

# ALTERNATIVE SOURCES TO IMPROVE SUSTAINABILITY AND RESILIENCE OF TEMPEH SUPPLY CHAINS



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### SUMMARY

Tempeh is a popular traditional plant-based protein that plays a vital role in Indonesian diets. Indonesia's reliance on imported soybeans (2.6 million tons/year) for tempeh production, however, creates market instability and food vulnerabilities, particularly regarding cost and supply fluctuations. This paper analyses the technical, economic, and market feasibility of alternative legumes—specifically, jack beans, mung beans, and peanuts—as sustainable substitutes for soybeans in tempeh production. The aim is to identify the most viable option for immediate scale-up to support local food systems and improve nutritional outcomes.

The analysis reveals that jack bean tempeh offers the most compelling opportunity for immediate scaling, primarily due to its low raw material cost, which translates into the highest potential profit margin for producers. Nutritionally, jack bean tempeh is the closest alternative to soybean, being rich in fibre and low in fat, making it attractive to consumers who prioritise nutrition. Mixed-bean tempeh, particularly a 60:40 soybean-jack bean mix, presents a lower-risk entry point for producers, leveraging existing soybean infrastructure while reducing cost dependency.

To strengthen Indonesia's food system and enhance public nutrition, decision-makers should prioritise targeted policy and investments into the jack bean value chain. Immediate actions should focus on developing guaranteed market access for jack bean farmers to stabilise supply, providing producers with specialised equipment and training to improve processing efficiency, and implementing public awareness campaigns that highlight the nutritional and environmental benefits of jack bean tempeh. The successful transition to jack bean cultivation represents a critical opportunity to build a more resilient, cost-effective, and nutrient-rich food supply.

### KEY MESSAGES

- Dependency on imported soybeans exposes Indonesian tempeh production to significant price volatility and supply risks, necessitating the urgent adoption of viable, locally sourced alternatives.
- Jack beans offer the highest potential profit margins due to their low cost and a nutritional profile that is superior to other alternative legumes.
- Jack bean tempeh production is technically established and food safety-certified in several regions of Indonesia.
- Prioritising policy and investment in jack bean farmer partnerships, specialised producer training, and consumer education is essential to ensure long-term stability and to capture significant market share for a healthier and sustainable tempeh alternative.

### BACKGROUND AND OBJECTIVE

Tempeh is a traditional food that is central to Indonesian diets, in addition to being a popular plant-based meat alternative in vegetarian and vegan diets worldwide. It is typically made from whole fermented soybeans and is rich in protein, fibre, vitamins, and minerals, with the fermentation enhancing the soybeans' digestibility and nutritional profile. Tempeh is widely appreciated across many regions of Indonesia, with the average adult consuming it about four times per week, and makes key contributions to nutrition, contributing about 10-14% of protein needs and about 30% of vitamin B<sub>12</sub> needs (1).

Indonesia's tempeh production is heavily reliant on imported soybeans due to a significant domestic supply shortfall. With an annual demand of approximately 2.8 million tons, local production only reaches about 0.8 million tons (2). This import dependence is primarily driven by the lower prices of imported soybeans compared to domestic varieties. Indonesian farmers face a dual challenge: high cultivation costs coupled with low local soybean prices at harvest. Domestic soybean productivity is also generally low, which is influenced by Indonesia's climate (3). To stabilise prices and manage the supply chain, the Indonesian Ministry of Trade regulates imports via state-owned enterprises and cooperatives, while price security for farmers is addressed through domestic sourcing or imports. Despite these regulatory efforts, Indonesia's reliance on imported soybeans persists.

The heavy reliance on imported soybeans leaves Indonesian tempeh production vulnerable to volatile global market prices. This instability, driven by the local supply shortfall and decades of import dependency, forces producers into a difficult choice: they must either raise consumer prices for this affordable, essential protein source or reduce the size of the tempeh sold to mitigate rising raw material costs (3).

To address these challenges, GAIN's Nourishing Food Pathways programme is exploring the feasibility of alternative legumes to promote sustainable consumption and minimise environmental impact. While high-yield soy production overseas may appear favourable, intensive monoculture systems can severely degrade soil health by continuously extracting nutrients. This necessitates a growing dependence on synthetic fertilisers and pesticides, which in turn accelerates soil acidification, disrupts microbial communities, and drives biodiversity loss through habitat destruction and chemical runoff (4). Locally produced alternatives, therefore, can offer opportunities to support agrobiodiversity, promote nature friendly farming practices, and enhance the overall resilience of the food system. Utilising local legumes instead of imported soybean could also strengthen domestic agriculture and enhance food security by lowering dependence on imported commodities (5).

To enable a shift to more local tempeh production, it is essential to identify alternative local legumes that are economically viable and environmentally sustainable and to understand the value chain readiness of such crops, from production and processing to market acceptance. Locally available options include jack bean, mung beans, peanuts, and mixes of different legumes. This paper investigates the feasibility of these alternative tempeh crops in Indonesia, focusing on their value chain readiness. The aim is to support pathways that increase the resilience of the country's tempeh supply chain.

## **METHODOLOGY**

### **MIXED METHODS DESIGN**

This study adopted a mixed-methods approach. Qualitative analysis involved field visits and interviews with key stakeholders across the tempeh value chain. This analysis focused on supply, processing, and logistics to assess the technical feasibility of alternative legumes as tempeh substitutes. Quantitative analysis utilised surveys targeting Indonesian consumers of soybean tempeh and other legume-based products. The survey was used to forecast demand and consumer acceptance of soybean-alternative tempeh, thereby supporting the subsequent analysis of production costs.

The main goal of the study was to undertake a comparative analysis across three different legumes for use in tempeh, as well as a mixed-bean product, to identify the most potential and feasible alternative legume for tempeh production. The study considered nutritional value, consumer acceptance, technical feasibility, and economic factors (production costs, tempeh sales price, and profit margins).

### **PRIMARY DATA COLLECTION**

Primary data collection included focus group discussions (FGDs), key informant interviews (KIIs), consumer surveys, and field observations in Aceh and Bogor, in 2024.

One FGD was conducted with 12 key participants from the tempeh value chain in Bogor, and another FGD was conducted with 10 key participants in Aceh. These explored aspirations, challenges, and opportunities in jack bean tempeh production, providing a baseline for subsequent survey activities. KIIs were carried out with 15 stakeholders to gain in-depth insights into the tempeh value chain. These interviews helped validate data from FGDs and surveys, identified gaps and inconsistencies, and ensured data reliability for a comprehensive industry understanding.

Consumer surveys were conducted with 210 respondents across Greater Jakarta and Aceh, with an equal distribution of 105 respondents in each region. The surveys aimed to gather insights on consumer usage and awareness of different protein sources, taste, marketing messages, and consumer perceptions. Additionally, Central Location Testing and In-Depth Interviews were conducted to identify the level of consumer acceptance of jack bean tempeh through direct taste testing. These methods were used to obtain a comprehensive understanding of market dynamics and the main challenges in promoting jack bean tempeh. Respondent demographics revealed distinct profiles in each region. The Greater Jakarta sample was 39% male and 61% female, with the majority (50%) being 31-40 years old, followed by 41-50 years old (35%). In the Aceh sample, 75% of respondents were female, with the majority (52%) also falling within the 31 to 40-year age group, followed by 20-30 years old (24%) and 41-50 years old (24%).

Field observations were conducted at Badan Usaha Milik Rakyat (BUMR) Paramasera<sup>1</sup> and Rumah Tempe Indonesia (RTI)<sup>2</sup>, both located in Bogor City, West Java, to examine production process variations. In Aceh, field observations were conducted at five tempeh producers (A-Zaki Tempeh Producer, Soybean Tempeh Producer, Ababil Tempeh Producer, Hasa Tempeh Producer and BTN Bandung Tempeh Producer) to analyse competitor positions within the tempeh market.

### SECONDARY SOURCES

Secondary data were gathered from several sources: government reports, legislation and policy reports, academic articles, industry reports, books on food science, nutrition, and Indonesian culinary traditions. The literature review provided essential background on soybean tempeh and its alternatives. It also analysed aspects related to soybean production and tempeh manufacturing.

Statistical databases from Indonesia's Central Bureau of Statistics (BPS) and industry reports were used to assess tempeh production, consumption trends, and market dynamics. Statistical data from Provinsi Aceh dalam Angka by BPS Aceh (6) were also used to understand demographic characteristics, income levels, and consumption trends in the target areas. Government publications and market research from industry analysts provided insights into regulatory frameworks, consumer preferences, and competitive analysis. This included reports from agricultural and health agencies related to tempeh production.

Integrating these data sources enabled a thorough analysis of the current state and prospects of tempeh production in Indonesia. This integrated approach ensured a comprehensive analysis of the production, market readiness, and development strategy for jack beans tempeh in Aceh and Bogor.

### DATA ANALYSIS

The data analysis focused on comparing assessment results of the nutritional content of the products, consumer acceptance, current production and market potential, technical feasibility, and economic feasibility. For the economic feasibility assessment, production cost determination was conducted based on material costs, labelling and packaging costs, and cost of inputs (e.g., water, gas, electricity) required to produce 250 grams of tempeh (using different local legumes).

Data from KIIs and FGDs were analysed using qualitative methods. The interviews and discussions were transcribed and coded to identify key themes and insights related to the tempeh value chain. Quantitative methods were used to analyse consumer survey data. This involved descriptive statistical analysis to calculate frequencies, percentages, and means to assess consumer preferences, willingness to pay, and product perceptions. By

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<sup>1</sup> BUMR Paramasera is a cooperative that specialises in producing products made from jack beans, including jack bean tempeh.

<sup>2</sup> Rumah Tempe Indonesia (RTI) is a business unit operating under the Indonesian Tofu and Tempeh Producers Cooperative (KOPTI).

validating and cross-referencing the data collected through these different methods, the analysis aimed to ensure the accuracy and reliability of the findings.

