Scientific Knowledge Analysis of Tempeh Mlanding Making Process Toward Empowerment Potential System Thinking

Suciati [1], Hanifa Apri Ainita[1], Febriani Sarwendah Asri Nugraheni [1,*]

[1]Departement of Science Education Study Program, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Indonesia
febrianisarwendahasri@staff.uns.ac.id

Abstract. Local wisdom in the process of making tempe *mlanding* (*Leucaena leucephala*) can be integrated in science learning, especially to empower junior high school students' systems thinking skills. The purpose of this study was to analyze the scientific knowledge in the process of making tempe *mlanding* and its potential for empowering systems thinking skills. This research used a descriptive qualitative approach with an ethnographic research design. The results showed that the stage of making tempe *mlanding* consisted of 16 stages: (1) preparation; (2) sorting; (3) first boiling; (4) first draining and cooling; (5) raking; (6) washing; (7) first soaking; (8) second soaking; (9) second boiling/steaming; (10) second draining; (11) second cooling; (12) making laru; (13) yeast feeding; (14) wrapping; (15) fermentation; (16) marketing which contains scientific knowledge of science aspects of Physics, Chemistry, and Biology. The system thinking has 8 indicators, they are (1) identifying the components of a system and processes in the system; (2) identifying relationships between system components; (3) organizing system components and processes in terms of relationships; (4) making generalizations; (5) identifying dynamic relationships in the system; (6) understanding the hidden dimensions of the system; (7) understanding the cyclic nature of the system; (8) thinking temporally: retrospection and prediction. Based on the results of the study, it can be concluded that scientific knowledge from each stage of the process of making tempeh *mlanding* can empower students' thinking skills although it is still need more study for its expediency before implement it to the real class teaching.

Keywords: Knowledge, Scientific, System, Tempeh, Mlanding.

1 INTRODUCTION

The development of science and technology as an impact of the Industrial Revolution 4.0 raises complex problems, thus requiring problem-solving skills [1]. Comprehensive thinking needs to be done to overcome complex problems, one of which is systems thinking [2]. Based on the results of the PISA survey from 2012 to 2015, Indonesia is at a low level (level 1 of 5) which shows that Indonesian students have low problem-solving skills, including systems thinking due to not being trained in learning to the fullest[3], [4], [5].

P. C. Kuswandi et al. (eds.), *Proceedings of the 6th International Conference on Current Issues in Education (ICCIE) 2023*, Advances in Social Science, Education and Humanities Research 847,
https://doi.org/10.2991/978-2-38476-245-3_41

Indonesia as a country rich in noble values in the form of local wisdom that can answer the challenges of life. Local culture is a material for learning studies as a preservation effort in facing global challenges [6]. Local wisdom can be integrated into science materials that help students gain knowledge, learning motivation, learning environment, and character development [7]. One of these local wisdoms is traditional food in the form of tempe mlanding made from lamtoro seeds (Leucaena leucephala) as an alternative protein source that supports the Indonesian food security system [8]. Local wisdom contains local knowledge, so it can be reconstructed into scientific knowledge[9].

Globalization decreases students' awareness of preserving local wisdom which causes a loss of identity as an Indonesian nation [10]. One of the factors causing this condition is local wisdom-based learning that has not been optimized due to the teacher's minimal understanding [11]. This causes students to lack local wisdom in their area, including tempe *mlanding* which is starting to be forgotten by the community [12].

Teachers need reference sources that support the presentation of local wisdom-based learning. Local knowledge is holistic, so it can empower the ability to think systems [13]. Systems thinking is a holistic way of thinking by not solving problems partially and segmentation[14]. This study aims to analyze scientific knowledge and the potential for empowering the ability to think systems in the process of making tempe mlanding.

2 RESEARCH METHODS

The research location is in Mangrih Hamlet and Gayam Hamlet, Mojopuro Village, Jatiroto District, Wonogiri with a subject of 6 mlanding tempeh craftsmen taken based on snowball sampling technique. This research is a descriptive qualitative with a research design in the form of ethnography.

