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CHARACTERISTICS OF STARCH ISOLATED FROM TOFU RESIDUE AS A TABLET EXCIPIENT USING VARYING SODIUM HYDROXIDE CONCENTRATIONS

Sumratussaleha, Nur Illiyyin Akib*, Ari Sartinah, Irnawati, Suryani, Fery Indradewi Armadany
Universitas Halu Oleo, Jl. HEA Mokodompit, Anduonohu, Kambu, Kendari, Sulawesi Tenggara 93232, Indonesia
*nurilliyyin@uho.ac.id

ABSTRACT
The utilization of tofu dregs as a solid waste source containing starch has not been optimized, despite its potential application as a pharmaceutical excipient. This study aimed to isolate starch from tofu dregs and characterize it according to pharmaceutical grade standards for use as a tablet excipient. Starch isolation was carried out using NaOH solutions at concentrations of 0.1%, 0.2%, and 0.3%. Parameter pharmaceutical grade observed included organoleptic properties, iodine test, pH, moisture content, and ash content, which were evaluated based on the experimental research results and analyzed descriptively. The results showed that the moisture content of the isolated starches was 11.09%, 11.55%, and 11.23%, respectively. The pharmaceutical grade evaluation met the requirements for organoleptic taste, as the starch powder was tasteless, and the iodine test produced a blue coloration. The pH values obtained were 5.94, 5.98, and 6.33. However, the organoleptic parameters related to color and odor, described as brownish-white powder with a characteristic odor, as well as the ash contents of 0.9%, 1.9%, and 1.9%, did not meet the required standards. In conclusion, starch can be successfully isolated from tofu dregs, with the 0.1% NaOH treatment providing the best characteristics and showing potential as an excipient for pharmaceutical tablet formulations.

Keywords: sodium hydroxide; tablet excipient; tofu dregs waste

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INTRODUCTION

Lambusa Village is home to 28 tofu industries and serves as the main tofu production center in Konda District, South Konawe Regency, Southeast Sulawesi Province. Each tofu industry processes approximately 50–100 kg of soybeans per day, generating a considerable amount of waste. Tofu dregs (okara) are solid residues produced during tofu manufacturing and have the potential to be utilized as raw materials in pharmaceutical applications (Suharyani et al., 2024). Currently, tofu dregs are mainly used as animal feed; however, the relatively high management costs limit their utilization by industry (Li et al., 2025). Consequently, most of the waste is either burned or discarded into rivers.

One of the major issues associated with tofu dregs is their unpleasant odor, rapid spoilage, and limited storage stability. These characteristics can create environmental problems if the waste is not managed properly (Suharyani et al., 2024). Therefore, alternative processing methods are needed so that tofu dregs are not merely treated as by-products but can also provide added value. One promising approach is the conversion of tofu dregs into starch, considering that tofu dreg flour contains 66.24% carbohydrates, 17.72% protein, 3.23% crude fiber, and 2.62% fat (Deglas, 2017). These findings indicate that tofu dregs have considerable potential to be developed as pharmaceutical excipients, particularly for tablet formulations (N. T. Sari et al., 2017). Tablets are among the most widely used solid pharmaceutical dosage forms. The selection of excipients plays a crucial role in formulation development because excipients can significantly influence the physical and chemical properties of the dosage form (Pratiwi et al., 2023; Rahma et al., 2024). In addition, excipients have been shown to contribute substantially to drug effectiveness and stability, both in vitro and in vivo (Sousa et al., 2023).

