***AGRITEKNO**: Jurnal Teknologi Pertanian*
Versi Online: http://ojs3.unpatti.ac.id/index.php/agritekno *Vol. 12, No. 2, 169-175, Th. 2023 ISSN 2302-9218 (Print) ISSN 2620-9721 (Online)*
DOI: 10.30598/jagritekno.2023.12.2.169 *Terakreditasi RISTEKDIKTI Peringkat SINTA 3, SK. 200/M/KPT/2020*

Functional Properties of Sago Grub Protein Concentrates With Different Initial Drying Methods

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Submitted: 26 Juli 2023; Accepted: 10 Oktober 2023; Published: 31 Oktober 2023

ABSTRACT

The objective of this study was to determine the effects of various initial drying methods on the functional properties of sago grub protein concentrates and characterize their functional properties. In this work, a block randomized design was employed to extract sago grub protein concentration using cabinet dryer, sun, and oven drying methods. The variables observed were the foaming capacity, foaming stability, water holding capacity, and fat absorption capacity of the protein concentrate. Results showed that different initial drying methods of sago grub did not affect the foaming capacity, foaming stability, or fat absorption capacity of the resulting protein concentrates. In contrast, the water holding capacity of the protein concentrates was significantly affected by different initial drying methods on sago grub. Various initial drying methods resulted in the protein concentrates having a foaming capacity of 7.5–12.5%, a foaming stability of 3.5-7.5%, a water holding capacity of 1.9–2.35 mL/g, and a fat absorption capacity of 299.12–306.75%.

***Keywords**: Drying methods; functional properties; protein concentrate; sago*

INTRODUCTION

Traditional dietary proteins have been and are still the subject of much research, to benefit from their nutritional and functional qualities in food formulation. Animal-based proteins have been widely employed in the food industry because of their functional features that help with the formulation of numerous food products, such as emulsifying, gelling, and foaming properties. Examples of these proteins are milk proteins and egg proteins (Kailasapathy, 2015). Due to the damaging consequences of animal production on the environment and their role in the development of degenerative diseases, plant-based proteins, particularly those found in legumes, have gained popularity in recent years (Aiking & de Boer, 2018; Aiking, 2014; Ekmekcioglu *et al*., 2018; Onwezen *et al*., 2021; Westhoek *et al*., 2014). However, plant-based protein lacks in certain amino acids and less digestible (Gorissen *et al*., 2018; Onwezen *et al*., 2021).

Because of these factors, more focus has been placed on using insects as a source of protein in the food industry. Insects have a high protein content (between 40 and 70%), an amino acid profile that complies with WHO essential amino acid standards (WHO, 2007), a good polyunsaturated to saturated fatty acid ratio, and significant amounts of vitamins and minerals. They are also 76–98% more digestible than proteins derived from plants (Rumpold & Schlüter, 2013; van Huis, 2013; Zielińska *et al*., 2018).

The larva of the *Rhynchophhorus ferrugineus* beetle's, one of many edible insects that can be utilized as a source of protein, is also known as a sago grub. Sago grub meets the requirements for 40% of the essential amino acids and 10.39 g of protein per 100 g of fresh weight. It also has a 0.60 ratio of unsaturated to saturated fatty acids (Köhler *et al*., 2020). One species of edible insect that is regularly consumed in Maluku is the sago grub. Sago grubs have also been used to create a number of food products, such as sago grub meatballs and sago grub crackers (Tuhumury *et al*., 2020).

Although eating insects has numerous benefits, it also has drawbacks, such as the fact that many people still do not embrace the idea of eating insects. By isolating and extracting proteins and employing them as a base for the creation of high-protein foods, this problem can be solved. The functional properties of the proteins through their numerous transformation stages must be thoroughly investigated in order to utilise insect proteins in different food products.

In several investigations, extraction techniques such water and hexane extraction have been developed (Ndiritu *et al*., 2017). A frequent technique used in the production of protein concentrates is defatting. However, in order to obtain the best extraction results, a sample drying procedure is necessary because doing so will break down the lipid structure, allowing the organic solvent to more easily permeate the material's structure and extract oil from it in an efficient manner (Maruatona *et al*., 2010).

