Analysis of Scientific Knowledge on The Process of Making Tempeh Gembus as Local Wisdom and Its Potential for Empowering Students' Analytical Thinking Skills

Lulu Nur Fajri¹, Suciati¹*, Isma Aziz Fakhrudin¹, Silvita², Opik Prasetyo², Hening Triandika Rachman³

¹Department of Science Education, Faculty of Teacher Training and Education, Sebelas Maret University, Surakarta, Indonesia
²Department of Biology Education, Faculty of Teacher Training and Education, Sebelas Maret University, Surakarta, Indonesia
³Department of Life Science, National Central University, Taiwan

*Email: suciati.sudarisman@yahoo.com

Abstract. The lack of teacher information regarding the scientific knowledge contained in the process of making tempeh gembus has an impact on students' low analytical thinking skills. This study aims to: (1) analyze the scientific knowledge in the process of making tempeh gembus; (2) analyze the potential of scientific knowledge in the process of making tempeh gembus towards empowering students' analytical thinking skills; and (3) analyze the correlation of scientific knowledge in the process of making tempeh gembus with the basic competencies in science learning materials. This research is a qualitative descriptive study with an ethnographic approach. The primary data sources for this research are from observations and interviews with tempeh gembus producers and junior high school science teachers in the Karangpandan District. The sampling technique used is snowball sampling. Data collection is carried out through observation, interviews, and documentation. The instrument validity test technique uses expert validation (two experts). Data validity test technique uses triangulation of data collection techniques. Data analysis is conducted using Miles and Huberman's interactive model analysis. The results show that the process of making tempeh gembus contains scientific knowledge (aspects of physics, chemistry, and biology). The scientific knowledge in the process of making tempeh gembus has the potential to empower students' analytical thinking skills. The scientific knowledge in the process of making tempeh gembus presented in booklet form is related to the basic competencies in junior high school science learning materials.

Keywords: Scientific knowledge, local wisdom, analytical thinking, tempeh gembus.
Introduction

The 21st-century human life, or the era of globalization, is characterized by the rapid development of science and technology (Primayana, 2019). This progress demands schools to cultivate high-level thinking skills in students (Saputra, 2016). An example of such high-level thinking skill is analytical thinking (Anderson et al., 2001). Teaching analytical thinking to students is crucial as it helps elaborate a concept into more detailed parts, explain the relationships between these parts, and identify the true meaning and conclusions of the relationships between concepts, descriptions, or other forms of representation to demonstrate beliefs, reasons, and acquired information (Blegur et al., 2023).

According to Widaningsih (2019), teachers need to improve students' problem-solving and critical thinking skills. This is based on the Programme for International Student Assessment (PISA) 2018 report, which shows a decline in the science performance of Indonesian students compared to the PISA 2015 report (The Organization of Economic Cooperation and Development (OECD), 2018). The low analytical thinking skills among students indicate the need for evaluation in learning processes conducted in the classroom because in general students's analytical thinking skills can be trained and sharpened through the learning process (Rosadi et al., 2019). Science learning in schools that remains theoretical and lacks the development of students's analytical thinking skills prevents students from making informed decisions as appropriate solutions to existing problems (Setiawaty et al., 2019). Recent studies have emphasized the importance of integrating local wisdom into science education to contextualized learning and promote students' thinking skills such as analytical thinking skills (Dewi et al., 2022; Kurniawan et al., 2021). However, there remains a paucity of research specifically examining the scientific aspects of traditional food production processes like tempeh gembus making (Syahadi et al., 2023; Manullang et al., 2022).

The advancement of technology in the current era of globalization has made it easier to access information, including information about foreign cultures, which can potentially displace local cultural values (Tresnawati, 2018). These displaced local cultures are at risk of being forgotten without more extensive efforts, particularly through education, to preserve the values of local wisdom (Parmin, 2015). One example of this shift in local wisdom values is the preference of many young generations for Western food over traditional cuisine in their regions (Basthomi & Rahmawati, 2022). Despite the cultural significance of tempeh gembus, there is a lack of research examining the scientific knowledge involved in its production process (Sari et al., 2022). As local wisdom is increasingly being displaced by globalization, there is a pressing need to preserve and promote traditional practices like tempeh gembus making (Yuliati et al., 2023).

One example of traditional Indonesian food is tempeh gembus. Tempeh gembus is a widely distributed traditional Indonesian food, especially in the provinces of Central Java and East Java (Gandjar & Slamet, 1972). One area in Central Java that produces tempeh gembus is in Karangpandan District, Karanganyar Regency (Ishartani et al., 2018). Tempeh gembus is made from tofu dregs fermented by the tempeh fungus *Rhizopus sp.* (Sari et al., 2022). The fermentation process in making tempeh gembus is believed to enhance the nutritional profile of tempeh by increasing nutrients such as vitamins and minerals, improving protein bioavailability, and reducing anti-nutrient content (Romulo & Surya, 2021). Tempeh gembus offers health benefits as an antioxidant, antimicrobial agent, inflammation reducer, and cholesterol-lowering agent (Manullang et al., 2020).