Three types of beans were considered as alternatives for tempeh production, based on the level of familiarity and supply: peanut, mung bean, and jack bean. According to BPS data (7), the productivity of peanuts in Bogor reached 15.22 tons per hectare, while mung bean productivity was recorded at 10.77 tons per hectare. Studies suggest that the potential productivity of jack beans can range between 3.9 to 12 tons per hectare (8). Jack beans have also been explored by several tempeh producers in Bogor City, providing a unique value compared to other underutilised beans. Jack beans are highly adaptable to severe environmental conditions, including drought, nutrient-depleted and highly leached soils, and high temperatures (9). Mixed beans, combining these different legumes, represent another alternative in tempeh production.

In Aceh, aside from soybeans, several local legumes hold potential as alternative raw materials for tempeh production, although their adoption remains limited. While official data on its annual productivity in Aceh is limited, the region's agroecological landscape supports the potential cultivation of jack beans, especially as a rotation or intercropping crop. According to field observations and interviews, jack bean cultivation has not yet reached a commercial scale in Aceh, but smallholder farmers show willingness to grow it if market linkages and guaranteed offtake exist.

The next section will explain the feasibility of the alternative beans compared to soybeans based on nutritional content, consumer acceptance, price, technical feasibility, and market response.

## COMPARING DIFFERENT LOCAL BEANS FOR ALTERNATIVE TEMPEH

### NUTRITIONAL ANALYSIS

Given the importance of nutritional value (including to consumers: 82.8% of those surveyed prioritise it when considering alternative tempeh), it is an important characteristic to examine. A comparative analysis (see Figure 1 and Table 1) shows that soybean tempeh sets the nutritional benchmark, leading with 42.29% protein. Jack bean tempeh is highly suitable for fat-restricted diets, as it contains the lowest fat content (1.73%) and the highest dietary fibre (11.3%). In contrast, mung bean tempeh is rich in carbohydrates (62.9%), supporting high energy needs. Peanut tempeh is challenging due to its exceptionally high fat content (47.5%), which contributes to high calorie density and makes it less suitable for low-fat diets.

Based on its nutritional profile (high fibre, moderate protein, and low fat), jack bean tempeh is likely the most comparable and suitable alternative to soybean tempeh for health-conscious consumers. Mixed-bean tempeh also offers a valuable option: by combining soybean with mung bean or jack bean, producers can potentially create a product with enhanced nutritional density, meeting consumer demand while addressing sustainability concerns related on a single bean.

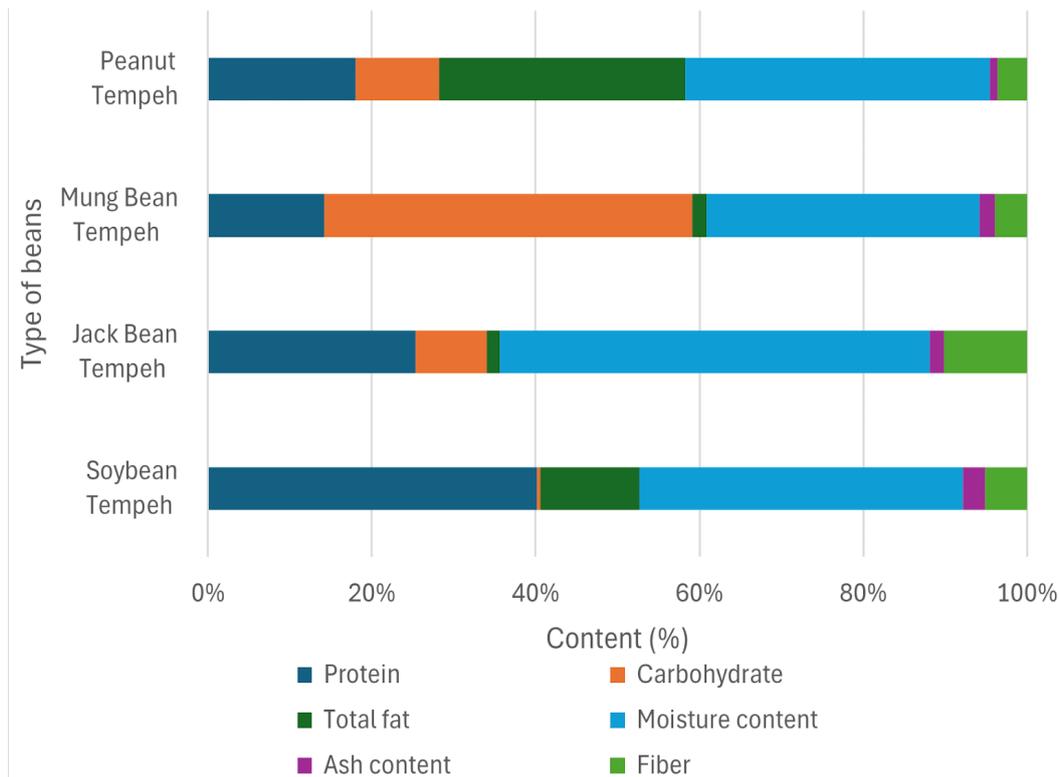


Figure 1. Comparative nutritional analysis of four different tempeh

Table 1. Key metrics for comparative nutrition analysis

Parameter	Unit	Soybean Tempeh	Jack Bean Tempeh	Mung Bean Tempeh	Peanut Tempeh
Protein	%	42.29	28.2	19.85	28.5
Carbohydrate	%	0.44	9.66	62.9	16.1
Total fat	%	12.79	1.3	2.54	47.5
Moisture content	%	41.66	58.45	46.66	58.89
Ash content	%	2.82	1.9	2.61	1.52
Fibre	%	5.39	11.3	5.5	5.68
Total calories	Kcal/100g	201	200	345	606

**Note:** Determination of ash content indicates the amount of mineral content in the product and is closely related to the nutritional content of an ingredient. The higher the ash content, the worse the quality of the food because the potential for inorganic materials to be toxic is high. The standard ash content of a product according to BPOM is 1.6%.

Compared to the raw ingredients, the fermentation process critically influences the nutrient composition of the final product (10-13). Protein increases because the fungi used to make tempeh (*Rhizopus spp.*) produce protease enzymes that break down complex proteins into readily available amino acids. Fat content decreases in most beans (soybeans, jack beans, and slightly decrease in mung beans) due to the lipase enzyme hydrolyse triacylglycerol into glycerol and free fatty acids. Peanuts are an exception, as their high initial fat content remains dominant even after fermentation. Carbohydrate content is reduced (in soybeans and jack beans), as the fungi consume carbohydrates for their own growth. Ash content decreases across all beans, likely due to mineral leaching during soaking and cooking. Moisture content increases because water is produced

during the substrate digestion process. Fibre remains largely stable, as fermentation primarily targets fats and carbohydrates. Calories decrease overall due to the reduction in energy-dense fats and carbohydrates.

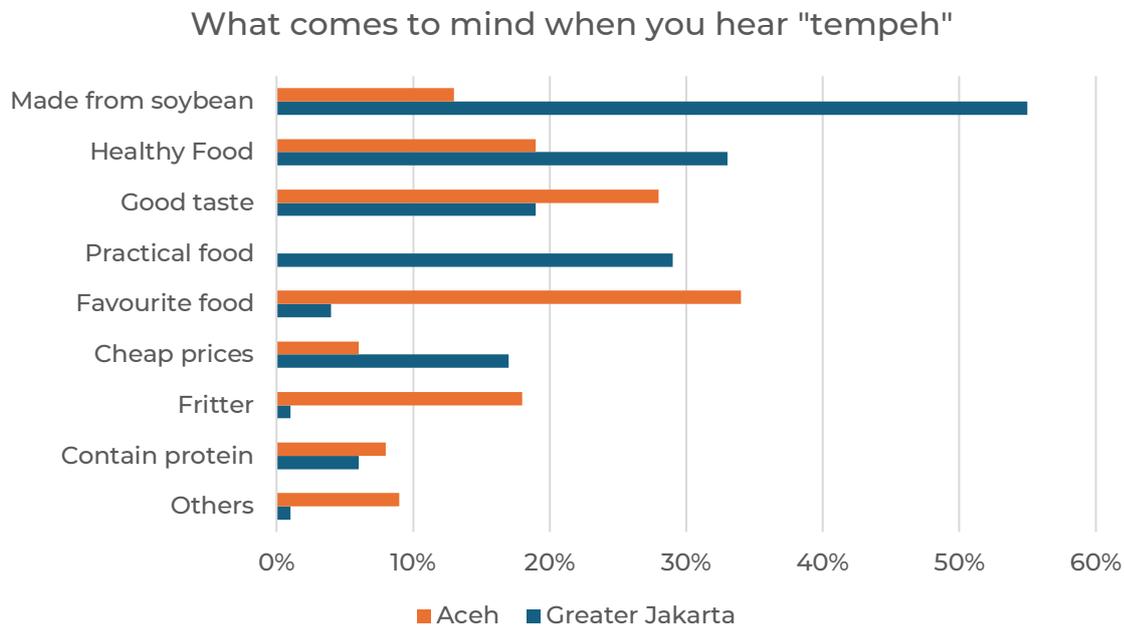
Further research is needed on the nutritional analysis of mixed-bean tempeh, as no dedicated studies or commercial analyses current exist. The interaction of different bean characteristics will likely produce results that vary significantly from single-bean measurements.

**MARKET RESPONSE**

**Consumer Acceptance**

The consumer survey in Greater Jakarta and Aceh further confirmed that tempeh is widely perceived as a staple food, strongly associated with soybean, health benefits, and affordability. In Greater Jakarta, tempeh is primarily associated with being made from soybean (55%) and as a healthy (33%) and practical food (29%), while in Aceh it is more commonly perceived as a favourite everyday dish (34%) with good taste (28%) (see Figure 2).