Data and sources of research data, namely data and primary data sources come from mlanding tempeh craftsmen in the form of interview results and observation results regarding the process of making mlanding tempeh. Secondary data and data sources come from literature, including journal articles and books.

The data collection technique used in this research is a non-test technique with three methods, namely interviews, observation, and documentation. Interview topics included ingredients, dosage, stages and reasons for each stage, results and consistency in the process of making tempeh mlanding. Observation topics explored were the process of making tempeh mlanding and the differences between each producer. Documentation was used to complement observation data. The data obtained were analyzed using the interactive analysis model from Miles, Huberman and Saldana (2014), namely: data condensation, data presentation, and conclusion drawing.

This study used three data validity tests, namely triangulation of sources and techniques, member checking, and expert judgment. Triangulation of sources, in the form of craftsmen, while triangulation of techniques, including interviews, observation, and documentation. Member checking was done to check the truth of the data written in the report. Expert judgment was conducted to validate scientific

knowledge and the process of making tempe mlanding and its potential in empowering system thinking skills by two lecturers with a science education background.

3 RESULT AND DISCUSSION

3.1 Analysis of Scientific Knowledge in the Process of Making Mlanding Tempeh

The process of making tempeh mlanding includes the preparation stage, processing stage, and marketing stage.

Preparation Stage.
The preparation stage aims to prepare tools and materials in the process of making tempeh mlanding. The tools and materials include: aluminum pots, stone stoves, rubber tubs, senik (bamboo baskets with tighter weaving), tomblok (woven bamboo shaped like a tub), tampah (woven bamboo like a large plate), bamboo steamer, plastic sheeting, old mlanding seeds, laru or usar, cassava flour, teak leaves, water, matches, and firewood.

Processing Stage.
Making tempeh mlanding consists of fourteen stages, namely: 1) sorting; 2) first boiling; 3) first draining and cooling; 4) raking; 5) washing; 6) first soaking; 7) second soaking; 8) second boiling/steaming; 9) second draining; 10) second cooling; 11) making laru; 12) yeast feeding; 13) wrapping; 14) fermentation. In each processing stage there is scientific knowledge as presented in Table 1.

Table 1. Identification of scientific knowledge in the processing stage of the tempeh *mlanding* making process

Stages	Indigenous Knowledge	Scientific Knowledge
Sorting	Select and obtain intact *mlanding* seeds with the help of the wind.	The *tampi* moving up and down quickly causes the air to fill the empty space and generate a large angular momentum, so the displacement distance of small grains is greater than that of large grains **(Physics Aspects)** [15].
First Boiling	Old *mlanding* seeds have a hard structure.	Old *mlanding* seeds experience dormancy which causes impermeability to water, so they have a hard structure **(Physical Aspects)**[16].

Stages	Indigenous Knowledge	Scientific Knowledge
First Draining and Cooling	1. Draining to remove mucus from the boiling process. 2. Cooling the *mlanding* seeds is done to facilitate the epidermis peeling stage because it uses the help of feet.	1. Temperature affects the osmotic pressure in seeds, resulting in the exchange of substances inside and outside the membrane to maintain the balance of pressure inside the cell **(Chemical Aspects)**[17]. 2. The foot is covered by skin that is a thermoreceptor, the cold receptor layer is just below the epidermis and the heat receptor is in the upper layer of the dermis (**Biological Aspects)** [18].
Raking	The epidermis will affect the density of tempeh *mlanding*.	Stripping the epidermis is done to make it easier for the fungus to penetrate the seed pieces in the fermentation process that supports the growth of mycelium in tempeh **(Biological Aspects)** [19].
Washing (floating)	The flaked *mlanding* seeds will float on the surface of the water.	The event of floating *mlanding* seeds is due to the downward force being smaller than the upward force according to Archimedes' law **(Physics Aspects)** [20] .
First Soaking	Soaking removes the odor and bitterness of the *mlanding* seeds.	The bitter taste comes from the content of mimosine in *mlanding* seeds which is toxic, so it can affect the function of organs when consumed **(Chemical Aspects)** [21].
Second Soaking	The second soaking is done by changing the soaking water due to the presence of mucus. This process is done to remove the rancid odor.	The soaking process will form organic acids, such as lactic acid and acetic acid due to bacterial growth, thus making the seeds acidic which facilitates the fermentation process **(Chemical Aspects)** [22].
Second Boiling/ Steaming	The second boiling is done to remove mucus and maximize the maturation of the *mlanding* seeds. Steaming is done to maximize the	Heating **(Physical Aspect)** can inactivate enzymes **(Chemical Aspect)** thus inhibiting the formation of lactic acid bacteria **(Biological Aspect)** [23]. Lactic acid **(Chemical Aspect)** from the soak is maintained because *Rhizopus oligosporus* can synthesize