The local wisdom of tempeh gembus as a traditional food has started to be forgotten by the younger generation. The use of tofu dregs as the main ingredient in making tempeh gembus gives a unique impression that has caused it to be less popular among the community (Ulandari et al., 2014). People consider tempeh gembus to have less nutritional
value due to the raw material derived from tofu production waste (Wijaya & Yunianta, 2015). Typically, people only use tofu dregs as animal feed or dispose of it because if left unused for too long, the stored tofu dregs will produce an unpleasant odor (Sunartaty & Nurman, 2021).

Therefore, the local wisdom of tempeh gembus needs to be reintroduced to the community so that they can not only appreciate traditional food products as part of local culture but also be educated that tempeh gembus also offers good nutritional value for health. One efforts to maintain the existence of local wisdom is through teaching in schools by integrating local wisdom into the learning process (Yuliatin et al., 2021). Moreover, integrating this scientific knowledge into science education can potentially enhance students’ analytical thinking skills, which are crucial for problem-solving and decision-making in the 21st century (Setiawaty et al., 2021; Rosadi et al., 2022). However, in reality, teachers face challenges in integrating local wisdom into students’ learning, especially in science subjects (Lubis et al., 2022). Teachers often struggle to develop teaching materials that align with the students’ social and cultural environment (Lestariningsih & Suardiman, 2017). This is believed to be because teachers find it difficulty identifying scientific knowledge embedded in local wisdom (Basuki et al., 2019). Consequently, students are not familiar with the local wisdom that exists in their area (Safitri et al., 2018). Additionally, students tend to undervalue traditional knowledge and richness within their cultural community (Sarini & Selamat, 2019).

Based on the description above, it can be concluded that the lack of information among teachers regarding the scientific knowledge embedded in the process of making tempeh gembus has an impact on students' low analytical thinking skills. While previous studies have examined the scientific knowledge in traditional food production, limited research has analyzed the scientific aspects of the tempeh gembus making process and its potential for empowering students' analytical thinking skills. This study aims to fill this gap by conducting an in-depth ethnographic analysis of the tempeh gembus production process in Karangpandan District and integrated this local wisdom into junior high school science education.

The objectives of this study are threefold: (1) to analyze the scientific knowledge embedded in the tempeh gembus production process in Karangpandan District; (2) to examine the potential of this scientific knowledge for empowering students' analytical thinking skills; and (3) to analyzing the relationship between scientific knowledge in the process of making tempeh gembus and basic competencies in science learning materials. Therefore, there is a need for activities to analyze the scientific knowledge in the process of making tempeh gembus as local wisdom in Karanganyar Regency. The analyzed scientific knowledge will later be used as teaching material to empower students's analytical thinking skills in the form of booklets that related to science subjects.

**Methods**

This study is a descriptive qualitative research with an ethnographic approach. An Ethnographic approach is utilized to observe and analyze cultural elements of a nation (Spradley, 2016). The ethnographic study in this research is focused on the scientific knowledge embedded in the process of making tempeh gembus as a local wisdom in Karangpandan District, Karanganyar Regency.

The primary data sources in this research were obtained from interviews with informants, observation and documentation of the tempeh gembus making process, while secondary data sources came from relevant scientific articles and books. The subject sampling technique used in this research was snowball sampling. Snowball sampling is a technique for identifying and sampling the cases in a network or a connected population.
(Noy, 2008). The criteria for selecting the informants were as follows: (1) tempeh gembus producers in Karangpandan District; (2) still operational until now; and (3) residing in Karangpandan District. The sample determination was considered sufficient when the data reached saturation point, where additional samples would not provide new information (Sugiyono, 2017).

Data collection was carried out through observation, interviews, and documentation. Observation was conducted to directly observe the process of making tempeh gembus and identify the scientific knowledge involved in each stage. Semi-structured interviews were carried out with tempeh gembus producers to obtain in-depth information about the tempeh gembus production process and the local wisdom associated with it. Documentation was used to collect relevant documents, such as photos and videos, related to the tempeh gembus making process (Creswell, 2014).

The data analysis process used the Miles and Huberman interactive analysis model, which includes data reduction, data display, and conclusion drawing (Miles et al., 2014). Data reduction involved selecting, focusing, simplifying, abstracting, and transforming the raw data from field notes and interview transcripts. Data display was done by organizing and compressing the reduced data into matrices, charts, or networks to facilitate conclusion drawing. Conclusion drawing and verification involved identifying patterns, explanations, causal flows, and propositions based on the displayed data.

The data validity testing technique used was data collection technique triangulation, where data was collected from the same source but checked using different techniques (Denzin, 1978). For example, the data obtained from interviews with tempeh gembus producers were cross-checked with the data from observation and documentation. This triangulation helps to enhance the credibility and trustworthiness of the findings.