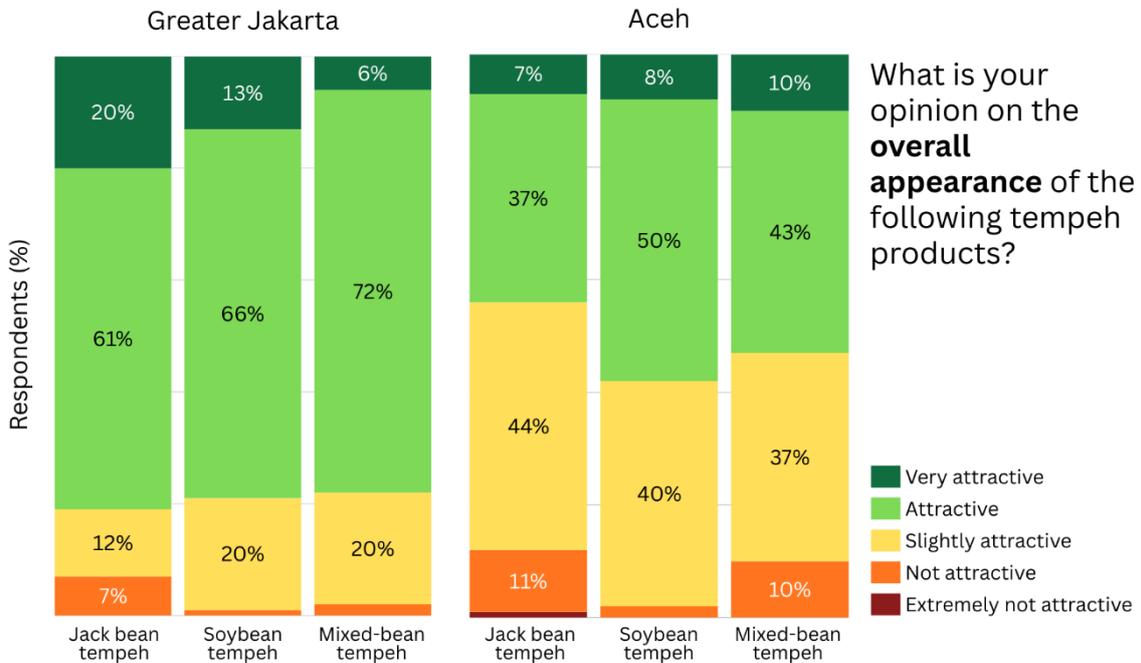
Price sensitivity analysis indicates that consumers generally perceive tempeh as a low-to mid-priced commodity, with acceptable prices for a 250 g package ranging from IDR 5,000 to IDR 7,500 (USD 0.30 – 0.45), although higher prices may be accepted when added value (such as improved nutrition, hygiene, or sustainability) is clearly communicated.



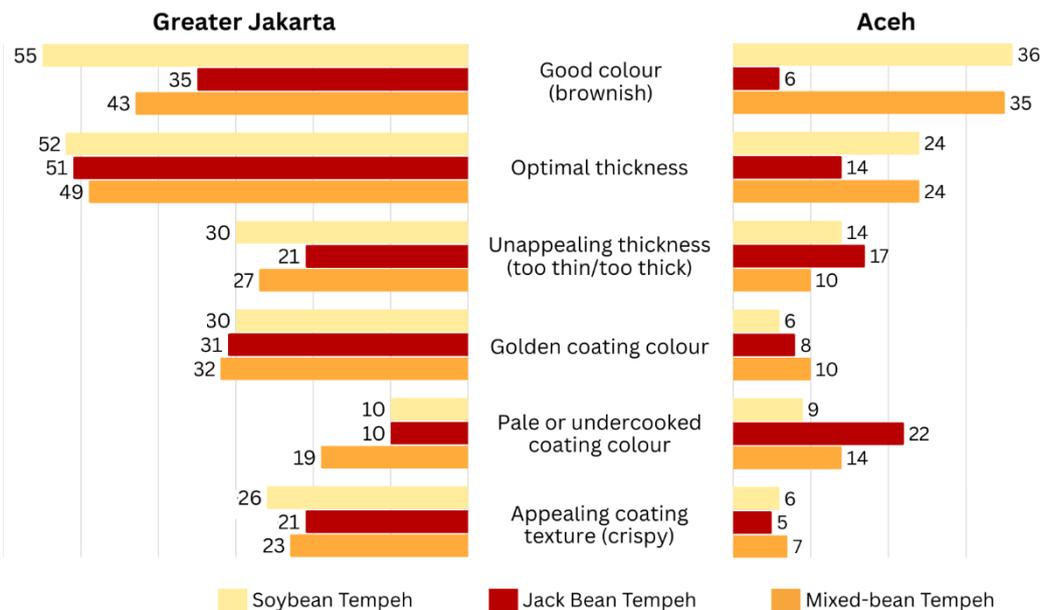
**Figure 2. Consumer perceptions of tempeh in Greater Jakarta and Aceh**

Considering alternative tempeh products, a study by Widianingrum et al. (14) found that 30 panellists preferred jack bean tempeh over soybean tempeh due to its brighter white colour and overall acceptability. However, its acidity was perceived differently, likely due to a lack of familiarity compared to soybean tempeh. This acidity is influenced by lectins and concanavalin. Based on our product testing, jack bean tempeh showed strong visual appeal, particularly in Greater Jakarta, where 81% of respondents rated it as attractive (see Figure 3). Respondents were also significantly more likely to rate jack bean tempeh as

very attractive compared with soybean and mixed-bean tempeh. The most noticeable features of jack bean tempeh were its appropriate thickness (51%) and good tempeh colour (35%). In Aceh, soybean tempeh remained slightly more preferred (58%) than the other variants. Similar patterns were observed in Aceh, where colour and size remain the dominant visual cues, although pale or undercooked coating was mentioned more frequently for jack bean tempeh (22%).



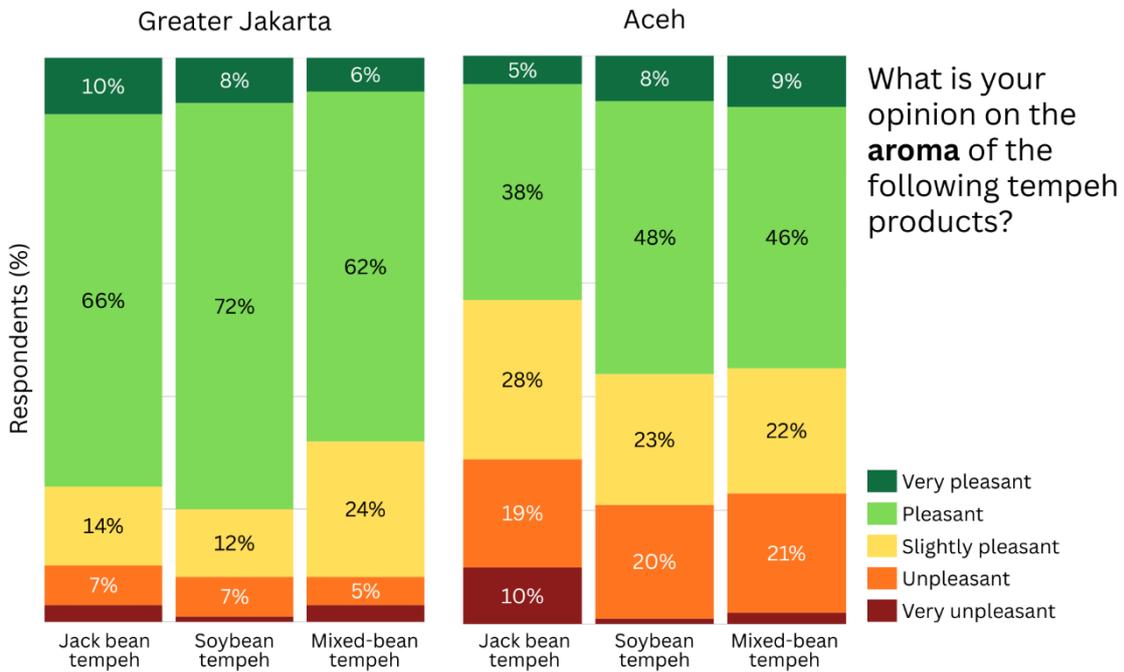
Reasons Underlying Respondents' Appearance Ratings (%)



**Figure 3. Overall appearance assessment of tempeh variants in Greater Jakarta and Aceh**

Figure 4 presents consumer perceptions of aroma across the three tempeh variants. Soybean tempeh continued to receive the highest aroma ratings in both areas. However, jack bean tempeh achieved a relatively high aroma rating in Greater Jakarta (76%), close

to soybean tempeh (80%) and higher than mixed-bean tempeh (68%). For jack bean tempeh, the dominant aroma perception in Greater Jakarta was the pleasant aroma of seasoned coating (71%), followed by savoury (31%) and fresh and appetising (30%). In Aceh, aroma acceptance was lower overall, but mixed-bean tempeh performed better (55%) than jack bean tempeh (43%). Aroma perceptions shifted across all products, with fresh aroma becoming the main overall impression (27% for jack bean tempeh and 29% for mixed-bean tempeh).