Stages	Indigenous Knowledge	Scientific Knowledge
	maturation of the *mlanding* seeds.	acid enzymes optimally in acidic environmental conditions **(Biological Aspect)** [24].
Second Draining	Draining is done to reduce the water content in the *mlanding* seeds which affects the density of the *mlanding* tempeh.	*Rhizopus sp.* can grow in a humid environment **(Biological Aspects)** [25].
Second cooling	*Mlanding* seeds that are given a hot seasoning will spoil faster.	The optimum growth for Rhizopus fungi (Biological Aspects) is at room temperature, which is (20-37)^{0}C **(Physical Aspects)**[19].
Making *Laru*	Drying leaf *laru* either by (a) drying or (b) roasting	Drying and heating **(Physical Aspects)** can activate spores that were previously in the dormancy stage **(Biological Aspects)**[26].
	Pulverizing the *laru* with (a) pounding or (b) rubbing	Crushing is done to expand the contact surface of the tempeh yeast with the seeds **(Physical Aspects)**[27].
	Mixing *laru* with cassava flour	Cassava flour contains high carbohydrates **(Chemical Aspect),** so it can fulfill the nutritional needs for the growth of *R. oligosporus* **(Biological Aspect)** [28].
Yeast Feeding	*Laru* will convert the mlanding beans into a solid structure.	*Laru* or natural yeast acts as a tempeh starter containing tempeh fungus culture as an agent to convert boiled *mlanding* seeds into tempeh **(Biological Aspects)**
Wrapping	The *mlanding* seeds are wrapped using teak leaves so that the *mlanding* tempeh can form a solid structure.	Wrapping aims to form tempeh into a compact structure (solid) **(Physical Aspects)**.
Fermentation	The *mlanding* seeds are kept for 2 days with the criteria that the room is not too cold or hot and avoid oil.	Oil can inhibit the germination of mold spores **(Chemical Aspects)**. Low ambient temperature will inhibit mold growth **(Physical Aspects)**.

Marketing Stage.
Mlanding tempeh is sold in several markets, such as Sidoharjo, Jatisrono, Solo and Ponorogo.

3.2 Analysis of Scientific Knowledge in the Mlanding Tempeh Making Process towards the Empowerment Potential of System Thinking

The process of making tempe mlanding can bring up several indicators of systems thinking ability, namely (1) identifying the components of a system and processes in the system; (2) identifying relationships between system components; (3) organizing system components and processes in the framework of relationships; (4) making generalizations; (5) identifying dynamic relationships in the system; (6) understanding the hidden dimensions of the system; (7) understanding the cyclic nature of the system; (8) thinking temporally: retrospection and prediction [33]. The analysis process refers to the results of interviews with mlanding tempe craftsmen.

Identify the components of a system and the processes within the system.
This potential can be seen when craftsmen mention the tools and materials as well as the stages of making tempeh mlanding. The ability to identify components and processes in the system is the first stage or prerequisite of systems thinking.

