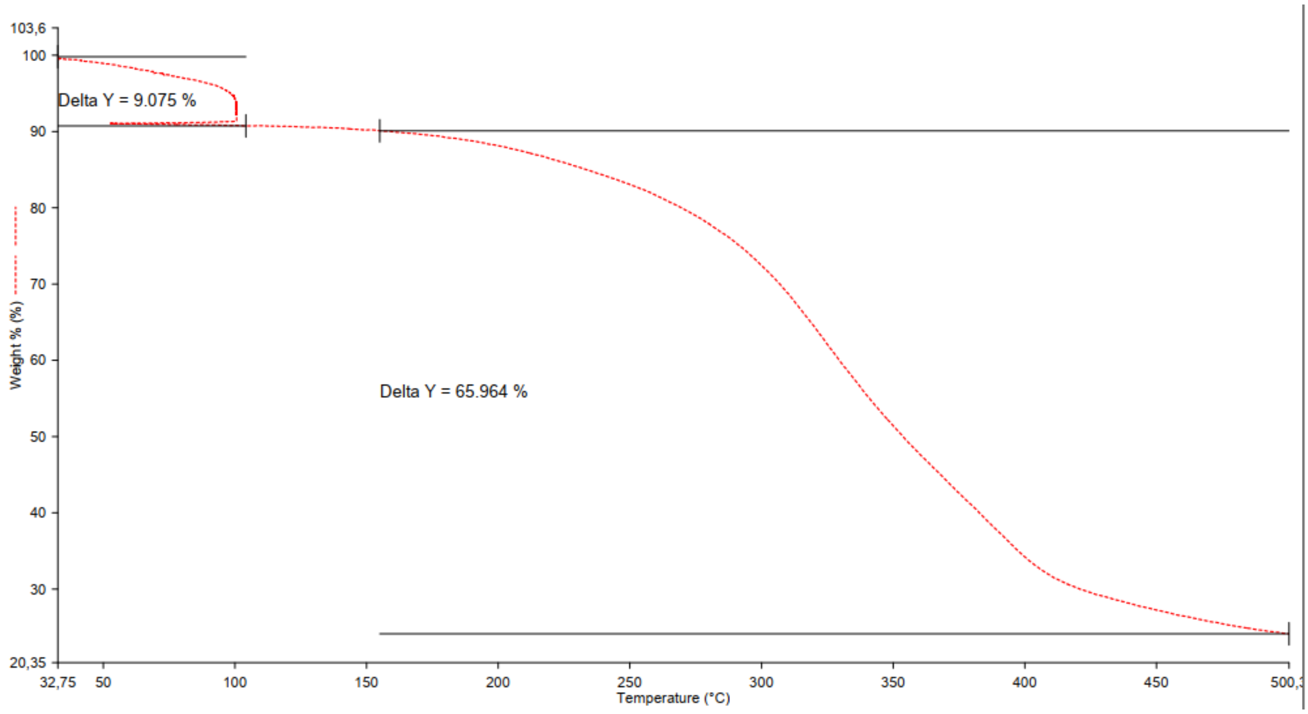

Figure 1 Black soldier fly meal TGA

The DSC curves for black soldier fly larvae flour (Figure 2) depict the heat flow (W/g) as a function of temperature (°C). The recorded curves show a sequence of transitions between -48 to -45°C, indicating the presence of residual water due to the strong hydrophilic behavior of proteins and glycerol [10]. The glass transition (Tg), defined as the temperature at which the bonding forces of molecules are relaxed, is detected as an endothermic change between 20 to 40°C [10,11], which aligns with the results. An exothermic peak is observed in the temperature range between 100-140°C, characteristic of the presence of chitins [11]. The thermograms of black soldier fly larvae flour exhibit an endothermic peak, attributed to the thermal unfolding of proteins at 140-150°C. Additionally, an endothermic peak around 210°C is observed, reported in some studies as the melting point and associated with weight loss [10,11].

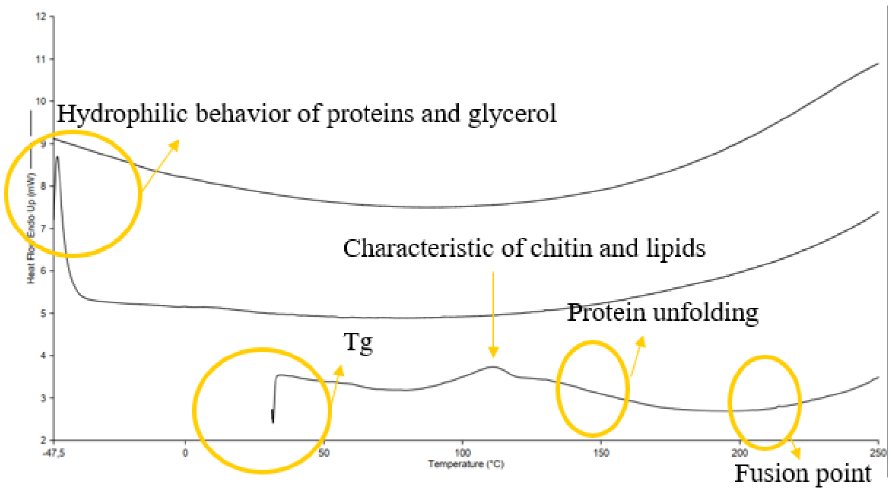

Figure 2 Black soldier fly meal DSC.

The DSC curves of black soldier fly larvae flour reveal patterns of thermal behavior, indicating the presence of residual water, glass transition, and exothermic and endothermic peaks at different temperature ranges. This information is important for developing processing strategies that maintain the nutritional and sensory characteristics of the final product, optimizing its quality and stability.

4 CONCLUSION

The growing inaccessibility of animal protein in developing countries and the unsustainable nature of traditional protein production necessitate the exploration of alternative, sustainable protein sources. Insects, particularly black soldier fly larvae, emerge as a promising solution due to their ability to convert organic waste into nutrient-rich food without the need for arable land or excessive resources. The analysis of the thermal stability of black soldier fly larvae flour conducted in this study provides valuable insights for optimizing processing conditions and maintaining desirable sensory characteristics. By better understanding the thermal properties of these ingredients, we can develop more efficient and sustainable processing methods, thus contributing to the production of more accessible and environmentally responsible foods.

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ACKNOWLEDGEMENTS

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001 and the Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina – FAPESC.