Reasons Underlying Respondents' Aroma Ratings (%)

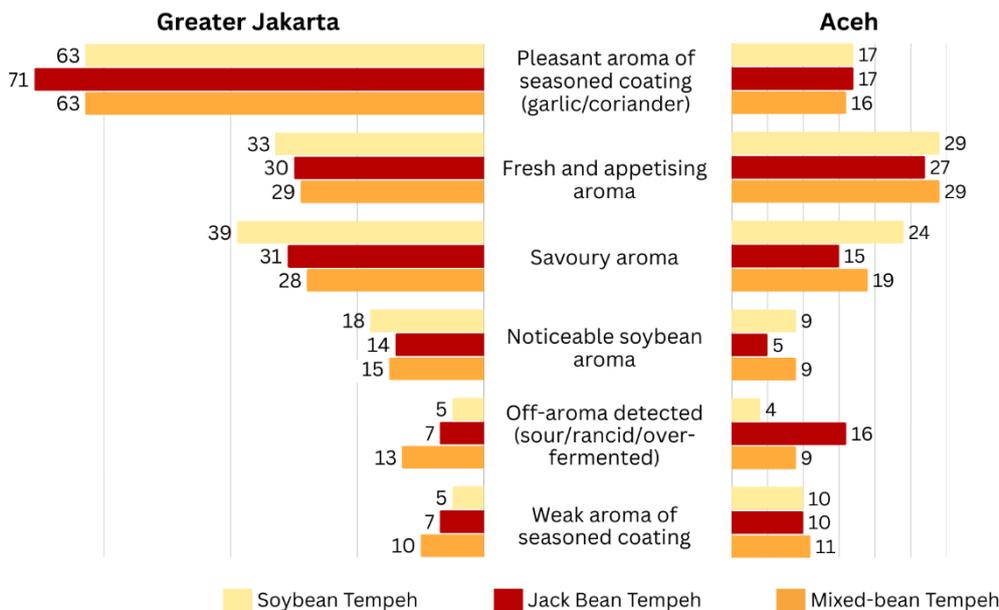
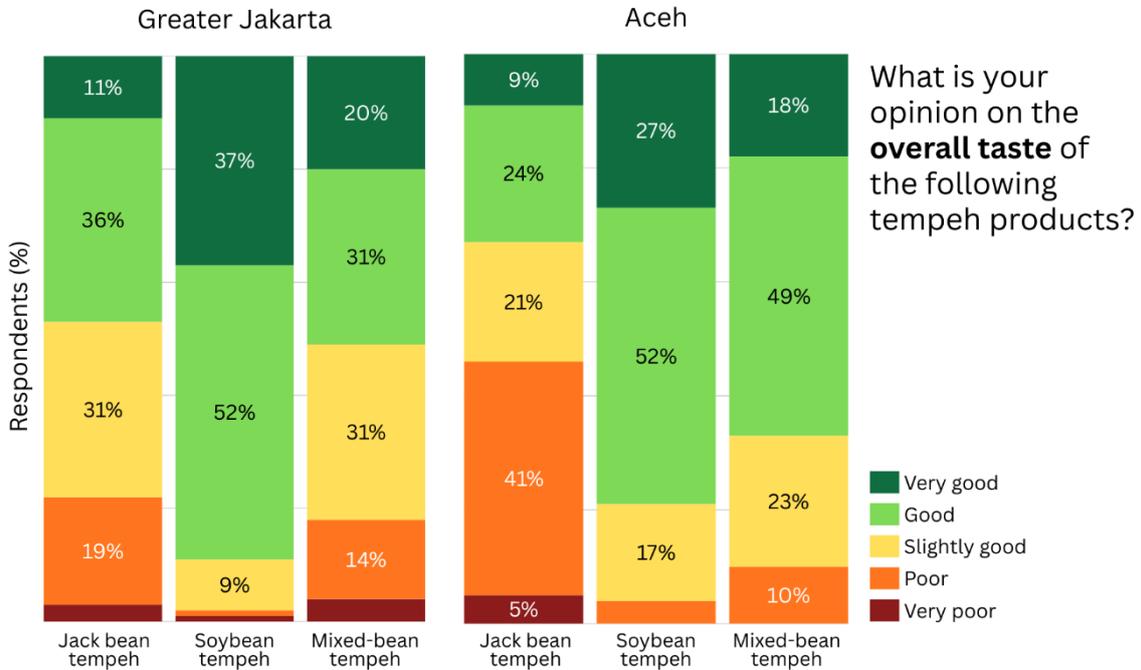


Figure 4. Aroma attributes of tempeh variants in Greater Jakarta and Aceh

In Greater Jakarta, 89% of respondents rated soybean tempeh highly in terms of overall taste, compared with 47% for jack bean tempeh and 51% for mixed-bean tempeh. 60% of respondents described the taste of jack bean tempeh as savoury, and 28% appreciated its texture; however, 34% considered its texture to be coarse. A similar pattern was observed

in Aceh, where soybean tempeh again ranked highest (79%), followed by mixed-bean tempeh (67%) and jack bean tempeh (33%). Respondents also recognised the savoury taste of the tempeh products, but jack bean tempeh was more frequently associated with unpleasant aroma (58%), with only 23% expressing liking for its taste.



Reasons Underlying Respondents' Taste Ratings (%)

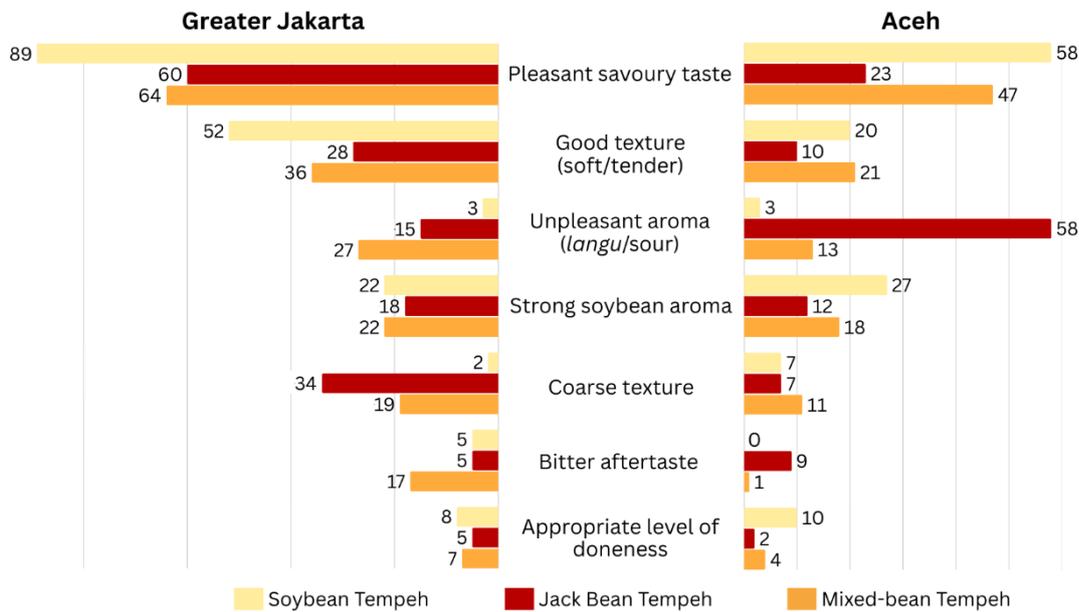
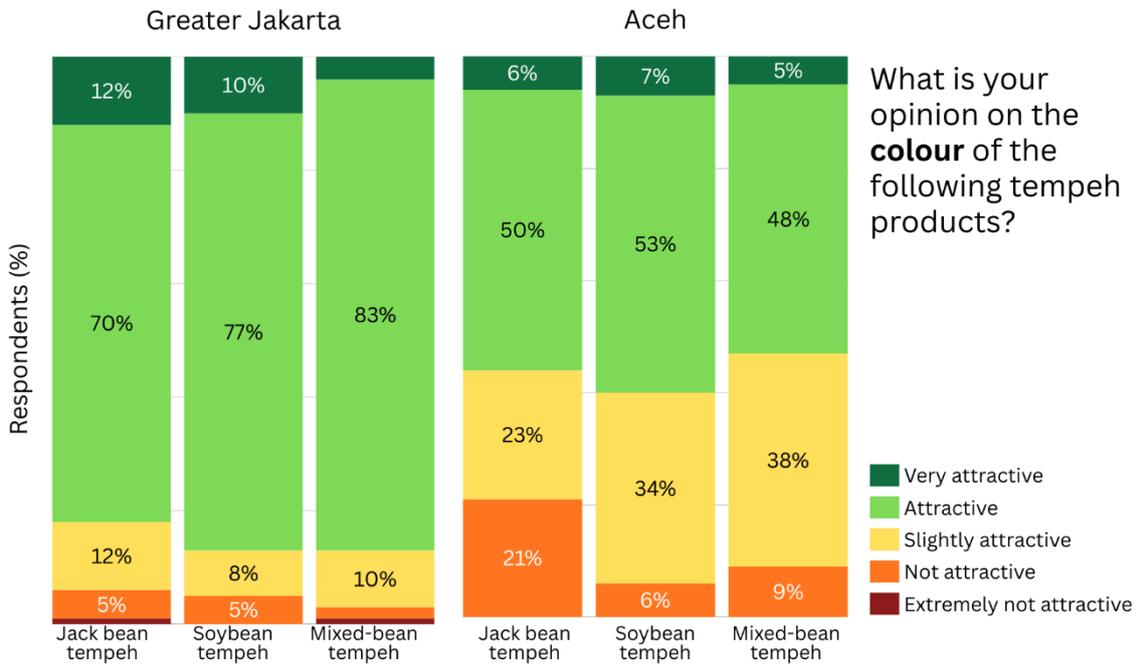