In order to obtain protein concentrates, various materials have been initially dried before extraction in several research. Examples include the protein concentrates from cow lungs (Yunianto, 2014), cow livers (Kariyanto, 2014), and chicken heads (Tafiany, 2021). Some have been done on insects such as mealworm larvae (Purschke *et al*., 2018).These research' findings indicate that the drying process has an impact on the protein concentrate's functional properties. Gravel & Doyen (2020) also highlighted the importance of drying as an initial step in making insect powder. The initial drying methods have been applied to study the chemical properties of sago grub protein concentrate, and results showed that sago grubs initially dried with the cabinet dryers produce protein concentrates with the best chemical characteritics (Talakua *et al*., 2023). It is therefore the objective of this study was to determine the effects of various initial drying methods on the functional properties of sago grub protein concentrates and characterize their functional properties.

RESEARCH METHODS

Materials

Sago grubs from Negeri Hutumuri, South Leitimur District, Ambon City, Maluku Province, were used as the study's main source of material. Chloroform-technical (Sinka), hexane-technical (Sinka), distilled water, H_2SO_4 (Merck), HCl (Merck), and NaOH (Merck) were among the chemicals utilized.

Research Procedures

Sago grubs were cleaned using distilled water, and the head was removed. Then the sago grubs were placed in a tray and dried according to the treatment, namely drying using a cabinet dryer (50 °C for 24 hours) with air flow velocity of 3 m/sec, sun drying (24 hours) with average temperature of 30°C, and oven (Modena) with air flow 6 L/min drying (50 °C for 24 hours). After that, it was pulverized using a blender and extracted using hexanes. Hexane extraction was carried out by mixing dried sago grubs with hexane in a ratio of 1:5. The mixture was homogenized with a mechanical shaker for 16 hours and filtered. The residue was then washed with hexanes to remove the fat content. The mixture was filtered again, and the residue was dried at room temperature and stored at 25°C. The variables observed included:

Foaming Capacity (Makri *et al*., 2005)

10 g of protein concentrate in 100 mL of suspension water was mixed for 2 minutes with a blender (Miyako) at speed 2. The volume of the initial solution (V1) was measured, and the volume after mixing was measured (V2) (Formula 1).

$$\text{Foaming capacity} = \left(\frac{V2-V1}{V1}\right) \times 100 \qquad \dots (1)$$

Foaming Stability (Makri *et al*., 2005)

10 g of protein concentrate in 100 mL of suspension water was mixed for 2 minutes with a blender (Miyako) at speed 2. The volume of the initial solution (V1) was measured, and the volume after mixing (V2) and rested for 5 minutes was measured (V3) (Formula 2).

$$\text{Foaming stability} = \left(\frac{V3-V2}{V1}\right) \times 100 \qquad \dots (2)$$

Water Holding Capacity (WHC)

1 g of sample was put in a centrifuge tube, and 3 mL of water was added. The sample was centrifuged (Hettich EBA 20, Germany) for 10

minutes at 2060 rpm. The volume of the supernatant was measured (Formula 3).

$$WHC = \frac{volume\ of\ water\ added - volume\ of\ supernatant}{sample\ weight} \quad \ldots (3)$$

Fat Absorption Capacity (FAC)

A 0.3-g protein concentrate sample was put in a 50-mL centrifuge tube that had been previously weighed and mixed with 3 mL of corn oil for 3 minutes. Then, after centrifuging (Hettich EBA 20, Germany) for 30 minutes at 2060 rpm, the supernatant was discarded and the centrifuge tube was reweighed (Formula 4).

$$FAC = 100 \times \frac{(sample\ weight + oil)}{sample\ weight} \quad \ldots (4)$$

Sample weigh + oil = $tube\ weight\ after\ centrifuge - tube\ weight\ before\ centrifuge + 0.3\ g$ … (5)

Data Analysis

The data obtained were analyzed statistically using analysis of variance (ANOVA) based on a randomized block design, followed by the Tukey test at the 95% confidence level (α 0.05).

RESULTS AND DISCUSSION

Foaming Capacity

The results of the analysis of variance showed that the way the sago grub were dried the first time didn't make a big difference (P > 0.05) in how well the resulting protein concentrate could foam. The average foaming capacity value of sago grub protein concentrates with various initial drying methods ranged from 7.5–12.5% (Figure 1). The protein concentrates from oven-dried sago grub produced the lowest foaming capacity (7.5%), while the cabinet dryer drying treatment produced the highest foaming capacity (12.5%).