Identify the relationship between system components.
This potential is seen when craftsmen understand the relationship between laru and cassava flour. Laru comes from white koro begog attached to teak leaves, which is a colony of Rhizopus oligosporus mold. The Rhizopus oligosporus mold needs nutrients to grow, so cassava flour is added as a nutrient because it contains high carbohydrates.

Organizing system components and processes in a relationship framework.
This potential is seen when craftsmen are able to regulate the number of repetitions of the stages of making tempeh mlanding, for example, the boiling process is only done twice to maintain the structure of the seeds. Boiling is a process of imbibition or absorption of water and oxygen into the seeds, so that the seeds become softer. Excessive imbibition will make the seeds more susceptible to damage.

Making generalizations.
This potential was seen when the craftsmen were able to understand that *laru* requires processing before being used as a starter for *mlanding* tempeh. *Laru* needs to be heated to activate the spores of *Rhizopus sp.* on the dormant *laru.*

Identifying dynamic relationships in the system.

This potential is seen when craftsmen are able to explain the interrelationship of each stage of making tempe mlanding, for example, the first boiling with grinding. Stripping the epidermis that is not clean enough can cause the texture of tempeh to become less dense.

Understanding the hidden dimensions of the system.
This potential was seen when the craftsmen explained that the use of laru would result in a better taste. Laru contains various types of Rhizopus sp. including Rhizopus microsporus and Rhizopus delemar, and each species contributes importantly in creating the flavor and nutritional value of tempeh. In contrast, artificial yeast "RAPRIMA" contains one particular type of Rhizopus sp. for example Rhizopus oligosporus. This potential also appears in the first and second soaking stages which are carried out to remove the bitter taste of mlanding seeds. The bitter taste comes from mimosine which has a negative impact on the body when consumed, such as inhibiting DNA synthesis, especially in rapidly dividing cells, causing damage to internal organs [35].

Understanding the cyclic nature of the system.
This potential is seen when craftsmen explain that the laru from the fermentation of tempeh can be reused in the fermentation process. The growth of Rhizopus sp. forms a cycle because it belongs to the Zygomycota group [36].

Temporal thinking: retrospective and temporal.
This potential is seen when craftsmen explain the reasons for using teak leaves. Teak leaves as leaf wrappers actually have their own advantages. Leaf wrapping will produce better aeration (air circulation) for tempeh through the gaps in the wrapping

4 CONSLUSION

Based on the explanation of the research results and discussion, it can be concluded that the process of making tempe mlanding contains scientific knowledge of science and has the potential to empower system thinking skills. The results show that the process of making tempe mlanding contains scientific knowledge of science that can empower students' systems thinking skills. The limitation of this research is that science learning has not been designed to apply the findings in the classroom. Future research can develop science learning tools based on the findings of this research to measure the improvement of students' thinking skills.

AUTHOR'S CONTRIBUTION.
The results of this study can be used as a reference for further research in the form of its implementation in science learning with different aspects and perspectives