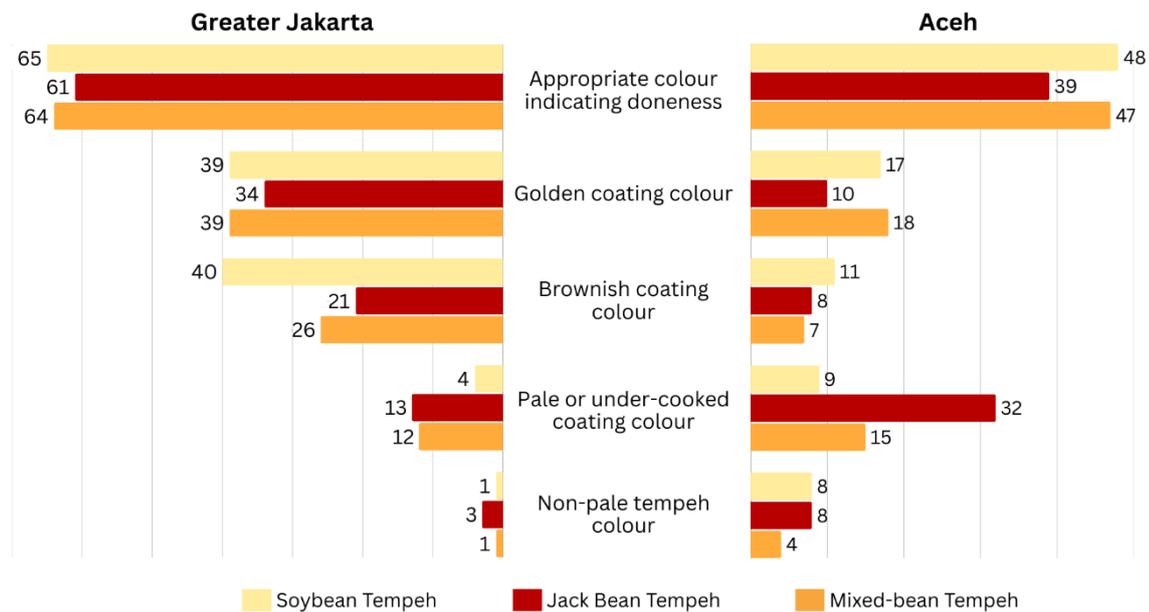
Figure 5. Taste and texture perceptions of tempeh variants in Greater Jakarta and Aceh

As shown in Figure 6, colour was consistently rated positively in Greater Jakarta, with overall attractiveness scores ranging from 82% to 87% across all tempeh variants. For jack bean tempeh, most respondents noted appropriate colour indicating doneness (61%), followed by a golden coating colour (34%). In contrast, colour ratings in Aceh were lower,

particularly for mixed-bean tempeh (53%). Appropriate doneness colour was also the most common response for all products, although a higher proportion of respondents noted pale or undercooked coating colour, particularly for jack bean tempeh (32%).



Reasons Underlying Respondents' Colour Ratings (%)



**Figure 6. Colour attributes of tempeh variants as perceived by consumers in Greater Jakarta and Aceh**

This survey also highlights regional differences in acceptance. In Greater Jakarta, consumers demonstrated higher openness to trying jack bean tempeh, particularly among upper socioeconomic groups and respondents aged 20-40 years. In Aceh, familiarity with jack bean tempeh was substantially lower, with most respondents having never encountered the product before. Despite this low familiarity, taste tests revealed that more than half of respondents in Aceh expressed a favourable response after trying

the product, citing perceived health benefits and acceptable taste and texture, while others noted unfamiliar aroma and flavours as barriers to acceptance. Interest in processed and convenience formats was also captured. A significant share of respondents expressed interest in purchasing ready-to-cook or frozen jack bean tempeh, particularly when positioned as a healthy and sustainable alternative protein source.

As for mung bean tempeh, Supriyanti et al. (15) found that consumers preferred mung bean tempeh made with perfectly peeled beans, as unpeeled beans resulted in a less desirable appearance. Mung bean tempeh also exhibits a softer texture due to uneven mycelium growth. While mung bean tempeh is not widely available on its own, RTI (Rumah Tempe Indonesia) offers a mixed soybean-mung bean tempeh, leveraging the high protein content of both legumes to appeal to health-conscious consumers.

Ahsanunnisa (16) suggests that peanut tempeh is favoured for its distinct aroma, derived from volatile compounds released during boiling, which distinguishes it from other varieties. Peanut tempeh is primarily found as a soybean-peanut blend offered by RTI. This combination is favoured for its enhanced protein and fat content, resulting in a richer flavour, aroma, and firmer texture, though it commands a higher price than standard soybean tempeh.

Overall, the data suggests that consumer openness toward jack bean tempeh exists but remains conditional. While many respondents expressed willingness to try alternative tempeh products, taste, aroma, and texture remain decisive factors influencing repeat purchase. Acceptance may potentially be further enhanced when products are supported by clear communication on nutritional benefits, local sourcing, sustainability credentials, and competitive pricing.

### Market viability

Sales of mixed soybean-jack bean tempeh in 2022 by one tempeh producer in Bogor (in collaboration with BUMR Paramasera) were hampered by the distinct jack bean taste. Thus, BUMR Paramasera has since developed a more acceptable version, fully produced in Indonesia from locally farmed jack beans. Priced at IDR 12,000 (USD 0.72) per 250g, it is comparable to mung bean or peanut tempeh. This premium price reflects fluctuating supply, high quality, and high production costs, limiting the current market to consumers focused on nutrition and sustainable local food. Despite this and its small-scale production, BUMR Paramasera has a consistent, slowly growing customer base. Consumers order the product via e-commerce or visit the production facility. BUMR Paramasera also distributes it to nearby stalls when pre-orders are low.

Other small businesses have also sold jack bean tempeh in traditional markets (e.g., Bogor, Cianjur, Kalimantan) for IDR 6,000/kg (USD 0.36; 70% cheaper than soybean tempeh), and some have explored mixed soybean-jack bean tempeh for higher profits. However, inconsistent jack bean supply forced these producers to revert to soybean tempeh. Reliable supply and refined production are therefore crucial for scaling jack bean tempeh production.

Despite its relatively small market share, jack bean tempeh shows potential among health-conscious and sustainability-oriented consumers, particularly in urban areas. Our findings indicate that online purchasing channels are more acceptable among wealthier socioeconomic groups in Greater Jakarta, whereas in Aceh, traditional markets remain the

primary point of purchase. These findings underline the importance of aligning pricing, distribution, and communication strategies with regional consumer characteristics.

The primary target market for jack bean tempeh consists of consumer aged 20-40 who regularly consume tempeh and are open to new variants, especially those aligned with health, sustainability, and local sourcing values. The survey also highlights socioeconomic differences between study locations, with Greater Jakarta respondents predominantly representing middle- to high-income groups, while Aceh respondents reflect more middle-income levels. These variations suggest that scaling jack bean tempeh will require region-specific strategies, including improved sensory quality, competitive pricing, and strong branding, to support its viability as a sustainable alternative within the Indonesian tempeh market.

### **PRODUCTION OF ALTERNATIVE TEMPEH**

Soybean tempeh production, dominated by micro, small, and medium-sized enterprises (MSMEs), relies on basic processing technology and enjoys stable pricing due to the supply of imported soybeans provided by KOPTI (the tempeh cooperative). This allows for stable profit margins, with the product retailing at IDR 3,750 (USD 0.22) per 250g, in 2024. BUMR Paramasera produced jack bean tempeh on a small scale, successfully addressing food safety concerns through licensing and food safety certified by BPOM. Despite positive consumer reception, inconsistent supply remains a critical challenge, forcing many producers to revert to soybeans. Priced at IDR 12,000 (USD 0.72) per 250g, jack bean tempeh's market remains niche. Mung bean tempeh production is limited, with RTI only offering it as a mixed product on a pre-order basis. It is easy to process and does not require special equipment. Priced at IDR 13,750 (USD 0.82) per 250g, its market is underdeveloped. Peanut tempeh is the least developed, with no MSME producers or enterprises involved in mass production in Bogor. The product is marketed for its nutritional benefits, particularly its high protein content. However, the market for peanut tempeh remains underdeveloped, with limited information on its economic viability. It is priced at IDR 9,375 (USD 0.56) per 250g.

### **Example of Two Alternative Tempeh Producers**

The two producers of alternative tempeh are BUMR Paramasera and RTI. BUMR Paramasera produced jack bean tempeh and RTI produced mixed bean tempeh.

Around 2022, Saeful, a tempeh producer and member of the Bogor Tempeh Association, experimented with creating a mixed tempeh product by combining soybean and jack bean. Driven by the high price of imported soybeans, which reached IDR 14,000 (USD 0.83) per kilogram at the same time, Saeful collaborated with BUMR Paramasera to source raw jack beans and developed an alternative tempeh using a 60:40 soybean-jack bean ratio. The resulting mixed-bean tempeh was sold at traditional markets at a price of IDR 16,000 (USD 0.95) per kilogram. While some consumers purchased the product, most could easily distinguish the taste difference between the mixed tempeh and original soybean tempeh. Consumer preference generally leaned towards the original soybean variety. BUMR Paramasera have the necessary production equipment, including a homemade crushing machine, though its efficiency could be improved. They produce tempeh 2-3 times weekly, yielding 100 pieces from 20 kilograms of jack beans. To address consumer safety concerns, BUMR Paramasera has registered jack bean as a food raw material and holds BPOM certification. BUMR Paramasera also frequently conducts training for tempeh

producers in Bogor to introduce jack beans as a soybean alternative, leading to awareness among several market vendors and producers.

RTI (Rumah Tempe Indonesia) has indicated that they can fulfil orders for mixed-beans tempeh on a small-scale and irregular basis, entirely tailored to consumer specifications regarding the bean composition. RTI did not adhere to a specific formula for mixed-beans tempeh; instead, production is conducted through a trial-and-error method due to the lack of a standardised production reference. The customised nature of this tempeh necessitates numerous adjustments to the production process and equipment settings, owing to the differing characteristics of the raw materials. This variability underscores the complexity of producing a standardised mixed-bean tempeh product. RTI's flexibility in accommodating consumer preferences, while advantageous for customisation, highlights the inherent challenges in maintaining consistency and efficiency in production.