The instrument validity testing technique involved expert validation by two experts in the field of science education and local wisdom. The experts evaluated the appropriateness and relevance of the research instruments, such as interview guides and observation checklists, in relation to the research objectives. The content validity of the instruments was analyzed using the Gregory formula (Gregory, 2011):

\[
V_C = \frac{D}{A + B + C + D}
\]

Information:
- \(V_C\) : Content validity
- A : Both experts disagree
- B : Expert 1 agrees, expert 2 disagrees
- C : Expert 1 disagrees, expert 2 agrees
- D : Both experts agree

Content validity categories can be seen in Table 1.

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8 – 1.0</td>
<td>High Validity</td>
</tr>
<tr>
<td>0.4 – 0.79</td>
<td>Medium Validity</td>
</tr>
<tr>
<td>0.00 – 0.39</td>
<td>Low Validity</td>
</tr>
</tbody>
</table>

(Gregory in Retnawati, 2016)

A research instrument can be said to be valid and suitable for use if the minimum level of content validity achieved is at medium validity.
Results and Discussion

The Scientific Knowledge in the Process of Making Tempeh gembus

Based on the research findings, the process of making tempeh gembus consists of seven stages: 1) preparation of tools and materials; 2) drying; 3) steaming; 4) cooling; 5) inoculation; 6) wrapping; and 7) curing. Each stage of the tempeh gembus making process contains local knowledge that can be analyzed scientifically. The scientific knowledge analysis at the stage of preparing tools and materials is presented in Table 2.

Table 2. Analysis of Scientific Knowledge in the Preparation of Tools and Materials Stage

<table>
<thead>
<tr>
<th>Local Knowledge</th>
<th>Scientific Knowledge</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>An aluminum steamer pot is used as a container for steaming tofu dregs.</td>
<td>Aluminum steamer pots are good heat conductors (chemical aspect) (Darmanto &amp; Zulfar, 2022).</td>
<td>Steamer</td>
</tr>
<tr>
<td>Tofu dregs come from the residue of tofu production as the basic material for making tempeh gembus.</td>
<td>Tofu dregs contain nutrients such as protein, carbohydrates, fats, and dietary fiber that can be fermented into tempeh gembus (biological aspect) (Sari et al., 2021).</td>
<td>Tofu dregs</td>
</tr>
<tr>
<td>Tempeh starter culture serves to allow tofu dregs to mold and become tempeh gembus.</td>
<td>Tempeh starter culture is a fermentation product or starter containing microorganisms of the Rhizopus sp. fungi, including Rhizopus oligosporus, Rhizopus oryzae, and Rhizopus stolonifer (biological aspect) (Mujianto, 2013)</td>
<td>Tempeh starter</td>
</tr>
</tbody>
</table>

Based on Table 2, it is shown that the preparation of tools and materials stage in the process of making tempeh gembus involves scientific knowledge. Dandang as a steamer made from aluminum is a good heat conductor (Darmanto & Zulfar, 2022). Aluminum is a metallic element from group III A, with a shiny silver-white color that is corrosion-resistant and non-toxic, making it suitable for household utensils (Suoth et al., 2019).

Tofu dregs as the main ingredient in making tempeh gembus come from the leftover tofu production waste which is a solid waste generated during the tofu production process (Firdaus et al., 2022). Fresh tofu dregs have a soft texture due to the high water content, are white in color, and have a distinctive soybean smell (Puger et al., 2015). Tofu dregs contain nutrients such as protein, carbohydrates, fats, and crude fiber that can be fermented by Rhizopus sp. into tempeh gembus (Sari et al., 2021).
Tempeh starter culture which enables tofu dregs to mold and become tempeh gembus contains microorganisms from the *Rhizopus sp.* fungus species such as *Rhizopus oligosporus*, *Rhizopus oryzae*, and *Rhizopus stolonifer* as a fermentation culture or starter that play an important role in the process of making tempeh gembus (Mujianto, 2013). *Rhizopus sp.* fungus has a multicellular body, acts as a non-septate saprophyte on land, its mycelium resembles a cluster of cotton (hyphae), and its colony initially appears whitish-gray which gradually turns black due to the abundance of spores (Nail et al., 2020). Tempeh starter culture acts as a modifier of complex compounds into simpler compounds (Setiarto, 2020). Powdered tempeh starter culture is the most commonly used type of starter culture by the community (Amaliyah et al., 2017).

The analysis of the scientific knowledge involved in the preparation of tools and materials stage is supported by studies from Darmanto and Zulfiar (2022) and Suoth et al. (2019), which highlight the heat conductivity and suitability of aluminum for household utensils. Additionally, Sari et al. (2021), Firdaus et al. (2022), and Puger et al. (2015) discuss the nutrient content and characteristics of tofu dregs as the main ingredient in making tempeh gembus. Moreover, Mujianto (2013, Nail et al. (2020), Setiarto, 2020 and Amaliyah et al. (2019) discuss the tempeh starter culture which play a crucial role in the fermentation process of making tempeh. Then, the analysis of scientific knowledge in the preparation stage of drying is presented in Table 3.

