G-Tech : Jurnal Teknologi Terapan
Vol. 9, No. 3, July 2025, p. 1657-1663
E-ISSN: 2623-064X | P-ISSN: 2580-8737

Proximate Characteristics of Tofu Dregs Flour as an Alternative Food Ingredient

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Article Information

Article History

Received : June 20, 2025
Revised : July 15, 2025
Published : July 26, 2025

***Keywords*:**

Alternative Food;
Tofu Dregs;
Ingredients.

ABSTRACT

Tofu dregs is an abundant waste from food production that is often not optimally utilized. In fact, tofu dregs have the potential to become an alternative food source if done in accordance with the ideal processing process and supported by the characterization of its nutritional content. This study aims to assess the chemical characteristics of tofu dregs flour through proximate analysis. The parameters analyzed included moisture content, ash, fat, protein, and carbohydrate by difference. Tofu dregs samples were obtained from tofu artisans in Bogor Regency, then dried, ground, and analyzed through the laboratory. The research was exploratory in nature using two replicates. The results showed that the moisture content of tofu dregs flour was 8.49 ± 1.34%, ash content 2.81 ± 0.19%, fat 7.86 ± 0.21%, protein 17.32 ± 0.27%, and carbohydrate by difference 63.53 ± 1.09%. The high protein content indicates that most of the soybean protein fraction is still left in the dregs. The low moisture content means the potential microbiological resistance of tofu bagasse flour during storage. These findings confirm that tofu dregs flour has promising nutritional value and it can be further developed as a sustainable ingredient for high-protein and fiber-rich food formulations. This will thereby contribute to waste reduction and functional food innovation.

INTRODUCTION

The issue of food security is very crucial in every country including Indonesia, because it includes guaranteeing the community, one of which is available and affordable food. Food security according to Law of the Republic of Indonesia No. 18 of 2012 is a condition of fulfilment of food for the state to individuals, which is reflected in the availability of sufficient food, both in quantity and quality, safe, diverse, nutritious, equitable, and affordable and does not conflict with religion, beliefs, and culture of the community, to be able to live healthy, active, and productive lives in a sustainable manner. One potential yet underutilized strategy to strengthen food security is optimal use of agricultural-by products. Tofu is one of the most popular dishes among Indonesians. It made from soya beans and known as plant-based source of protein in levels ranging from 6-12% (Khofipah et al. 2023). However, its production actually generates a significant amount of tofu dregs, which is can reach 37 kg per day (Sagita et al., 2024).

These tofu dregs are often directly discarded or only used for low-value purposes such as for making tempe gembus and oncom (Sari et al. 2023). If disposed of immediately, then it can contribute to environment pollution and produce unpleasant odors (Zaki et al. 2023). In fact, tofu

dregs still contain valuable nutrients. Even if it through simple processing such as drying and grinding, it can be converted into tofu dregs flour or commonly referred to as okara. This processed form has greater shelf stability and it opens up wider possibilities for using it in food formulations (Rahayu et al. 2016). To support its utilization, then proximate characteristics including moisture, ash, protein, fat, and carbohydrate are essential as a basic step to determine its nutritional value.

Several previous studies have discussed the potential of tofu dregs in food product formulations, such as sweet bread, cookies, and sponge cake (Ayunir et al. 2017; Sakinah et al. 2019; Athiyyah 2021; Kurniasari 2024). However, these studies have mostly focused on product development, and comprehensive analysis of the proximate characteristics of tofu dregs flour as raw material is still very limited. This represents a gap in the current literature, particularly the lack fundamental data needed to support the wider use of tofu dregs flour as functional ingredient. Therefore, this study aims to analyze the proximate characteristics of tofu dregs flour by measuring its moisture content, ash, fat, protein, and carbohydrate fat, protein, and carbohydrate by difference. The results are expected to serve as foundational nutritional data and to support its future development as an alternative, nutritious, and sustainable food ingredient

RESEARCH METHODS

Location

The sampling location of the tofu dregs was carried out at the house of one of the Bandung tofu craftsmen 'Anshor' located on Jalan Cibanteng project, Bogor district, West Java. The research was conducted at the SEAFAST Center IPB pilot plant laboratory for the drying process of tofu dregs, while the technopark laboratory of the faculty of agricultural technology of IPB for the manufacture of tofu dregs flour, and the laboratory of the ITP-Fateta department of IPB for the analysis of the chemical characteristics of tofu dregs flour.

Materials And Tools

The material used was fresh tofu dregs. Materials used for analysis were hydrochloric acid solution, potassium sulfate, mercury (II) oxide, concentrated sulfuric acid solution, sodium hydroxide solution, boric acid, 60% NaOH-5% Na2S2O3 solution, methylen red-methylen blue indicator, hexane solvent, and distilled water. Tools used were 60 mesh sieve, cabinet dryer (Pilot plant engineering & equipment GmbH 6072 Dreieich - West Germany), disc mill (Fukuta 3-Phase Induction Motor), refrigerator and freezer, analytical balance, desiccator, water bath, drying oven, furnace, deconstruction apparatus, distillation apparatus, titration apparatus, soxhlet extraction apparatus (condenser and fat heater), and glassware.