### TECHNICAL FEASIBILITY

#### Processing technology

Although soybean tempeh production methods are varied, standardised practices and training are available to ensure quality and safety. The National Professional Certification Board (BNSP) offers competency certification for tempeh processing (SKM/0097/00003/3/-0001/6), which covers work safety procedures, production processes, and packaging. RTI also provides a tempeh production training programme covering production processes through waste management. Despite these resources, soybean tempeh production in Indonesia remains largely unregulated, allowing anyone with knowledge of tempeh production to produce and sell soybean tempeh. Optimised soybean processing techniques are well-established, involving soaking, dehulling, cooking, inoculation with *Rhizopus*, and fermentation, and many established soybean tempeh producers utilise soybean-skin-peeling machines to accelerate production. KOPTI provides various tempeh production equipment, including large boiling pots, soaking containers, skin-seed separating tubs, washing tubs, soybean-skin-peeling machines, fermentation tables, and fermentation trays.

Differences were noted between RTI and the Bogor Tempeh Association (Paguyuban), where RTI soaks soybeans before boiling, while the Paguyuban skips the soaking step. RTI also pours hot water over cleaned beans, whereas the Paguyuban drains and dries them directly. Despite these variations, no significant impact on flavour acceptance was observed, as both producers successfully met market demand.

Jack bean tempeh production cannot use all the same equipment as soybean tempeh; it requires a specialised seed crushing machine. BUMR Paramasera has an own-made machine. For every 1 kilogram of jack beans processed, 700 grams of crushed jack bean are produced, with the remaining 300 grams of flour diverted to other uses. Jack beans also require extended soaking and often mechanical assistance for dehulling due to their hard texture. Cyanide in jack beans is water-soluble and removable through proper processing (soaking, boiling, and fermentation) (14-16).

Tempeh producers in Bogor are generally familiar with jack beans as a potential alternative to soybeans. This awareness often comes from participation in training programmes or through general knowledge. However, despite this familiarity, they were still hesitant to produce jack bean tempeh due to taste differences, limited availability,

and a more complex production process. In 2024, only the BUMR Paramasera Cooperative in Bogor regularly produces and distributes jack bean tempeh on a small scale regularly.

The processing technology of jack bean tempeh in Aceh faces several challenges, including longer boiling and soaking times compared to soybeans, which increase energy use and reduce efficiency, particularly for small-scale producers relying on manual methods. Consumers have also reported less favourable texture and aroma, indicating the need for improved fermentation techniques and bean pre-treatment. Despite these challenges, significant opportunities exist, including adapting bean-cutting equipment to improve texture, optimising fermentation processes to reduce strong odours, developing ready-to-eat or frozen tempeh products (which interest consumers), mixed-bean formulations to enhance taste, processing compatibility, and affordability, and better packaging solutions using traditional and eco-friendly materials, supported by hygienic processing infrastructure. With targeted training, equipment support, and collaboration with research institutions, jack beans tempeh holds strong potential as a scalable, high-quality, and sustainable food product in Aceh.

Mung bean tempeh production, supported by readily available research and recipes, required no specialised machinery and less energy, making it suitable for large-scale production. Mung beans, due to their smaller size and softer texture, require less soaking and simpler dehulling, but their higher surface area to volume ratio necessitates careful fermentation monitoring. Mung bean tempeh, despite available research and online resources, has not been significantly upscaled commercially, nor has peanut tempeh. While RTI produces mixed soybean-mung bean and soybean-peanut tempeh for specific orders, neither mung bean nor peanut tempeh are widely available as original products.

Peanut tempeh, while recipes are accessible, presents a more challenging dehulling process, typically requiring a mechanical dehuller for efficient removal of the skin. Peanut tempeh processing also requires careful cooking to prevent overcooking, which affects texture. Peanuts' higher fat content can also hinder *Rhizopus* growth during fermentation, presenting another challenge.

Table 2 summarises the steps in tempeh production across the different bean types.

**Table 2. Comparative analysis of tempeh production process**

Process	Soybean	Jack Bean	Mung Bean	Peanut	Mixed Beans	
Grain cleaning	Cleaning under running water	Cleaning under running water	Cleaning under running water	Cleaning under running water	Each type of bean is processed separately following its own method from cleaning to cooling steps. Subsequently they are mixed with yeast and ready for fermentation	
Soaking	15-24 hours per 50 kg	12 hours	10 hours	14 hours		
Boiling	3 hours per 50 kg	2 hours	30 minutes	30 minutes		
Peeling	Manual peeling Regular peeling machine	Using regular peeling machine Require additional machine to chop jack bean into smaller size Re-soak for 48 hours, changing the water every 24 hours	Does not require peeling Manual peeling	Manual peeling		
Steaming	Not applied	Not applied	10 minutes	Not applied		
Draining	Draining from water	Draining from water	Draining from water	Draining from water		
Cooling	Room temperature 25-30°	Room temperature 25-30°	Room temperature 25-30°	Room temperature 25-30°		
Yeast mixing (Beans: Yeast)	1000 grams: 1 gram	1000 grams: 1 gram	1000 grams: 1 gram	1000 grams: 1 gram		1000 grams: 1 gram
Packing	Using plastic with holes, banana leaf, or teak leaf	Using plastic with holes	Using plastic with holes	Using plastic with holes		Using plastic with holes
Fermentation at room temperature	24 hours	48 hours	30-40 hours	48 hours		48 hours

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### Operational Considerations

Jack bean tempeh production is more established than other alternatives, with BUMR Paramasera consistently producing it for over four years in their small-scale facility. In Aceh, the operational considerations for jack bean tempeh production are still under development but show strong foundational potential. Unlike BUMR Paramasera, tempeh producers in Banda Aceh and Aceh Besar are just beginning to explore the use of jack beans. Pilot initiatives under the Rumoh Pangan Aceh project have introduced jack bean tempeh through limited-scale production using existing soybean processing setups and new tools, such as bean cutters or optimised fermentation containers. Mechanised equipment and fermentation monitoring tools tailored to jack bean's unique processing needs are currently under development. Additionally, as in Bogor, a producer in Aceh has registered jack bean as a certified food raw material with BPOM. More local producers and consumers have shown interest, and early consumer testing has driven awareness of the product's health and sustainability benefits. With institutional support, future operations in Aceh could include structured producer training, equipment innovation, and regulatory compliance, laying the groundwork for a more formalised and scalable jack bean tempeh industry.

### Implementation Requirements

Scaling jack bean tempeh production in Bogor requires targeted interventions across the value chain:

- **Raw Material:** More partnerships with established jack bean farmers are crucial to ensure a consistent supply.
- **Production:** Specialised training for producers is needed to address jack bean tempeh processing, dispel misconceptions about toxicity, and educate on safe handling and nutritional benefits.
- **Market:** Interventions focus on increasing consumer awareness and acceptance through educational campaigns, product trials, and highlighting the nutritional and cost advantages of the product.

These combined efforts are essential for the sustainable growth of jack bean tempeh production in the region.

The implementation of jack bean tempeh in Aceh requires addressing several key components simultaneously to ensure success and scalability:

- **Raw Material Supply:** The development of a stable raw material supply is essential, requiring collaboration with local farmers, provision of quality seeds, and guaranteed market access.
- **Processing and SOPs:** Producers need training and access to equipment (e.g., bean slicers, improved boiling tools) to adapt to the longer cooking time and firmer texture of jack beans. Standard operating procedures (SOPs) must also be disseminated to all producers for consistency.
- **Branding and Marketing:** Branding and packaging must highlight the product being local, healthy, and sustainable. Targeted education and marketing campaigns (especially via social media and community tastings) must be improved to build wider acceptance.
- **Institutional Support:** Support from government agencies, NGOs, and universities can facilitate producer training, infrastructure support, and regulatory guidance and foundation.
- **Distribution:** Strategies should prioritise both traditional markets and emerging channels (e.g., e-commerce and ready-to-eat formats) to match shifting consumer preferences.

### SUPPLY AND PRICE

#### Beans and Tempeh Supply

Locally cultivated soybeans are often more expensive in Indonesia than imported varieties. Furthermore, imported soybeans offer uniformity in colour and size, a crucial factor for producing high-quality tempeh, making them the preferred raw material. KOPTI and RTI sources imported soybeans, stabilising prices for their network that serves the Greater Jakarta market.

Jack bean supply in West Java has fluctuated due to limited cultivation, though BUMR Paramasera has worked to increase production through training and seed distribution. While cultivation is concentrated in Sumedang, some Bogor farmers and women's groups have also contributed. In Central Java and East Java, jack bean supply is higher due to higher demand for jack bean tempeh production by local producers.

The supply of beans in Aceh, particularly in Banda Aceh and Aceh Besar, is characterised by high dependency on imported soybeans, as local soybean cultivation is minimal and inconsistent. Tempeh producers rely heavily on distributors from outside the region (e.g., North Sumatra), making their supply vulnerable to roadblocks due to disasters and fluctuations in price, quality, and availability. The supply of alternative beans such as jack beans is still growing. There is currently structured local cultivation done in partnership with Rumoh Pangan Aceh, where agroecological conditions are suitable. This represents an opportunity to build a more resilient and localised bean supply chain.

Mung beans, a significant Indonesian legume crop cultivated across diverse regions, experienced a production decrease from 222,629 tons in 2020 to 211,176 tons in 2021. Peanut supply, however, has remained relatively stable from 2018-2022 (17). While information on mung bean and peanut suppliers is limited, both legumes are widely available in shops and traditional markets.

#### Price

While imported soybean availability is generally stable, it is subject to fluctuations in global supply, quality, and price, which can range from IDR 10,000 to 13,000 (USD 0.60 – 0.77) per kilogram. Soybean tempeh prices in Bogor's traditional markets range from IDR 10,000 to 15,000 (USD 0.60 – 0.89) per kilogram. Despite lower production costs, profits are generally lower than for other legumes, though premium production can improve margins.