Starch derived from tofu dregs offers several advantages, including an attractive appearance, ease of use, good storage stability, and relatively low production costs. Furthermore, starch can be utilized in pharmaceutical formulations as an excipient, especially as a filler in tablet production. Through this application, tofu dregs may not only help reduce environmental waste problems but also generate added economic value for other industries (Aussanasuwannakul et al., 2025). Starch is commonly used as a binder in granule preparation (Elisabeth et al., 2018). It is a primary metabolite in the form of abundant carbohydrates stored in various parts of plants (Nurdianti et al., 2022). Due to its high carbohydrate content, starch can be processed into flour and utilized as an excipient in tablet manufacturing (Zulfa & Prihantini, 2019). The use of starch as a filler and binder plays an important role in tablet formulation (Kelana et al., 2018). The strength of the interaction between starch and the active pharmaceutical ingredient may affect the drug dissolution rate. Excessively strong interactions can hinder drug dissolution and reduce drug absorption, ultimately decreasing therapeutic effectiveness. Therefore, the selection of starch type and concentration in tablet formulations is essential to ensure optimal dissolution and therapeutic performance (Ngurah et al., 2019).

Starch is a natural polysaccharide composed primarily of two major fractions, amylose and amylopectin, both of which are widely applied in food and pharmaceutical industries because of their diverse functional properties (Rosida, 2021). The characteristics of starch are strongly influenced by the raw material source and the isolation method employed. According to (Lara et al., 2025), the purpose of starch isolation is to separate starch granules from non-starch components such as proteins, fibers, and pigments, which, if not adequately removed, may affect the color, odor, and purity of the resulting starch. One of the most commonly applied methods for starch isolation is alkaline treatment using sodium hydroxide (NaOH). Alkali treatment is known to effectively denature proteins and loosen the interactions between starch and non-starch components by disrupting hydrogen bonds. According to (Polaskova et al., 2019), the use of low-concentration alkali generally does not damage the fundamental structure of starch, thereby preserving its primary characteristics, including its ability to form complexes with iodine. This is indicated by a positive iodine test, characterized by the appearance of a blue coloration that confirms the presence of amylose.

Recent studies have demonstrated that mild alkali treatment is increasingly preferred because it is considered more efficient and environmentally friendly. In a recent review, (Rashwan et al., 2024) reported that starch extraction using low-concentration alkali can enhance the removal of proteins and impurities without causing significant degradation of starch structure. However, the effectiveness of this method largely depends on the post-isolation washing process to prevent residual alkali or inorganic minerals from remaining in the final product. NaOH treatment is also known to influence the chemical properties of starch, particularly pH and ash content. Studies by (Andreina et al., 2025; Lara et al., 2025) reported that alkali-treated starch tends to exhibit a higher initial pH, although adequate washing can restore the pH to levels consistent with standard requirements. On the other hand, increasing alkali concentration may elevate ash content due to the accumulation of mineral residues. As reported by (Polaskova et al., 2019), inorganic residues often indicate insufficient purification during starch processing.

A recent study by (Z. Xu et al., 2024) demonstrated that mild alkali treatment may induce ionization of hydroxyl (–OH) groups in starch molecules and promote protein removal without significantly damaging starch granules. These findings support the use of low-concentration NaOH as an effective starch isolation agent, provided that processing conditions, particularly alkali concentration and washing procedures, are carefully optimized to obtain starch that meets

pharmaceutical-grade standards. Furthermore, (Panwar et al., 2024) reported that NaOH treatment during starch isolation affects the whiteness and purity of starch, both of which are directly associated with the successful removal of non-starch components.
In addition, previous studies have reported that tofu dreg starch can function as a disintegrant, binder, and flow-regulating agent during tablet compression processes. Based on these functional properties, it may also be assumed that tofu dreg starch has potential as a filler in tablet formulations (Halik et al., 2022). Therefore, this study was conducted to isolate starch from tofu dregs and evaluate its characteristics to determine its suitability as a pharmaceutical-grade excipient for tablet dosage forms.

METHOD

Equipment
The equipment commonly used in this study included glassware (Pyrex®), an oven (Wiggens WF-02G), a pH meter (Erweka®), a volumeter (Pyrex®), a desiccator (Pyrex®), a moisture balance (Ohaus®), a furnace (Carbolite CWF 1300), ICP-OES (Perkin Elmer®), and a colony counter (Infitek®).