Analysis Procedure

Proximate analysis for parameters of moisture content and fat content refers to SNI 01-2891-1992, ash content refers to AOAC 923.03 (2012), protein content refers to AOAC 960.52 (1995), and carbohydrate content is calculated by difference. This research was conducted with two replicates and duplo.

RESULTS AND DISCUSSION

Proximate analysis is one approach that can be used to measure the nutritional composition of food. This analysis includes the determination of moisture, ash, protein, fat, and carbohydrate content, which are the main indicators of the nutritional value and stability of a food. The analysis results showed that the moisture content of tofu dregs flour was 8.49 ± 1.34%;, the ash content of tofu dregs flour was 2.81 ± 0.19% (wt); the protein content of dregs flour was 17.32 ± 0.27%; the fat content of tofu dregs flour was 7.86% ± 0.21%, and the percentage of carbohydrates by difference in tofu dregs flour was 63.53 ± 1.09% (Table 1).

Table 1. Chemical composition (%bk) of tofu dregs flour

Chemical composition	Content (%bk)
Water	8,49 ±1,34
Ash	2,81 ±0,19
Fat	7,86±0,21
Protein	17,32±0,27
Carbohydrate by difference	63,53± 1,09

Values shown are the mean of duplicates and standard deviation

Moisture Content

Moisture content is an important indicator to determine the stability of a food. High moisture content generally correlates with a decrease in food shelf life, one of which is due to microorganism damage. The analysis results showed that the moisture content of tofu dregs flour was 8.49 ± 1.34% (Table 1). When compared to the SNI of maximum wheat flour moisture content of 14.5% (2009), the moisture content of tofu dregs flour tends to be low. This indicates that the drying process of tofu dregs is effective in reducing moisture so that the shelf life tends to be longer. This finding is in line with the research result from Kementerian Kesehatan Republik Indonesia (2017), who reported that the moisture content of tofu dregs flour around 9% as well as with Rahmawany and Ginting (2021), who found a value og 8.46%. Hasnelly et al. (2020) has also reported that flour has high durability because it has low moisture content, while Lestary et al. (2019) found that the flouring process enhances the durability of cassava flour.The low moisture content of tofu dregs flour expands the opportunity to be formulated in the dough of processed dry food products.

Ash content

Ash content shows an indicator of the high and low total minerals or inorganic materials contained in a food ingredient (Hasnelly et al. 2020). The analysis results showed that the ash content of tofu dregs flour was 2.81 ± 0.19%. The ash content value shows that the tofu dregs still contain mineral components even though it has gone through a separation process from soya juice in the process of making tofu liquid. The high ash content (exceeding the maximum ash content limit for wheat flour of 0.7%) indicates that the flour has the potential to be a source of micronutrients in the formulation of a food product. The result was quite different from Ginting et al. (2024) who found ash content around 4.8% while Sari and Syamsudin (2019) reported a much lower value of approximately around 0.7%. Such variation may be attributed to differences in soybean quality, including the variety used, soil mineral content, and also the tofu production or drying methods employed. In addition, the particle size distribution of tofu dregs flour can also influence ash content. Typically, finer particles that pass through sieves tend to have lower specific gravity and reduced ash content compared to the coarser fractions retained on the sieve. This is likely due to the finer particles containing fewer mineral-rich components such as cell wall residues or soybean skin fragments, which tend to remain in the coarser fraction.

Wagiyono and Fadholi (2022) explained that single sieving separates the material into two parts: material that is the same size as or smaller than the sieve holes passes through and is located at the bottom (undersize), and material with larger particle sizes is retained at the top of the sieve (oversize). Ratana-airporn dan Chirapart (2006) reported that the difference in ash content is influenced by the mineral content in this case the mineral elements in the sample. Although a high ash content can be beneficial in terms of micronutrient contribution, it is important to consider its impact on product acceptability. For instance, in wheat flour-based products. Kusnandar et al. (2022) reported that higher ash content may produce undesirable aroma and sensory properties in bread due to excess mineral residues. Therefore, further investigation into the sensory impact of tofu dregs flour in food formulations is warranted.

Protein Content

Protein is a food source that represents the presence of amino acids containing C, H, O, and N atoms that characterize proteins (Hetrik et al. 2024). Quantitative analysis of protein content using the Kjeldahl method can measure the crude protein content of a food ingredient. The Kjeldahl method will detect total nitrogen from both protein and non-protein, then the total nitrogen value will be multiplied by a conversion factor of 6.25 to estimate the crude protein content of the sample. The stages in the Kjeldahl method generally consist of three stages, namely deconstruction, distillation, and titration (Hetrik et al. 2024; Ispitasari and Haryanti 2022). The results showed that the protein content of dregs flour was 17.32 ± 0.27%. This value is considered high for a by-product of food processing and is in line with the range reported by Li et al. (2012), which was 15.22–33.4%. These findings indicate that the process of filtering soya juice in making tofu does not pass all soy protein.