Jack bean prices range from IDR 5,600 to 9,000 (USD 0.33 – 0.54) per kilogram, and while jack bean tempeh offers the highest profit margin, it also requires higher production costs due to supply instability and processing complexity. However, the low raw material cost makes jack beans a suitable soybean alternative.

Mung beans are generally priced around IDR 25,000 (USD 1.49) per kilogram. Using them in mixed-bean tempeh thus result in a higher final consumer price (IDR 13,750 / USD 0.82 per 250 grams of tempeh) than jack bean mixed tempeh, but unknown production costs preclude profit assessment. Peanuts are the most expensive raw material (IDR 28,000-32,000 / USD 1.67 – 1.91 per kilogram), creating a challenge for peanut tempeh production. Limited production cost data makes profit calculation impossible, and online prices

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suggest lower margins than other legume-based tempeh, making it the least economically attractive soybean alternative.

Table 3 presents the production costs and final consumer price for the different options; the estimated consumer price per 250g is IDR 12,736 (USD 0.76) for soybean-mung bean tempeh, compared to 10,553 (USD 0.63) for soybean-jack bean tempeh.

**Table 3. Comparative analysis of tempeh production price**

		Bean Price	Total production Cost	Sales Price	Profit
Soybean Tempeh	IDR	1,700	1,870	3,750	1,880
	USD	0.10	0.11	0.22	0.11
Jack Bean Tempeh	IDR	933.3	5,297	12,000	6,703
	USD	0.056	0.32	0.72	0.40
Mung Bean Tempeh	IDR	4,188	7,843	13,750	5,907
	USD	0.25	0.47	0.82	0.35
Peanut Tempeh	IDR	4,480	8,135	9,375	1,240
	USD	0.27	0.49	0.56	0.074
Soybean-Jack Bean Tempeh	IDR	1,393	6,949	10,553	4,059
	USD	0.083	0.39	0.63	0.24
Soybean-Mung Bean Tempeh	IDR	2,944	7,838	12,736	4,899
	USD	0.18	0.47	0.76	0.29

We calculated production cost for two types of mixed bean tempeh: soybean and jack bean, and soybean and mung bean. Table 4 estimates the cost of mixed-beans tempeh using a 60:40 soybean-jack bean ratio, which was preferred by tempeh producers for its flavour similarity to 100% soybean tempeh. Costs for non-raw material components were derived from established financial analysis for pure jack bean tempeh production. By examining all input costs, including raw materials, labour, packaging, and other overhead, we calculate the production cost for mixed bean tempeh.

**Table 4. Production cost analysis for mixed bean tempeh (soybean-jack bean)**

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No.	Description	Production Component	Unit Price		Price/250 gr package	
			IDR	USD	IDR	USD
1	Raw Soybean (60%)	kg	10.200	0.61	1.020	0.061
2	Raw Jack bean (40%)	kg	5.600	0.33	33	0.002
3	Product labels	pcs	500	0.03	500	0.03
4	Plastic packaging	pcs	1.000	0.06	131,9	0.0079
5	Water for production	cubic meter	9.000	0.54	50	0.003
6	Fuel/LPG for cooking	tube	180.000	10.77	562,5	0.034
7	Yeast	pack	19.000	1.14	19	0.0011
8	Labor cost	person/month	4.000.000	239.27	2.778,8	0.17
9	Electricity for peeling machine	kWH	1.467,28	0.088	19,6	0.0012
10	Electricity for drying machine	kWH	1.467,28	0.088	11,8	0.00066
11	Fuel/LPG for drying	tube	180.000	10.77	1.028,6	0.062
	<b>Production Cost</b>				<b>6.494</b>	<b>0.39</b>

Based on the calculations, the production cost for mixed bean tempeh was IDR 6,494 (USD 0.39) per 250 grams. To determine the final consumer price, we assumed a mark-up of 30% due to additional costs incurred by distributors plus a 25% consignment fees charged by retailers, resulting in a final consumer price of IDR 10,553 (USD 0.63) per 250 grams.

The second alternative considered for price analysis was soybean-mung bean mixed tempeh. Assuming a 50:50 composition, the cost estimates are shown in Table 5. All production costs, including those for labelling, packaging, water, fuel, yeast, labour, and electricity, were derived from the cost structure established for jack bean tempeh.

**Table 5. Production cost analysis for mixed bean tempeh (soybean-mung bean)**

No.	Description	Production Component	Unit Price		Price/250 gr package	
			IDR	USD	IDR	USD
1	Raw Soybean	kg	10.200	0.61	850	0.051
2	Raw Mung bean	kg	25.000	1.50	2.094	0.13
3	Product labels	pcs	500	0.03	500	0.03
4	Plastic packaging	pcs	1.000	0.06	131,9	0.0079
5	Water for production	cubic meter	9.000	0.54	30	0.0018
6	Fuel/LPG for cooking	tube	180.000	10.77	375	0.022
7	Yeast	pack	19.000	1.14	19	0.0011
8	Labor cost	person/month	4.000.000	239.27	2.777,8	0.17
9	Electricity for peeling machine	kWH	1.467,28	0.088	19,6	0.0012
10	Electricity for drying machine	kWH	1.467,28	0.088	11,8	0.00071
11	Fuel/LPG for drying	tube	180.000	10.77	1.028,6	0.062
	<b>Production Cost</b>				<b>7.838</b>	<b>0.47</b>

Based on the calculations, the production cost for mix-bean tempeh is IDR 7,838 (USD 0.47) per 250 grams. The final consumer price, accounting for additional costs incurred by distributors and consignment fees charged by retailers as above, is estimated to be IDR 12,736 (USD 0.76)

Our consumer surveys indicate a willingness to pay up to IDR 10,000 (USD 0.60) per 250 g as the acceptable price ceiling. Both alternative tempeh prices are above this limit, suggesting that neither would be aligned with market demand. It is possible, however, that the price could be justified if consumers see sufficient added value in the product (e.g., freshness, hygiene, quality of raw material, and packaging), but this remains to be seen.

### **SUMMARY OF COMPARATIVE ANALYSIS**

Figure 7 summarises the results of the analysis considering nutrition, price, production, and consumer acceptance aspects. From this study, the two most feasible alternative tempeh products to be scaled up in Indonesia appear to be jack bean tempeh and mixed-bean tempeh, particularly the 60:40 soybean–jack bean mix. Both alternatives offer nutritional benefits, appealing strongly to health-conscious consumers. Among the alternatives, jack bean tempeh shows the most nutritional promise as a direct soybean substitute due to its high fibre, moderate protein, and low-fat content. Furthermore, jack bean tempeh production can be scaled immediately, benefiting from readily available equipment and established facilities, unlike mung bean and peanut tempeh, which are still in the research phases.

Given favourable consumer preferences and existing infrastructure, mixed bean tempeh (soybeans with jack beans) demonstrates relatively strong acceptance, particularly in terms of aroma and taste in both Greater Jakarta and Aceh. Integrating jack beans into the current soybean tempeh infrastructure with necessary ratio adjustments could promote a resilient supply chain and appeal to health-conscious consumers, supporting the long-term sustainability, resilience, and growth of the tempeh industry.

In terms of production efficiency, 100% jack bean tempeh is preferable to the mixed soybean-jack bean variety, due to the simpler process and reduced need for specialised equipment. Moreover, jack beans provide the best price efficiency, featuring the lowest raw material cost while yielding the highest potential profit margin. Although current production costs are slightly elevated due to supply chain instability, they are projected to decrease significantly as jack bean supply stabilises. With effective farmers' partnerships and marketing that highlights its nutritional advantages and quality comparable to soybean tempeh, jack bean tempeh could capture a substantial market share.