Materials
The materials used in this study included tofu dregs, sodium hydroxide (NaOH), distilled water, iodine, and potassium iodide (KI), Tofu dreg starch, standard solutions of mercury (Hg), lead (Pb), arsenic (As), cadmium (Cd), Plate Count Agar (PCA), and Potato Dextrose Agar (PDA).

Preparation of Starch as an Excipient
Sample Collection
Tofu dregs were obtained from one of the tofu industries in Lambusa Village, Konda District, South Konawe Regency, Southeast Sulawesi Province, Indonesia. The tofu dregs were collected immediately after the tofu production process was completed.

Flour Preparation
The tofu dregs were drained, dried under sunlight, and then oven-dried at 50°C for 3 × 24 hours. Subsequently, the dried tofu dregs were ground using a grinder and sieved through a 40-mesh sieve to obtain tofu dreg flour (A. M. Sari et al., 2018).

Starch Isolation
A total of 150 g of tofu dreg flour was immersed in 500 mL of NaOH solution at concentrations of 0.1%, 0.2%, and 0.3%, respectively, and stored in a refrigerator for 24 hours. The solid starch phase was then mixed with distilled water and allowed to stand for 20 minutes, followed by washing until a neutral pH was achieved. Subsequently, the starch was dried in an oven at 50°C for 2 × 24 hours. The obtained starch was then ground using a grinder and sieved through an 80-mesh sieve.

Pharmaceutical-Grade Characterization of Tofu Dreg Starch
Organoleptic Evaluation
Organoleptic properties, including color, shape, odor, and taste, were evaluated through visual observation and recorded using descriptive terminology (Aswathy et al., 2022).

Iodine Test
A total of 10 g of starch was heated in 90 mL of distilled water until boiling for 5 minutes. Subsequently, 1 mL of the solution was mixed with iodine solution(Zulharmitta et al., 2011). A positive result was indicated by the formation of a dark blue or purple color, which disappeared upon heating and reappeared after cooling (N. T. Sari et al., 2017).

pH Test
A total of 4 g of starch was mixed with 25 mL of distilled water, stirred for 5 minutes, allowed to stand for 10 minutes, and then measured using a pH meter. The acceptable pH range was 4.5–7 (N. T. Sari et al., 2017).
Moisture Content Test
A total of 1.05 g of starch was placed in a moisture balance dish at 105°C, and its moisture content was determined. According to the Loss on Drying method described by Rowe (2009), the acceptable moisture content limit is ≤ 15% (Aswathy et al., 2022).

Ash Content Test
The crucible was dried in an oven at 100–105°C for 30 minutes or until a constant weight was achieved. A total of 1.05 g of starch was placed into the crucible and weighed. The crucible was then transferred into a furnace at 800°C for 6 hours, cooled, and reweighed. The standard ash content requirement was 0.7% (Habib & Kusumayanti, 2024).

$$\text{Ash Content (\%)} = \frac{B2 - B1}{sample\ weight} x100\%$$

Description:
B1 = weight of the crucible after reaching a constant weight
B2 = weight of the crucible + sample after incineration

Pharmaceutical-Grade Characterization of Tofu Dreg Starch at 0.1% Sodium Hydroxide Concentration: Heavy Metal and Microbial Tests

Heavy Metal Test
Heavy metal contamination, including cadmium (Cd), lead (Pb), tin (Sn), mercury (Hg), and arsenic (As), was analyzed according to reference (Hartesi et al., 2022). The dissolved metal contaminants were determined using Inductively Coupled Plasma–Optical Emission Spectroscopy (ICP-OES).

Microbial Test
Total Plate Count Test
The Total Plate Count test was carried out using the pour plate method. At the 10^{-1} dilution, 1 mL of the sample suspension was pipetted into a Petri dish, followed by the addition of approximately 12 mL of Plate Count Agar (PCA) medium, and prepared in duplicate. The Petri dish was immediately shaken and rotated in a figure-eight motion until the suspension was evenly distributed. The same procedure was repeated up to the 10^{-4} dilution. All Petri dishes were allowed to solidify and then incubated in an inverted position at 35–37°C for 24–48 hours. After incubation, the number of growing colonies was observed and counted. Colony counts were recorded in colony-forming units per gram (CFU/g).