Table 3. Analysis of Scientific Knowledge in the Drying Stage

<table>
<thead>
<tr>
<th>Local Knowledge</th>
<th>Scientific Knowledge</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>The drying process is carried out using a pressing tool so that the water</td>
<td>The drying process can occur due to the presence of compressive force (physical</td>
<td>Press tool</td>
</tr>
<tr>
<td>contained in the tofu dregs comes out.</td>
<td>aspect) originating from the hand in the form of a transverse force applied to the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>press tool handle that exceeds the adhesion force between solid waste and liquid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>waste, and the cohesive force between liquid waste (chemical aspect), resulting in</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the separation process between solid waste and liquid waste (Catur et al., 2022).</td>
<td></td>
</tr>
</tbody>
</table>

Based on Table 3, it is shown that the drying stage in the process of making tempeh gembus involves scientific knowledge. The drying process using a press tool can occur due to the presence of compressive force originating from the hand in the form of a transverse force applied to the press tool handle that exceeds the adhesion force between solid waste and liquid waste, and the cohesive force between liquid waste, resulting in the separation process between solid waste and liquid waste (Catur et al., 2022). The tofu dregs must have its moisture content reduced to 20% to be processed because if the water content in the tofu dregs is still high, it can hinder oxygen diffusion, which will inhibit the growth of fungal mycelium, leading to more bacterial growth than fungal growth (Rhohman et al.,
Additionally, tofu dregs will easily spoil, indicated by the presence of mucus and unpleasant odor (Masir et al., 2020).

The analysis of the scientific knowledge involved in the drying stage is supported by studies from Catur et al. (2022) that the drying process using a pressing tool can result in the separation of solid and liquid waste. Moreover, Rhohman et al. (2021), Arsini et al. (2023), and Masir et al. (2020) discuss the importance of reducing the moisture content in tofu dregs to optimize the fermentation process. Then, the analysis of scientific knowledge in the steaming stage is presented in Table 4.

**Table 4. Analysis of Scientific Knowledge in the Steaming Stage**

<table>
<thead>
<tr>
<th>Local Knowledge</th>
<th>Scientific Knowledge</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steaming is done to make the tofu dregs ripe.</td>
<td>Steaming is one of the thermal processes involving heat energy transfer (physical aspect) that includes convection processes from the steaming medium and conduction processes within the food product (Waziroh et al., 2017).</td>
<td><img src="image" alt="Steaming process" /></td>
</tr>
</tbody>
</table>

Based on Table 4, it is shown that the steaming stage in the process of making tempeh gembus involves scientific knowledge. The steaming stage of soybean pulp is one of the thermal processes involving heat energy transfer that includes convection processes from the steaming medium and conduction processes within the food product (Waziroh et al., 2017). Steaming is done using steam or direct hot water at a temperature of 100°C (Putri & Kartikawati, 2022). Steaming can reduce the activity or even kill harmful microorganisms such as Coliform bacteria, *E. Coli*, and *Salmonella sp.*, which will be destroyed at cooking temperatures of 60°C-70°C, and most bacterial spores will be destroyed in a heating process at 100°C for 30 minutes (Kartika et al., 2014; Dwikandana et al., 2018).

The analysis of the scientific knowledge involved in the steaming stage is supported by studies from Waziroh et al. (2017) that the steaming stage of soybean pulp as a thermal process involving heat energy transfer through convection from the steaming medium (water) and conduction within the food product (soybean pulp). The role of steaming in reducing the activity of harmful microorganisms is highlighted by Kartika et al. (2014) and Dwikandana et al. (2018). Then, the analysis of scientific knowledge in the cooling stage is presented in Table 5.
Table 5. Analysis of Scientific Knowledge in the Cooling Stage

<table>
<thead>
<tr>
<th>Local Knowledge</th>
<th>Scientific Knowledge</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Cooling is done to make the tofu dregs cold.</td>
<td>- During the cooling process, heat is transferred from a high temperature to a lower temperature (<em>physical aspect</em>) (Supu et al., 2016).</td>
<td>(a)</td>
</tr>
<tr>
<td>- The tofu dregs are sifted to form tempeh gembus.</td>
<td>- The larger the surface area of the hot tofu dregs, the more heat is released into the environment (<em>physical aspect</em>) (Supu et al., 2016).</td>
<td>(b)</td>
</tr>
<tr>
<td></td>
<td>- The change of water vapor into gas occurs due to the heat obtained from the steaming process (<em>physical aspect</em>) (Supu et al., 2016).</td>
<td></td>
</tr>
</tbody>
</table>

Based on Table 5, it is shown that the cooling stage in the process of making tempeh gembus involves scientific knowledge. During this cooling process, heat transfer occurs from a high temperature to a lower temperature. The sieving process of tofu dregs are carried out to accelerate the cooling process, where the larger the surface area of the hot object, the more heat is released to its surroundings. Moreover, changes in the temperature of an object are usually accompanied by changes in its shape or form (Supu et al., 2016). In this cooling stage, the transformation of water vapor into gas occurs due to the heat obtained from the steaming process (Wandini et al., 2022). This cooling is necessary because if the tempeh yeast is added while the tofu dregs are still hot, the growth of tempeh mold will not be optimal (Fazrin et al., 2020). This aligns with the statement by Fauziyah et al. (2022) where excessively high temperatures can trigger yeast inactivation leading to fermentation failure.