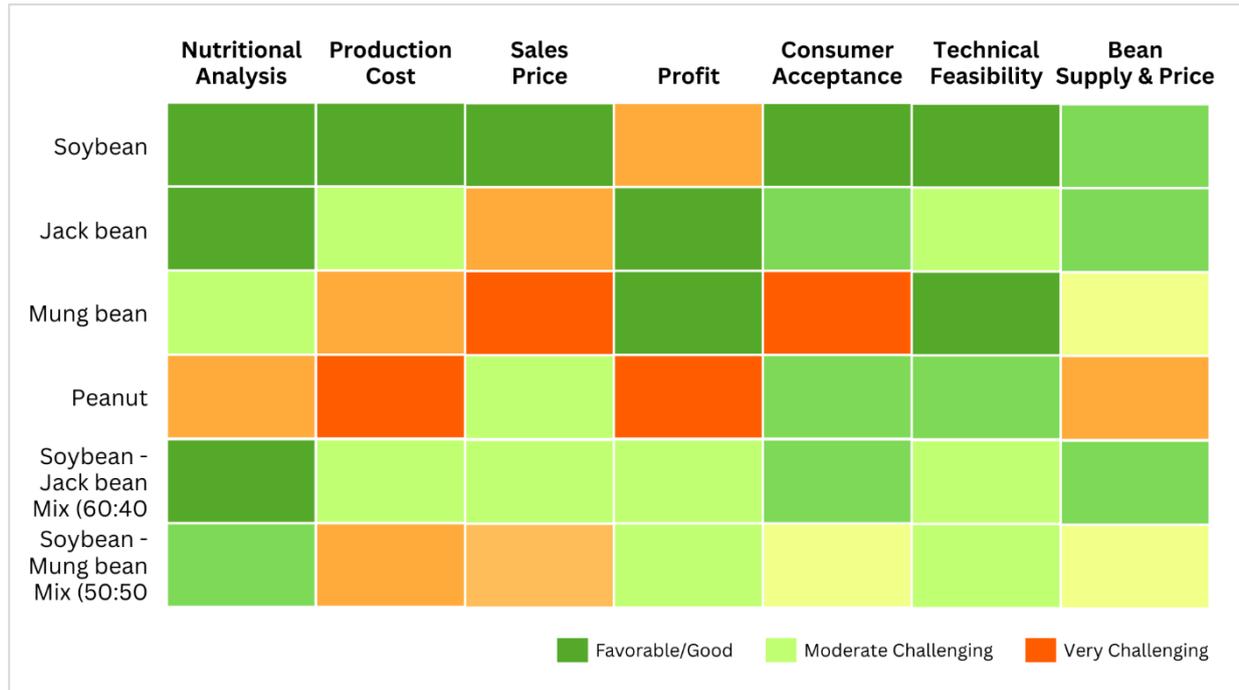


Figure 7. Comparative Analysis summary

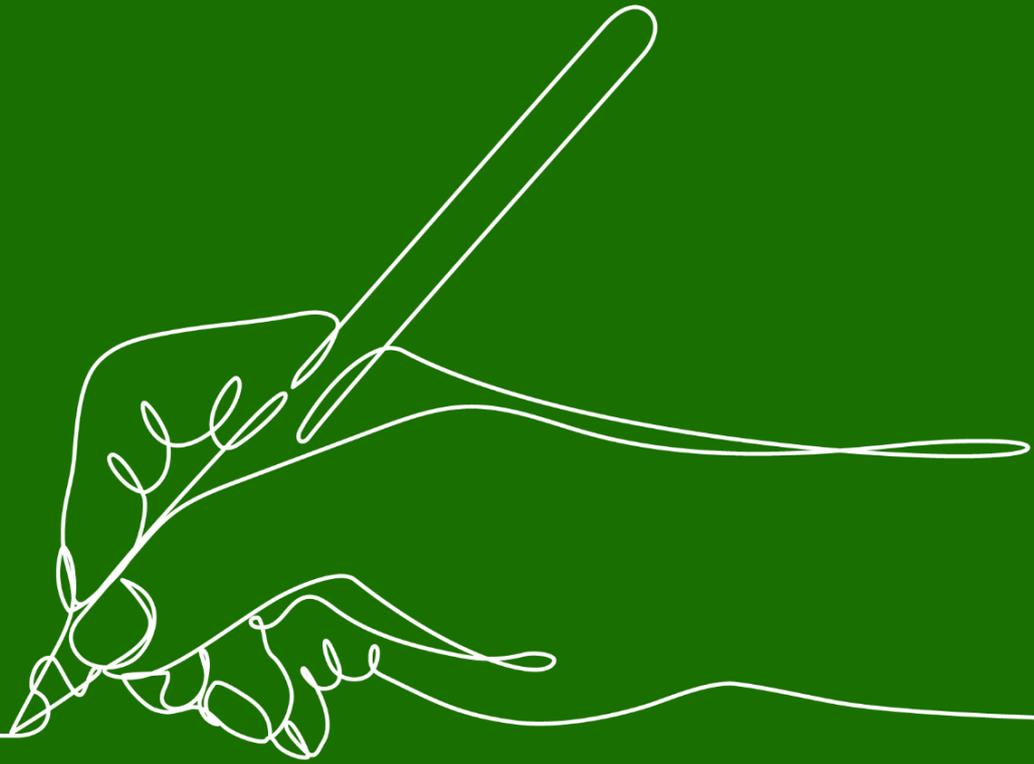
## CONCLUSIONS

This paper has examined three different legumes as alternatives to soybean in tempeh production, as well as mixed-bean options. Mung beans and peanuts have moderate raw material prices and availability; their challenges lie in market acceptance and health concerns. Jack bean emerges as a strong alternative, being nutritionally close to soybean. Jack bean tempeh has demonstrated a positive consumer response, particularly in terms of visual appeal and selected sensory attributes. Product testing shows that its appearance, especially colour and thickness, is well received, while taste and texture acceptance varied across regions. While soybean tempeh continues to maintain near-universal acceptance, jack bean tempeh could potentially achieve moderate to high acceptability, with differences in perceived acidity and aroma largely linked to unfamiliarity and processing characteristics. Jack beans also provide high profit margins due to lower raw material cost. Several enterprises have capacity to scale up jack bean tempeh production.

Thus, strong potential exists for exploring options to scale up production of jack bean tempeh and mixed jack bean-soybean tempeh as alternatives to soybean tempeh with potential benefits for local food security and environmental sustainability, while maintaining access to an affordable, highly nutritious food long central to Indonesian diets. To make this, possible stakeholders must work to increase jack bean supply and focus on stronger marketing to health-conscious and sustainability-focused consumers.

REFERENCES

1. Astuti, Trina; Sitompul, Marudut; Faadhilanisyah, Amirah. Tempeh consumption patterns in Indonesian family and contribution nutritional adequacy. *Action: Aceh Nutrition Journal*. 8, n. 4, p. 518-525, dec. 2023. ISSN 2548-5741 [dx.doi.org/10.30867/action.v8i4.1006](https://doi.org/10.30867/action.v8i4.1006).
2. Khumairah FH, Irwandhi, Hibatullah FH, Ambarita DD, Hendra, Islamiati A, et al. Revealing the import dilemma and attributing factors to Indonesia's inability to achieve soybean self-sufficiency: a bibliometric analysis and systematic literature review. *International Journal of Agricultural Sustainability*. 2025;23(1):2492546. doi:10.1080/14735903.2025.2492546.
3. Sibuea FA, Sibuea MB, Safitri SA. Indonesian soybean import in international trade. *Jurnal Manajemen & Agribisnis*. 2024;21(1):122-131. doi:10.17358/jma.21.1.122.
4. Peng D, Zhang H, Zhang Y, Yu L, Chen M, Chen JM, et al. Global soybean trade dynamics: Drivers, impacts, and sustainability. *The Innovation*. 2025;7(2):101124. doi:10.1016/j.xinn.2025.101124.
5. Lisciani S, Marconi S, Le Donne C, Camilli E, Aguzzi A, Gabrielli P, et al. Legumes and common beans in sustainable diets: nutritional quality, environmental benefits, spread and use in food preparations. *Frontiers in Nutrition*. 2024;11:1385232. doi:10.3389/fnut.2024.1385232.
6. Badan Pusat Statistik Provinsi Aceh. Provinsi Aceh dalam Angka 2024. <https://aceh.bps.go.id/id/publication/2024/02/28/9a8a3c2e62d9b541aba178db/provinsi-aceh-dalam-angka-2024.html> [Accessed 1st June 2025].
7. Badan Pusat Statistik Kabupaten Bekasi. Harvested Area, Production, and Productivity of Peanut and Mungbean by Regency/City in Jawa Barat Province, 2015. <https://bekasikab.bps.go.id/id/statistics-table/1/Mjc4MCMx/luas-panen-produksi-dan-produktivitas-kacang-tanah-dan-kacang-hijau-menurut-kabupaten-kota-di-provinsi-jawa-barat-2015.html> [Accessed 2nd June 2025].
8. Darini MT, Susilaningsih SE, Sunaryo Y. The potential of jack bean (*Canavalia ensiformis* L.) developed in suboptimal soil to Succeeding Food Sufficiency. *International Journal of Current Science Research and Review*. 2021;4(07):740-744. doi:10.47191/ijcsrr/V4-i7-17.
9. Sari E, Budiman I. Jack bean: A resilient legume to improve 'tempeh security' in Indonesia. <https://www.gainhealth.org/blogs/jack-bean-resilient-legume-improve-tempeh-security-indonesia> [Accessed 1st June 2025].
10. Affandi DR, Handajani S, Utami R. kajian kandungan protein, senyawa antinutrisi, aktivitas antioksidan, dan sifat sensoris tempe koro babi (*Vicia faba* L.) dengan variasi pengecilan ukuran. *Jurnal Teknologi Hasil Pertanian*. 2010;3(2):77-86.
11. Rizal S, Kustyawati ME, Suharyono AS, Suyarto VA. Changes of nutritional composition of tempeh during fermentation with the addition of *Saccharomyces cerevisiae*. *Biodiversitas*. 2022;23(3):1553-1559. doi:10.13057/biodiv/d230345.
12. Dewi IWR, Anam C, Widowati E. Sensory characteristic, nutrient value and antioxidant activities of pigeon pea tempeh (*Cajanus cajan*) and cow pea tempeh (*Vigna unguiculata*) with variations of fermentation time. *Biofarmasi*. 2014;12(2):73-82. doi: 10.13057/biofar/f120204.
13. Lelatobur LE, Dewi L. Optimasi Perebusan Biji Ketapang (*Terminalia cattapa*) Dalam Fermentasi Tempe. In *Prosiding SNPBS (Seminar Nasional Pendidikan Biologi dan Saintek) 2016:153-164*.
14. Widaningrum FN, Ermi S, Yuli PE. Introductory study on processing of fermented jack bean (*Canavalia ensiformis*). *Indonesian Journal of Agricultural Postharvest Research*. 2015;12(3):129-36.
15. Setyawan B, Ulfa R. Analisis Kandungan Protein dan Organoleptik Tempe dengan Media yang Berbeda: Analysis of Protein and Organoleptic Content of Tempeh with Different Media. *Jurnal Teknologi Pangan Dan Ilmu Pertanian (JIPANG)*. 2022;4(2):23-29. doi:10.36526/jipang.v4i2.2681.
16. Ahsanunnisa R. Perbandingan Mutu Tempe Dari Kacang Kedelai Dengan Kacang Tanah. *Alkimia: Jurnal Ilmu Kimia Dan Terapan*. 2018;2(1):43-46. doi: 10.19109/alkimia.v2i1.2262.
17. Directorate General of Food Crops. Laporan Tahunan 2021. Indonesian Ministry of Agriculture. 2021.



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