Yeast and Mold Count Test
The Yeast and Mold Count test was conducted using the spread plate method. At the 10^{-1} dilution, 0.1 mL of the sample suspension was pipetted onto a sterile Petri dish containing Potato Dextrose Agar (PDA) medium and evenly spread across the entire surface of the medium using a bent glass rod. The test was performed in duplicate. The same procedure was repeated up to the 10^{-4} dilution. The Petri dishes were then inverted and incubated at 25°C for 3–5 days. After 3 days of incubation, the number of yeast and mold colonies was recorded, and observations were continued until the fifth day of incubation (Berata et al., 2024).

RESULT
Pharmaceutical grade is a term used to describe materials or substances that meet officially established standards of quality and purity, ensuring that they are safe and suitable for use in the manufacture of pharmaceutical products. In the context of the Indonesian Pharmacopoeia,

pharmaceutical grade refers to materials that comply with the quality requirements and standards specified in the Indonesian Pharmacopoeia or other internationally recognized pharmacopoeias, including aspects such as purity, identification, dosage, and suitability for use as active pharmaceutical ingredients or excipients in pharmaceutical preparations. Pharmaceutical grade specifically refers to pharmaceutical raw materials and excipients that fulfill the standards of quality, safety, and purity as regulated in the Indonesian Pharmacopoeia, 6th Edition, 2020 (Depkes, 2020). The results of this study can be seen in Table 1 and Figures 1 to 6.Pharmaceutical-Grade Characterization of Tofu Dreg Starch

Table 1.
Standardization of Tofu Dreg Starch in Compliance with SNI/HOPE/FI Requirements

No	Characterization	Isolation Results NaOH			Requirement (SNI/HOPE/FI)	Remarks
		0,1%	0,2%	0,3%		
1.	Organoleptik					
	Color	Brownish white	Brownish white	Brownish white	White	-
	Form	Powder	Powder	Powder	Powder	√
	Odor	Characteristic odor	Characteristic odor	Characteristic odor	Odorless	-
	Taste	Tasteless	Tasteless	Tasteless	Tasteless	√
2.	Iodine Test	Blue	Blue	Blue	Blue/Purple	√
3.	pH Test	5,94	5,98	6,33	4,5-7	√
4.	Moisture Content	11,09 %	11,55 %	11,23 %	≤ 15%	√
5.	Ash Content	0,9%	1,9%	1,9%	0,7%	-

Notes:
√ = Meets the requirement
– = Does not meet the requirement

Figure 1. Tofu Dreg Starch

Figure 2. Iodine Test

Figure 3. pH Test

Figure 4. Moisture Content Test

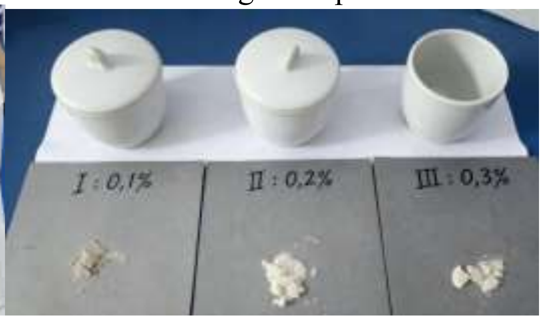

Figure 5. Ash Content Test

Pharmaceutical-Grade Characterization of Tofu Dreg Starch at 0.1% Sodium Hydroxide Concentration: Heavy Metal and Microbial Tests

Heavy Metal Test Results
Heavy metal testing is a critical parameter in evaluating the quality of pharmaceutical excipients, including starch isolated from agro-industrial waste such as tofu dregs. The presence of heavy metals, including lead (Pb), cadmium (Cd), mercury (Hg), and arsenic (As), must be carefully controlled because these substances are toxic, non-biodegradable, and tend to accumulate in

human body tissues (Tchounwou et al., 2012). In the development of biomass-based excipients, such as tofu dreg starch, this analysis is particularly important since the raw material originates from food industry waste that may be exposed to environmental contaminants during production, processing, and storage (Souza et al., 2022).