The analysis of the scientific knowledge involved in the cooling stage is supported by studies from Supu et al. (2016) that during the cooling process, heat transfer occurs from a high temperature to a lower temperature. Wandini et al. (2022) noted that the transformation of water vapor into gas occurs due to the heat obtained from the steaming process. Fazrin et al. (2020) emphasized that cooling is necessary before adding the tempeh yeast to ensure optimal mold growth, as excessively high temperatures can trigger yeast inactivation and fermentation failure. Then, the analysis of scientific knowledge in the inoculation stage is presented in Table 6.
Table 6. Analysis of Scientific Knowledge in the Inoculation Stage

<table>
<thead>
<tr>
<th>Local Knowledge</th>
<th>Scientific Knowledge</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tempeh powder yeast is added to the tofu dregs to allow it to mold into tempeh gembus.</td>
<td>The <em>Rhizopus oryzae</em> fungus will synthesize the enzyme amylase (starch breaker) and the <em>Rhizopus oligosporus</em> fungus will synthesize the enzyme protease (<em>biological aspect</em>) (Agustina et al., 2023).</td>
<td>Fermentation process</td>
</tr>
</tbody>
</table>

Based on Table 6, it is shown that the inoculation stage in the process of making tempeh gembus involves scientific knowledge. Tempeh powder yeast consists of a collection of fungal spores of the Rhizopus species such as *Rhizopus oligosporus* and *Rhizopus oryzae* which play a crucial role in the fermentation process of making tempeh (Amaliyah et al., 2017 & Ari et al., 2020). During fermentation, the *Rhizopus oryzae* fungus will synthesize the enzyme amylase (starch breaker) and the *Rhizopus oligosporus* fungus will synthesize the enzyme protease (Agustina et al., 2023). *Rhizopus oryzae* produces denser tempeh, while *Rhizopus oligosporus* produces tempeh with better protein content (Wahyudi, 2018).

The analysis of the scientific knowledge involved in the inoculation stage is supported by studies from Amaliyah et al. (2017) and Ari et al. (2020) that the tempeh starter culture used in the inoculation stage contains a collection of fungal spores such as *Rhizopus oligosporus* and *Rhizopus oryzae*. Moreover, Agustina et al. (2023), Ellent et al. (2022), and Wahyudi (2018) found that during fermentation, fungi synthesize several enzymes that influence the final result of tempeh. Then, the analysis of scientific knowledge in the wrapping stage is presented in Table 7.

Table 7. Analysis of Scientific Knowledge in the Wrapping Stage

<table>
<thead>
<tr>
<th>Local Knowledge</th>
<th>Scientific Knowledge</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>The tofu dregs mixed with yeast are placed in plastic bags with holes to allow sweating.</td>
<td>Fungi require oxygen to carry out fermentation (<em>biological aspect</em>) (Mufidah, 2018).</td>
<td>Wrapping process</td>
</tr>
</tbody>
</table>

Based on Table 7, it is shown that the wrapping stage in the process of making tempeh gembus involves scientific knowledge. The fungus *Rhizopus sp.* is a living organism that undergoes respiration and releases carbon dioxide and water vapor, causing the surface inside the plastic of tempeh gembusto be wet with water droplets, resembling sweating (Bukhari, 2022). Fungi require oxygen to carry out fermentation (Mufidah, 2018). Plastic as the wrapping material has low air, vapor, and heat permeability and needs to be punctured to allow fungi to grow (Kristiadi, 2022).

The analysis of the scientific knowledge involved in the wrapping stage is supported by studies from Mufidah (2018) and Kristiadi (2022) discuss that fungi require oxygen to carry out fermentation, and plastic as a wrapping material has low air, vapor, and heat...
permeability, necessitating punctures for fungal growth during the fermentation. Then, the analysis of scientific knowledge in the fermentation stage is presented in Table 8.