References

1. Suciati, W. Sunarno, and Sarwanto, "Penerapan Bimbingan Tesis Berbasis Lesson Study terhadap Percepatan Penyelesaian Studi Mahasiswa dalam Menerapkan Model Problem Based Learning (PBL)," *BIOEDUKASI*, vol. 10, no. 1, pp. 58–64, 2017.
2. R. Bungsu and K. I. Rosadi, "Faktor Yang Mempengaruhi Berpikir Sistem : Aspek Internal dan Eksternal," *JESMI J. Ekon. Manaj. Sist. Inf.*, vol. 2, no. 2, pp. 205–215, 2020.
3. OECD, PISA 2012 Results in Focus. OECD, 2014.
4. OECD, PISA 2015: PISA Results in Focus. OECD, 2018.
5. OECD, *PISA 2018 Assessment and Analytical Framework*. 2019. [Online]. Available: https://doi.org/10.1787/b25efab8-en
6. P. No.81A, Permendikbud No.81A Tahun 2013 Tentang Implementasi Kurikulum. 2013, p. 4. doi: 10.4324/9780203821411-19.
7. E. S. Indrawati and Y. Nurpatri, "Problematika Pembelajaran IPA Terpadu (Kendala Guru Dalam Pengajaran IPA Terpadu)," *Educ. J. Pendidik.*, vol. 1, no. 1, pp. 226–234, 2022, doi: 10.56248/educativo.v1i1.31.
8. A. Nursiwi, B. I. Dwikiputra, D. Ishartani, and A. M. Sari, "Changes on microbial growth during Mlanding tempeh (Leucaena leucocephala) over fermentation," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 379, no. 1, 2019, doi: 10.1088/1755-1315/379/1/012001.
9. I. Aldeva, S. Revi, U. Maisyarah, and D. Diniya, "Kajian Etnosains Tradisi Maauwo di Danau Bakuok Sebagai Sumber Pembelajaran Biologi," *J. Pendidik. Biol.*, vol. 2, no. 2, pp. 79–86, 2020, [Online]. Available: http://jurnal.unimed.ac.id/2012/index.php/JPB
10. Habibi, T. S. Pitana, and Susanto, "Protecting National Identity Based On The Value Of Nation Local Wisdom," *Int. J. Malay-Nusantara Stud.*, vol. 1, no. 2, pp. 24–40, 2018, [Online]. Available: http://journal.unhas.ac.id/index.php/IJoM-NS/article/view/5516
11. I. Oktavianti and Y. Ratnasari, "Etnopedagogi Dalam Pembelajaran Di Sekolah Dasar Melalui Media Berbasis Kearifan Lokal," *Refleks. Edukatika J. Ilm. Kependidikan*, vol. 8, no. 2, pp. 149–154, 2018.
12. A. Rusilowati and A. Widiyatmoko, "Pembelajaran Kebencanaan Alam Bervisi Sets Terintegrasi Dalam Mata Pelajaran Fisika Berbasis Kearifan Lokal," *J. Pendidik. Fis. Indones.*, vol. 11, no. 1, pp. 42–48, 2015, doi: 10.15294/jpfi.v11i1.4002.
13. M. Basdew, O. Jiri, and P. L. Mafongoya, "Integration of indigenous and scientific knowledge in climate adaptation in KwaZulu- Natal, South Africa," *Chang. Adapt. Socio-Ecological Syst.*, vol. 3, no. 1, pp. 56–67, 2017, doi: 10.1515/cass-2017-0006.
14. R. Nurmalina, "Berpikir Sistem (System Thinking) Dalam Pendekatan Sistem (System Aproach)," *Agribus. Ser. 2017*, no. June, pp. 15–24, 2017, [Online]. Available: http://agribisnis.ipb.ac.id/wp-content/uploads/2017/11/02-Rita-Nurmalina.pdf
15. R. Munir, H. D. Rahmayanti, R. Murniati, D. Y. Rahman, S. Viridi, and M. Abdullah, "Experiment and Modeling of Rice Winnowing: Granular Segregation Method in Ancient Traditions," *Granul. Matter*, vol. 22, no. 24, 2020, doi: https://doi.org/10.1007/s10035-019-0991-6.
16. Y. A. Rachma, R. Indrati, and Supriyadi, "Karakteristik Perkecambahan Biji Lamtoro [Leucaena leucocephala (Lam .) de Wit] dan Perubahan Nilai Gizi Kecambah dengan Perlakuan Skarifikasi Germination," *Bul. Anat. dan Fisiol.*, vol. 7, no. 1, pp. 11–18, 2022.
17. S. Shin and A. S. Kim, "Temperature Effect on Forward Osmosis," in *Osmotically Driven Membrane Processes - Approach, Development and Current Status*, no. October, INTECH, 2018. doi: 10.5772/intechopen.72044.
18. E. Arens and H. Zhang, "The Skin's Role in Human Thermoregulation and Comfort," in *Thermal and Moizture Transfort in Fibrous Materials*, San Fransisco: UC Berkeley, 2006.