Table 2.
Heavy Metal Contamination Test Results of Tofu Dreg Starch Isolated Using 0.1% NaOH

Parameter	Unit	Result	Requirement	Remarks
Hg	mg/kg	0,75	Max. 0,05	–
Pb	mg/kg	7,59	Max. 0,25	–
As	mg/kg	2,92	Max. 0,5	–
Cd	mg/kg	<0,001	Max. 0,2	√

Notes:
√ = Meets the requirement
– = Does not meet the requirement

Microbial Contamination Test
Microbial contamination testing was conducted to determine the level of microbial contamination in the produced tofu dreg starch, including Total Plate Count (TPC) and Yeast and Mold Count (YMC). These parameters were used to evaluate the microbiological safety and quality of the material, as well as to ensure its compliance with the standards established in the Indonesian Pharmacopoeia (Depkes, 2020).

Table 3.
Microbial Contamination Test Results of Tofu Dreg Starch Isolated Using 0.1% NaOH

Test	Medium	Results	Average Value	Requirement	Remarks
TPC	PCA	8×10^3 8×10^3 9×10^3	$8{,}33 \times 10^3$	$\leq 1 \times 10^6$ colonies/g	√
YMC	PDA	1×10^3 4×10^3 9×10^3	$4{,}76 \times 10^3$	$\leq 1 \times 10^4$ colonies/g	√

Notes:
TPC = Total Plate Count
YMC = Yeast and Mold Count
√ = Meets the requirement

DISCUSSION

The pharmaceutical-grade characterization of tofu dreg starch included organoleptic evaluation, iodine test, pH test, moisture content, and ash content analysis (Halik et al., 2022). The organoleptic evaluation of tofu dreg starch showed results consistent with previous studies (Figure 1). The results demonstrated that tofu dreg starch isolated using 0.1%, 0.2%, and 0.3% NaOH exhibited relatively similar characteristics, namely powder form, brownish-white color, characteristic tofu odor, and tasteless properties (Halik et al., 2022). These findings are in agreement with previous studies reporting that tofu dreg starch generally appears as a powder with a color that is not completely white due to the presence of residual non-starch components such as proteins and pigments. This indicates that the purification process did not completely eliminate impurity compounds, and therefore, organoleptically, tofu dreg starch has not fully met the characteristics of pharmaceutical starch, which is generally odorless and white in color (Depkes, 2020).

The iodine test was conducted to detect the presence of carbohydrates, particularly starch, in tofu dregs (N. T. Sari et al., 2017). Based on the test results, tofu dreg starch showed a blue color change after the addition of iodine reagent, indicating the presence of starch containing amylose and amylopectin (Rosida, 2021). This reaction occurs because iodine molecules form complexes with the helical structure of amylose, producing the characteristic blue coloration observed in (Figure 2)

(Kelana et al., 2018). These findings confirm that the isolation process using NaOH did not damage the fundamental structure of starch, allowing it to remain chemically detectable as a carbohydrate (NGUYỄN THỊ MAI HƯƠNG et al., 2022).

The pH test was carried out to determine the acidity or alkalinity level of tofu dreg starch, which greatly influences its stability and safety during storage (N. T. Sari et al., 2017). In this study, tofu dreg starch isolated using 0.1% NaOH exhibited a pH value of 5.94, while isolation with 0.2% NaOH produced a pH of 5.98, and isolation with 0.3% NaOH resulted in a pH of 6.33, indicating slightly acidic conditions as shown in (Figure 3). These results are in accordance with the requirements stated in the Handbook of Pharmaceutical Excipients (Raymond C rowe, Paul J Sheskey, 2009). The relatively near-neutral pH values indicate that the post-alkalization washing process was sufficiently effective in removing residual NaOH. However, starch with excessively low or high pH values may promote degradation or microbial growth, potentially reducing starch quality during storage (Rashwan et al., 2024).