**Table 8. Analysis of Scientific Knowledge in the Curing stage**

<table>
<thead>
<tr>
<th>Local Knowledge</th>
<th>Scientific Knowledge</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>The packaged tofu dregs are left for 2 days in a dry place to sweat and mold.</td>
<td>In the curing process of tempeh gembus, fungi will digest the substrate and produce water, as well as some energy (biological aspect) (Ellent et al., 2022).</td>
<td>Curing process</td>
</tr>
</tbody>
</table>

Based on Table 8, it is shown that in the curing stage in the process of making tempeh gembus involves scientific knowledge. In the curing process of tempeh gembus, fungi will digest the substrate and produce water, as well as some energy. Fungi will produce several enzymes, such as protease enzymes that break down proteins into shorter peptides and free amino acids, along with lipase enzymes that break down fats into fatty acids, and amylase enzymes that break down complex carbohydrates into simple carbohydrates (Ellent et al., 2022). Good quality tempeh gembus is characterized by a uniform clean white color on the surface, a solid texture, and a distinctive tempe aroma (Santosa et al., 2024). The color of tempeh gembus is produced by fungi that grow during the curing process, where the longer the fermentation process, tempeh will gradually change from white to dark brown to overall black due to the sporulation event of the tempe fungus (Ulandari et al., 2014). According to Syahadi et al. (2022), to produce good quality tempeh gembus, a fermentation time of 36 to 48 hours is required. Therefore, the duration of fermentation significantly impacts the continuity of the tempe fermentation process, where longer fermentation times providing more opportunities for the mold to digest the substrate (Fauziah et al., 2022).

The analysis of the scientific knowledge involved in the curing stage is supported by studies from Ellent et al. (2022) that during the curing stage, fungi digest the substrate and produce water and energy. Fauziah et al. (2022) found that the duration of fermentation significantly impacts the continuity of the tempe fermentation process. Santosa et al. (2024) described the characteristics of good quality tempeh gembus. Moreover, Syahadi et al. (2022) recommended a fermentation time to produce good quality tempeh gembus.

Subsequently, the findings of scientific knowledge in the process of making tempeh gembus are compiled into a booklet for instructional material for students. This is based on interviews with teachers who have not integrated local wisdom into the process of making tempeh gembus in science lessons and have not implemented local wisdom-based booklets in science teaching.

**The Potential of Scientific Knowledge in the Process of Making tempeh gembus on Students’ Analytical Thinking Skills**
Based on previous analyses, it is evident that every stage in the process of making tempeh gembus contains scientific knowledge. Scientific knowledge presented in booklet form has the potential to empower students’ analytical thinking skills. Analytical thinking skills consist of several indicators including differentiating, organizing, and attributing (Anderson et al., 2001). The potential of the scientific knowledge in the process of making tempeh gembus in empower analytical thinking skills is presented in Figure 1.

**Figure 1.** The Potential of Scientific Knowledge in the Process of Making Tempeh Gembus to Empower Analytical Thinking Skills

Based on Figure 1, it is shown that each stage of the tempeh gembus making process has potential to empower analytical thinking skills. The potential of analytical thinking skills at each stage of the tempeh gembus making process is detailed as follows:

**a. Potential of Analytical Thinking Skills in the Differentiating Indicator**

The potential of analytical thinking skills in the differentiating indicator is relevant to the first stage of the tempeh gembus making process, which is the preparation of tools and materials. This stage requires the ability to select the tools and materials to be used. This corresponds to the analytical thinking skills in the differentiating indicator that distinguish the relevant or essential part from the irrelevant or unimportant part of the material presented (Anderson et al., 2001).

When students engage in learning using the booklet, they will select the tools and materials for the tempeh gembus making process according to their functions.
Students who initially only knew that tempeh gembus comes from tofu residue (assimilation) will acquire new knowledge (scientific knowledge) where the tools and materials used involve aspects of physics, chemistry, and biology, necessary in the process of making tempeh gembus (accommodation). Subsequently, students will attempt to adapt the new knowledge acquired with their existing knowledge (adaptation). Then, students' knowledge will increase after they are able to reconcile their initial knowledge with the new knowledge (equilibration). This is in line with Piaget's learning theory where when individuals react to the environment (assimilation) and the environment reacts to the individual (accommodation), an adjustment (adaptation) occurs, leading to achieving a balance of understanding (equilibration) (Whildan, 2021).

Additionally, students who initially had a basic understanding of the process of making tempeh gembus (initial arrangement) will gain new knowledge (scientific knowledge) that in the stage of preparing tools and materials (general concept), there are aspects of physics and chemistry (specific concept) (progressive differentiation) after undergoing the learning process using a booklet. Subsequently, students will strive to construct their existing knowledge with the new knowledge acquired (superordinate learning). Once students can connect their initial knowledge with the new knowledge, their knowledge will expand (integrative adjustment). This is in line with Ausubel's learning theory where meaningful learning is the process where an individual can connect newly acquired knowledge with previously existing knowledge (Darmayanti et al., 2023).

Winarni et al. (2022) found that students who engaged in learning activities involving the differentiation of relevant and irrelevant information showed improved analytical thinking skills. Pratama et al. (2021) reported that the ability to distinguish between essential and non-essential parts of a problem is a crucial aspect of analytical thinking. Sari et al. (2023) demonstrated that students who participated in learning experiences that required them to select and focus on relevant information developed better analytical thinking skills compared to those who did not engage in such activities.

b. Potential Analytical Thinking Skills in the Organizing Indicator

The potential for analytical thinking skills in the organizing indicator aligns with the drying stage, steaming stage, and cooling stage of the tempeh gembus making process. During these stages, students are required to have the ability to discover how the drying, steaming, and cooling of tofu dregs influence the success of the process of making tempeh gembus. This corresponds to the analytical thinking skills in organizing indicators that determine how elements fit or function within a structure (Anderson et al., 2001).