Rahmawany and Ginting (2021) also confirmed that tofu dregs still retain a significant amount of protein because not all of it is extracted during tofu production. The high protein content in tofu dregs flour suggests its potential use in healthy food formulations, supporting sustainable food systems through waste valorization. Incorporating tofu dregs flour can increase vegetable protein intake and improve nutritional balance. However, testing acceptability through sensory analysis is important to produce products that are superior in terms of nutrition as well as liking. As stated by Ratnasari (2023), the percentage of the use of tofu dregs flour with the presence of superior components, namely high enough protein, does not necessarily correlate with the acceptance of panelists in the sensory analysis of a food product. It is highlighting the need for product testing and optimization.

Fat Content

Besides being a major energy provider, dietary fat is integral to the food matrixthat affecting both nutritional and sensory attributes, including texture, flavor, and aroma, which determine the product's palatability. The fat content of the tofu dregs flour was 7.86% ± 0.21%. This value is notably higher than the 3.32% reported by Dos Santos et al. (2019), but lower than the 12.6% reported by Razavizadeh et al. (2021). These findings indicate that a portion of the soybean's fat remains in the dregs even after undergoing the boiling and filtration processes. The retained fat is likely derived from the non-polar (water-insoluble) fraction, which remains trapped in the solid matrix of the dregs during the separation of soymilk prior to coagulation. The presence of fat in tofu dregs can contribute to the flavor profile and enhance the energy value of food products. This is in line with the statement by Ariani et al. (2024), who emphasized that fat is a key component in food due to its role in contributing to desirable texture and flavor.

Carbohydrate by difference

The carbohydrate content in tofu dregs flour, calculated indirectly by difference, was 63.53 ± 1.09%. This value is consistent with findings from Putri et al. (2022), who reported 66.24%, and higher than that of Tridtitanakiat et al. (2023), who found 35.6%. The variation may be attributed to differences in processing methods, such as boiling and the extent of pressing or filtering used to separate soybean juice from the dregs which can affect the carbohydrate content extracted. According to Fatimatuzzahrah (2024), the nutritional quality of tofu dregs is significantly influenced by the tofu-making process, as not all nutrients are extracted during production.

This value is obtained from subtracting the total of all macro food components (water, ash, protein, and fat) from 100%. Carbohydrate by difference can collect the value of sugar, starch, and fiber that have not been analyzed separately. Fiber in tofu dregs can contribute to improving digestive health. Fiber is categorized as a non-nutritional component that plays a role in reducing the risk of a number of degenerative diseases such as obesity, diabetes mellitus, and atherosclerosis. According to the SKI Compilation Team (2023), more than 96% of Indonesians do not consume fiber, in this case fruits and vegetables, as recommended. This shows that it is necessary to identify alternative food fiber sources that are abundant and accessible to the Indonesian people. Therefore, identifying accessible alternative fiber sources such as tofu dregs flour is highly relevant.

Amalia et al. (2021) reported that tofu dregs contain 36.41% fiber based on the results of the acid method crude fiber analysis. This shows that the carbohydrate fraction is dominated by water-insoluble polysaccharides. Saputro and Estiasih (2015) revealed that based on its solubility properties, insoluble dietary fiber plays a role in increasing stool volume while reducing stool transit time in the colon. In addition, fibre in tofu dregs contributes to improving the physical properties of the product, such as good water-holding capacity. However, these physical properties need to be adjusted to the characteristics of the food product to be made. Rachmayani (2017) found that the incorporation of tofu dregs flour enhanced the hardness of snack bars, providing a denser and more stable structure. However, in products like donuts, fiber can negatively impact sensory quality. Alfarisi et al. (2023) noted that higher fiber content led to a drier and harder texture due to moisture loss during frying. This emphasizes the importance of adjusting the use of tofu dregs flour according to the type of product and processing technique to achieve optimal nutritional and sensory outcomes.

CONCLUSION

This study shows that tofu dregs flour has chemical characteristics that support its use as an alternative food ingredient in a food product formulation. The relatively high protein content, low moisture content, and presence of fiber from carbohydrates make tofu dregs flour an opportunity to be formulated to increase fibre and protein intake for consumers. Further research is recommended to assess the physical characteristics and sensory impression of tofu dregs flour in various product formulations. This is to ensure consumer acceptance and product stability of tofu dregs flour substitutes during storage. However, this study is limited to proximate composition only, and it did not evaluate other potential components such as anti-nutritional factors or bioactive compounds that may influence its application.

ACKNOWLEDGEMENTS

The authors would like to thank the SEAFAST Centre IPB team and the Technopark laboratory of the faculty of agricultural technology of IPB University.

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