Moisture content is an important parameter in determining the quality and shelf life of starch. Moisture content testing of tofu dreg starch was conducted to evaluate its quality and resistance to potential deterioration. High moisture content may increase the risk of microbial growth and accelerate material degradation (Hartesi et al., 2022). The results showed that the moisture content of tofu dreg starch isolated using 0.1%, 0.2%, and 0.3% NaOH was 11.09%, 11.55%, and 11.23%, respectively, as presented in (Figure 4). These values met the requirements specified in the Indonesian Pharmacopoeia 5th Edition and the Handbook of Pharmaceutical Excipients, which require moisture content to be ≤15% (Depkes, 2020; Raymond C rowe, Paul J Sheskey, 2009). The relatively low moisture content indicates that the drying process was effective and supports the stability of starch during storage (Halik et al., 2022).

Ash content analysis was conducted to determine the amount of residual minerals or inorganic materials remaining after the incineration process. Ash content is an important indicator of starch purity, particularly for pharmaceutical applications. The results showed that the ash content of tofu dreg starch isolated using 0.1% NaOH was 0.9%, while starch isolated using 0.2% and 0.3% NaOH each exhibited an ash content of 1.9%, as shown in (Figure 5). These values were lower than those reported in previous studies, which found tofu dreg starch ash content of 2.73% (Halik et al., 2022), indicating an improvement in starch purity in the present study. Nevertheless, the ash content values remained higher than the acceptable limit for pharmaceutical starch. The increase in ash content with increasing NaOH concentration suggests the presence of residual minerals or alkali that were not completely removed during the washing process (Z. Xu et al., 2024).

Based on the pharmaceutical-grade characterization results of tofu dreg starch (Table 4), it can be concluded that isolation using 0.1% NaOH produced starch with quality closest to the required standards compared to the 0.2% and 0.3% NaOH concentrations. This was indicated by the lowest ash content value and the fulfillment of other parameters, including pH, moisture content, iodine test, and organoleptic characteristics. Increasing the NaOH concentration above 0.1% did not improve starch quality and instead tended to reduce its purity due to increased mineral residues. Therefore, 0.1% NaOH can be recommended as the optimal concentration for isolating tofu dreg starch with characteristics approaching pharmaceutical grade.

Based on the characterization results, the starch isolated using 0.1% NaOH was considered the optimal treatment; therefore, heavy metal analysis was further conducted. The heavy metal test results presented in (Table 2) showed that mercury (Hg) content was 0.75 mg/kg, lead (Pb) was 7.59 mg/kg, and arsenic (As) was 2.92 mg/kg, all of which significantly exceeded the maximum permissible limits. In contrast, cadmium (Cd) levels of <0.001 mg/kg still met the established requirements. These findings indicate that the produced tofu dreg starch has not yet fulfilled safety standards for pharmaceutical excipients, particularly when compared with the limits recommended by the World Health Organization and the Indonesian Food and Drug Authority (Depkes, 2020). Nevertheless, the starch still has potential for development provided that appropriate treatment and purification processes are applied to achieve safety standards. The significant differences observed suggest that the starch isolation process used in this study may not have been optimal in eliminating heavy metal contaminants. Therefore, the elevated levels of Pb, Hg, and As were likely caused by a combination of raw material contamination and insufficient purification processes (Tchounwou et al., 2012).