When students engage in learning processes using booklets, they will discover how the drying, steaming, and cooling of tofu dregs influence the success of making tempeh gembus. Students who initially only knew that the process of making tempeh gembus involves drying, steaming, and cooling (assimilation) will gain new knowledge (scientific knowledge) where the processes of drying, steaming, and cooling involve physical and chemical aspects that affect the success of making tempeh gembus (accommodation). Subsequently, students will attempt to adjust the new knowledge acquired with their existing knowledge (adaptation). Then, students' knowledge will increase after they are able to reconcile their initial knowledge with the new knowledge (equilibration). This aligns with Piaget's learning theory where when individuals react to the environment (assimilation) and the environment reacts to individuals (accommodation), adjustment (adaptation) occurs leading to achieving a balance of understanding (equilibration) (Whildan, 2021).
Additionally, students who initially had a preliminary understanding of the drying, steaming, and cooling processes (initial setup) will acquire new knowledge (scientific knowledge) that in drying, steaming, and cooling processes (general concept), there are physical and chemical aspects (specific concept) (progressive differentiation) after engaging in learning processes using booklets. Subsequently, students will strive to construct their existing knowledge with the new knowledge acquired (superordinate learning). Once students are able to connect prior knowledge with new knowledge, their knowledge will increase (integrative adjustment). This is in line with Ausubel's learning theory where meaningful learning is the process where an individual can connect new knowledge acquired with the knowledge they previously had (Darmayanti et al., 2023).

Purnomo et al. (2021) reported that students who engaged in learning activities that required them to organize information and identify relationships between elements demonstrated improved analytical thinking skills. Sulistiani et al. (2022) found that the ability to determine how parts fit into a larger structure is an essential component of analytical thinking. Hidayat et al. (2023) showed that students who participated in learning experiences that involved organizing and structuring information developed better analytical thinking skills compared to those who did not engage in such activities.

c. The potential for analytical thinking skills in the attributing indicator

The potential for analytical thinking skills in the attributing indicator aligns with the inoculation stage, wrapping stage, and curing stage of the tempeh gembus making process. In these stages, individuals are required to have the ability to comprehend the purpose of the inoculation, wrapping, and fermentation processes in the tempeh gembus making process. This corresponds to the analytical thinking skills in the attributing indicator that determine the point of view, bias, value, or intent that underlies the material presented (Anderson et al., 2001).

When students engage in learning processes using booklets, they will comprehend the purpose of the inoculation, wrapping, and curing processes, influencing the success of the tempeh gembus making process. Students who initially only knew that the tempeh gembus making process involves inoculation, wrapping, and curing (assimilation) will acquire new knowledge (scientific knowledge) where the inoculation, wrapping, and curing processes contain biological aspects resulting in the formation of tempeh gembus (accommodation). Subsequently, students will attempt to adapt the new knowledge acquired with their existing knowledge (adaptation). Following this, students' knowledge will increase once they are able to align prior knowledge with new knowledge (equilibration). This aligns with Piaget's learning theory where when individuals react to the environment (assimilation) and the environment reacts to individuals (accommodation), adjustment occurs (adaptation) leading to the attainment of a balanced understanding (equilibration) (Whildan, 2021).

In addition, students who initially have a basic understanding of the processes of inoculation, wrapping, and curing (initial arrangement) will acquire new knowledge (scientific knowledge) that in the stage of inoculation, wrapping, and curing (general concept), there are biological aspects (specific concept) (progressive differentiation) after engaging in learning processes using a booklet. Subsequently, students will attempt to construct their existing knowledge with the new knowledge acquired (superordinate learning). Once students can connect their prior knowledge with the new knowledge, their knowledge will increase (integrative adjustment). This aligns with Ausubel's learning theory, where meaningful learning is the process of attributing new knowledge with previously acquired knowledge (Darmayanti et al., 2023).
Wulandari et al. (2022) demonstrated that students who engaged in learning activities that required them to identify the underlying purpose, point of view, or bias in presented information showed improved analytical thinking skills. Nurhayati et al. (2021) reported that the ability to determine the intended meaning or motive behind presented material is a key aspect of analytical thinking. Permatasari et al. (2023) found that students who participated in learning experiences that involved attributing meaning and identifying the underlying intent of information developed better analytical thinking skills compared to those who did not engage in such activities.