The amount of interphase area that the protein can produce when whipped determines its foaming capacity. Heating the protein to partial denaturation usually improves the foaming characteristics. The structure of the protein will open up and show its hydrophobic side. This makes it easier for the protein to be absorbed in the space between the air and water, which lowers the tension between the two phases, catches more air, and makes the foaming capacity higher (Mauer, 2003).

According to Ndiritu *et al*. (2017) and Torruco-Uco *et al*. (2019), the foaming capacity of hexane-extracted protein concentrate from locusts and crickets was approximately 6.17% and 1.42%, respectively, while it was only about 61% for soybeans (Chove *et al*., 2007). This demonstrates that the sago grub protein concentrate's foaming capacity value, when initial drying techniques were varied, was slightly better than cricket protein concentrate but still less than soybean that was much higher, since soybean was determined as protein isolate not protein concentrate. Lower values for foaming capacity are undesirable. Therefore, the sago grub protein concentrate obtained using these initial drying techniques is still not suitable for use as a foaming agent in the food product.

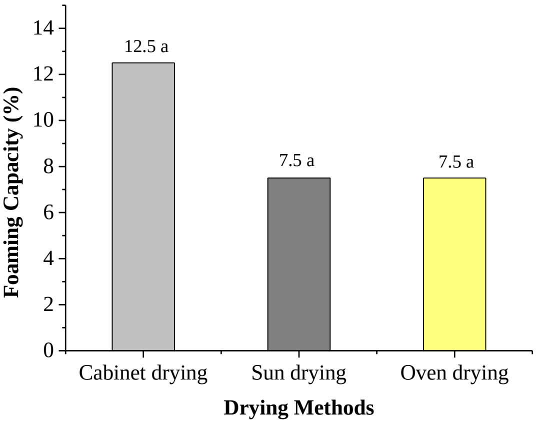

Figure 1. Foaming capacity of sago grub protein concentrate with various initial drying methods

Foaming Stability

An ingredient's capacity to produce a stable foam is known as foam stability. The amount of time needed to lose 50% of the liquid or 50% of the foam volume is known as foam stability. The analysis of variance results revealed that the differences in the initial drying techniques had no significant impact (P > 0.05) on the foam stability of the sago grub protein concentrate. With various initial drying techniques, the average foam stability value of sago grub protein ranged from 3.5-7.5% (Figure 2). Sago grubs dried in an oven generated the least stable foam (3.5%), whereas those dried in a cabinet drier created the most stable foam (7.5%).

The foam stability of cricket protein concentrate was 1.26% (Ndiritu *et al*., 2017), soybean was 21% (Chove *et al*., 2007), and locust was 7.13% (Torruco-Uco *et al*., 2019). Foam formation is necessary for products such as beverages and foods topped with whipping cream. So, sago grub protein concentrate made with these initial drying methods needs to be further processed to reduce the amount of fat in it so that it can foam better and stay stable. Otherwise, it can't be used as an ingredient in the products above.

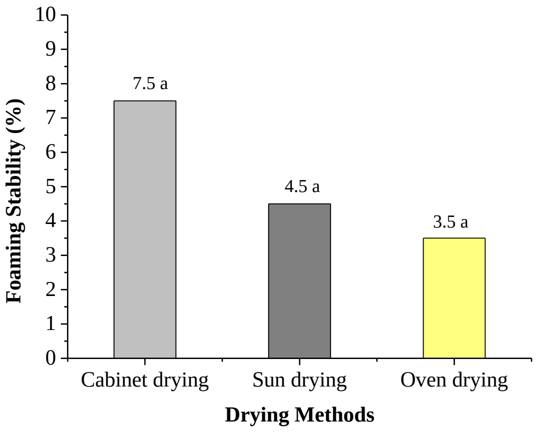

Figure 2. Foaming stability of sago grub protein concentrate with various initial drying methods

Water Holding Capacity

The results of the analysis of variance showed that the variation in the initial drying methods had a very significant effect ($P < 0.01$) on the water holding capacity of sago grub protein concentrate. Figure 3 shows that the average amount of water that sago grub protein concentrates could hold when they were first dried ranged from 1.9 to 2.35 mL/g. Sago grub with the cabinet drying method produced the protein concentrates with the lowest water holding capacity (1.9 mL/g), which was significantly different from oven drying but not different from sun drying, while the oven drying treatment produced the highest water holding capacity (2.35 mL/g).