Recent studies have shown that tofu dregs (okara) are agro-industrial by-products rich in polysaccharide components and possess considerable potential for development as functional materials, including as a starch source for industrial and pharmaceutical applications (Adeyanju & Adebo, 2025; Tian et al., 2025). However, the complexity of the okara matrix may influence isolation efficiency and the purity of the final product. Recent investigations have also reported that polysaccharide-based biomaterials tend to interact with metal ions through adsorption and complexation mechanisms, thereby increasing the possibility of heavy metal accumulation if purification processes are not properly optimized (A. Xu et al., 2018). Furthermore, studies in agro-industrial waste processing have demonstrated that raw material quality and processing environments greatly influence heavy metal contamination levels in the final product (Tchounwou et al., 2012). Therefore, further process optimization is required to ensure that tofu dreg starch meets safety standards for pharmaceutical excipients.

Overall, when compared with previous literature, the quality of tofu dreg starch obtained in this study remains below the standards reported in several earlier studies. However, these findings do not eliminate its development potential. Improvements in processing techniques remain the key factor in enhancing the quality of tofu dreg starch so that it may become suitable for pharmaceutical excipient applications(Depkes, 2020; Raymond C rowe, Paul J Sheskey, 2009).

Similarly, the microbial contamination test results presented in (Table 3) showed that tofu dreg starch had a Total Plate Count (TPC) value of 8.33×10^3 CFU/g and a Yeast and Mold Count (YMC) value of 4.67×10^3 CFU/g. These values were still below the maximum limits established in the Indonesian Pharmacopoeia, namely $\leq 1 \times 10^6$ CFU/g for TPC and $\leq 1 \times 10^4$ CFU/g for YMC (24), indicating compliance with microbiological quality standards. The low microbial contamination levels suggest that the starch isolation process was effective in suppressing microbial growth. Tofu dregs (okara) are known to possess high moisture and nutrient contents, making them highly susceptible to microbial growth and deterioration during storage. This finding is consistent with reports by (Devanthi et al., 2024; Duan et al., 2025), which stated that okara is a substrate easily colonized by microorganisms if not properly processed. Therefore, processing steps such as washing, alkali treatment, and drying play important roles in improving the microbiological stability of the material.

When associated with the moisture content results, the low microbial contamination observed in this study indicates that the drying process effectively reduced moisture levels to conditions unfavorable for microbial growth. Moisture reduction is known to inhibit water activity, which is essential for microbial proliferation. This finding is supported by research (Wang et al., 2024), which reported that okara drying significantly improves storage stability and reduces the risk of microbial contamination. In addition, the relatively low ash content indicates that the starch purification process proceeded effectively, thereby minimizing inorganic contaminants and non-starch residues. Such contaminants may serve as attachment sites for microorganisms; therefore, lower ash content is associated with lower microbial contamination potential. These findings are in agreement with previous studies (Duan et al., 2025), which reported that purification and processing of okara-based materials can improve product quality and stability.

The use of alkali treatment (NaOH) during starch isolation also contributed to reducing microbial populations. Alkaline conditions may damage microbial cell structures and inhibit metabolic activity, thereby exerting antimicrobial effects. Moreover, this treatment effectively removes non-starch components such as proteins and fats that may serve as nutrient sources for microorganisms. This finding is supported by (Chen et al., 2025), which reported that chemical and physical processing of okara can improve material safety and quality. Overall, the results of this study demonstrate that the combination of drying, purification, and alkali treatment processes was capable of producing tofu dreg starch with good microbiological quality. These findings further support the potential of okara or tofu dregs as a safe and value-added alternative raw material, particularly for the development of pharmaceutical excipients.

CONCLUSION

Tofu dreg starch isolated using 0.1%, 0.2%, and 0.3% NaOH fulfilled the pharmaceutical-grade requirements, except for the color, odor, and ash content parameters, which did not yet comply with starch quality standards. Among the three concentrations, starch isolated using 0.1% NaOH showed the best quality, as indicated by its lower ash content value. Increasing the NaOH concentration above 0.1% did not improve starch quality and instead tended to reduce its purity due to the increased presence of mineral residues.

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