The Relationship of Scientific Knowledge in the Making of tempeh gembus with Basic Science Competencies

Building on the previous discussion, the scientific knowledge involved in the making of tempeh gembus has the potential to empower analytical thinking skills as a teaching material for junior high school science subjects as it can be linked to several basic competencies (BC) outlined in the curriculum. The mapping of the relationship between junior high school science subject and basic competencies with the scientific knowledge in the process of making tempeh gembus is presented in Table 9 below.

Table 9. The Mapping of the Relationship between Junior High School Science Subject and Basic Competencies with the Scientific Knowledge in the Process of Making Tempeh Gembus

<table>
<thead>
<tr>
<th>Grade</th>
<th>Junior High School Science Subject</th>
<th>Basic Competencies</th>
<th>Scientific Knowledge in the Process of Making Tempeh Gembus</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Classification living creatures</td>
<td>3.2 Classify living things and objects based on observed characteristics</td>
<td>The use of Rhizopus sp fungus in the process of making “tempeh gembus” Rhizopus sp. need oxygen for respiration</td>
</tr>
<tr>
<td></td>
<td>Elements, compounds and mixtures</td>
<td>3.3 Explain the concept of mixtures and single substances (elements and compounds, physical and chemical properties in everyday life)</td>
<td>The use of aluminum as a metal element in the steaming process</td>
</tr>
<tr>
<td></td>
<td>Heat transfer and changes in temperature and shape of objects</td>
<td>3.4 Analyze the concepts of temperature, expansion, heat, heat transfer, and their application in everyday life including mechanisms for maintaining stable body temperature in humans and animals</td>
<td>Basic principles of heat transfer and changes in temperature and shape of objects in the steaming and cooling processes</td>
</tr>
<tr>
<td></td>
<td>Food as a source of energy</td>
<td>3.5 Analyze the concept of energy, various sources energy, and changes in energy forms in everyday life including photosynthesis</td>
<td>The nutritional content of tempeh gembus</td>
</tr>
</tbody>
</table>
Scientific knowledge in the process of making tempeh gembus has a connection with the basic competencies in the junior high school science subject, including: a) the use of *rhizopus sp.* fungus in the production process of tempeh gembus and the fact that *rhizopus sp.* fungus requires oxygen to carry out respiration in line with the competency standard 3.2 classifying living organisms and objects based on observed characteristics in the classification of living organisms in grade 7; b) the use of aluminum as a noble gas element in the steaming process in accordance with competency standard 3.3 explaining the concept of mixtures and pure substances (elements and compounds), physical and chemical properties, physical and chemical changes in daily life in the elements, compounds, and mixtures subject in grade 7; c) the basic principles of heat transfer and changes in temperature and the state of matter in the steaming and cooling processes in accordance with competency standard 3.4 analyzing the concepts of temperature, expansion, heat, heat transfer, and their application in daily life including the mechanisms of maintaining body temperature stability in humans and animals in the heat transfer and changes in temperature and state of matter subject in grade 7; d) the nutritional content found in tempeh gembus in line with competency standard 3.5 analyzing the concepts of energy, various energy sources, and changes in energy forms in daily life including photosynthesis in the food as an energy source subject in grade 7 and competency standard 3.5 analyzing the digestive system and understanding disorders related to the digestive system, as well as efforts to maintain the health of the digestive system. e) the concepts of adhesion and cohesion in the process of drying tofu dregs in accordance with competency standard 3.8 explaining vapor pressure and its application in daily life, including blood pressure, osmosis, and capillarity in plant transport tissues in the water and nutrient transport in plants subject in grade 8; and fermentation process in the production of tempeh gembus aligns with the application of biotechnology concepts and its role in human life in the basic principles of biotechnology for 9th-grade students. The mapping of the relationship between the scientific knowledge in the tempeh gembus making process and the basic competencies in junior high school science subjects is based on the curriculum document by the Ministry of Education and Culture (Kemendikbud, 2013). The relevant basic competencies cover various topics, such as the classification of living organisms, mixtures and pure substances, temperature and heat transfer, the digestive system and nutrition, pressure and capillarity, and biotechnology.

**Conclusion**
In conclusion, this study successfully achieved its objectives by analyzing the scientific knowledge embedded in the process of making tempeh gembus as local wisdom in Karanganyar Regency, examining its potential for empowering students' analytical thinking skills, and analyzing the relationship between scientific knowledge in the process of making tempeh gembus and basic competencies in science learning materials. The findings reveal that each stage of the tempeh gembus production process, including (a) preparation of tools and materials, (b) drying, (c) steaming, (d) cooling, (e) inoculation, (f) wrapping, and (g) curing, involves scientific knowledge in the aspects of physics, chemistry, and biology. Furthermore, the analysis showed that the different stages of the tempeh gembus making process align with the three indicators of analytical thinking skills: (a) differentiating, (b) organizing, and (c) attributing. The scientific knowledge of tempeh gembus production, is related to several basic competencies in junior high school science learning materials. This study contributes to the understanding of the scientific aspects of traditional food production and provides a framework for incorporating local wisdom into science education to enhance students' analytical thinking skills and appreciation for their cultural heritage.

References