The water holding capacity of cricket protein concentrate was about 2.03 mL/g (Ndiritu *et al*., 2017), mealworms about 1.87 mL/g, and Grylliidae sp. concentrate about 2.38 mL/g (Adebowale *et al*., 2005). The important water-holding capacity of protein concentrates is desirable for products that require water retention, such as meat products and bakery products. Differences occur due to differences in the amino acid profile, protein concentration, charge characteristics, and conformation of protein concentrates. Different drying methods affect the above-mentioned characteristics. The increased ability of side chains and polar groups exposed on the protein to form hydrogen bonds with water is thought to be the cause of the increased water holding capacity (Stone *et al*., 2015). In comparison to cabinet drying and solar drying, the unfolding of the protein during oven drying exposes its polar group to hydrogen bonding to a greater extent, hence the higher the water holding capacity.

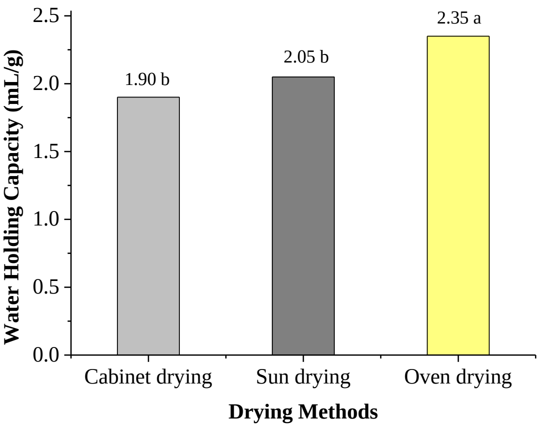

Figure 3. Water holding capacity of sago grub protein concentrate with various initial drying methods

Fat Absorption Capacity

The analysis of variance showed that the different ways of drying the sago grubs at the beginning didn't make a significant difference ($P > 0.05$) in how well the protein concentrate could absorb fat. Figure 4 shows that the average value of the fat-absorbing ability of sago grub protein concentrate dried in different ways ranged from 299.12 to 306.75%. Sago grub dried with the cabinet dryer drying method produced the lowest fat absorption capacity (299.12%), while the oven drying treatment produced the highest fat absorption capacity (306.75%).

The ability of cricket protein concentrate with hexane extraction to absorb fat was 337.24% (Ndiritu *et al*., 2017), compared to mealworm

(Zhao *et al*., 2016) and *Cirinia forda* (Osasona & Olaofe, 2010) concentrates at 178.7% and 233%, respectively. With different drying techniques, the sago grub protein concentrate's ability to absorb fat was still greater than that of mealworms but less so than that of crickets. According to various research findings, this is due to the varying availability of amino acids with non-polar side chains (Ndiritu *et al*., 2017). Therefore, the availability of non-polar side chains in the final protein concentrations might not alter according on the initial drying techniques used on sago grub. Protein concentrates with high fat absorption capacities have the potential to enhance processed food flavors.

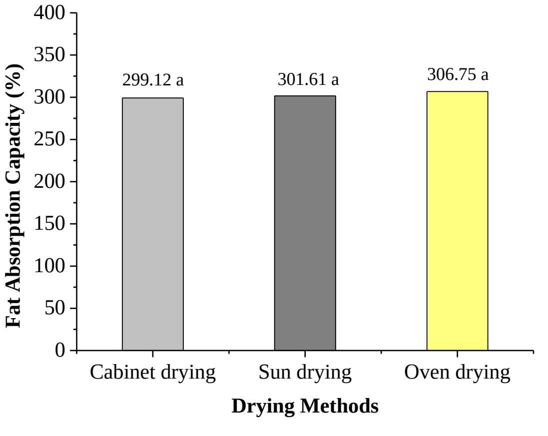

Figure 4. Fat absorption capacity of sago grub protein concentrate with various initial drying methods

CONSLUSIONS

Different initial drying methods of sago grub did not affect the foaming capacity, foaming stability, or fat absorption capacity of the resulting protein concentrates. In contrast, the water holding capacity of the protein concentrates was significantly affected by different initial drying methods on sago grub. Various initial drying methods resulted in the protein concentrates having a foaming capacity of 7.5–12.5%, a foaming stability of 3.5-7.5%, a water holding capacity of 1.9–2.35 mL/g, and a fat absorption capacity of 299.12–306.75%.

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DOI: 10.30598/jagritekno.2023.12.2.169 *Terakreditasi RISTEKDIKTI Peringkat SINTA 3, SK. 200/M/KPT/2020*

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