19. S. L. Suknia and T. P. D. Rahmani, “Proses Pembuatan Tempe Home Industry Berbahan Dasar Kedelai (Glycine max (L.) Merr) Dan Kacang Merah (Phaseolus vulgaris L.) di Candiwesi, Salatiga,” *Southeast Asian J. Islam. Educ.*, vol. 03, no. 01, pp. 59–76, 2020.
20. G. Cavazzini, “A New Physical Interpretation of Archimedes ’ Principle,” *J. Appl. Math. Phys.*, vol. 6, pp. 215–223, 2018, doi: 10.4236/jamp.2018.61020.
21. M. Rusdy, “Improvement of Seed Germination and Early Seedling Growth of Leucaena leucocephala by Cold Water , Mechanical and Acid Scarification Pretreatment,” *Int. J. Res. Sci. Publ.*, vol. 01, no. 01, pp. 1–6, 2016.
22. A. Safitry, M. Pramadani, W. Febriani, A. Achyar, and R. Fevria, “Uji Organoleptik Tempe dari Kacang Kedelai (Glycine max) dan Kacang Merah (Phaseolus vulgaris),” *Pros. SEMNAS BIO Univ. Negeri Padang*, pp. 358–368, 2021.
23. A. Rohman, B. Dwiloka, and H. Rizqiati, “Pengaruh Lama Fermentasi Terhadap Total Asam , Total Bakteri Asam Laktat , Total Khamir dan Mutu Hedonik Kefir Air Kelapa Hijau (Cocos nucifera),” *J. Teknol. pangan*, vol. 3, no. 1, pp. 127–133, 2019.
24. A. W. Nugraha, O. Suparno, N. S. Indrasti, and H. Hoerudin, “The Properties of Wet Blue Added Crude Enzyme firm Rhizopus oligosporus in the Acid Bating Process,” *Trop. Anim. Sci. J.*, vol. 45, no. 1, pp. 104–111, 2022, doi: 10.24264/lfj.22.2.6.
25. F. N. Atika, A. Susanto, and I. N. Zuhroh, “Identifikasi Rhizopus Sp Dan Aspergillus Sp Pada Tempe Yang Tersimpan Dalam Suhu Ruang,” *Anal. Standar Pelayanan Minimal Pada Instal. Rawat Jalan di RSUD Kota Semarang*, vol. 3, no. 2, pp. 103–111, 2018.
26. T. T. Wyatt, H. A. B. Wösten, and J. Dijksterhuis, *Fungal spores for dispersion in space and time*, 1st ed., vol. 85. Elsevier Inc., 2013.
27. R. B. Halimu, R. S.Sulistijowati, and L. Mile, “Identifikasi Kandungan Tanin pada Sonneratia alba,” *J. Ilm. Perikan. dan Kelaut.*, vol. 5, no. 4, pp. 93–97, 2017.
28. S. Rizal, Murhadi, M. E. Kustyawati, and U. Hasanudin, “Growth optimization of saccharomyces cerevisiae and rhizopus oligosporus during fermentation to produce tempeh with high β-glucan content,” *Biodiversitas*, vol. 21, no. 6, pp. 2667–2673, 2020, doi: 10.13057/biodiv/d210639.
29. D. Hernawati and V. Meylani, “Variasi Inokulum Rhizopus sp. Pada Pembuatan Tempe Berbahan Dasar Kedelai Dan Bungkil Kacang Tanah Inoculum,” *BIOMA J. Biol. Makassar*, vol. 4, no. 1, pp. 58–67, 2019.
30. F. Kusnandar, A. T. Wicaksono, A. S. Firlieyanti, and E. H. Purnomo, “Prospek Pengolahan Kacang Merah (Phaseolus vulgaris L .) Dalam Bentuk Tempe Bermutu,” *Manajamen IKM*, vol. 15, no. 1, pp. 1–9, 2020.
31. N. Gemeda, Y. Woldeamanuel, D. Asrat, and A. Debella, “Effect of essential oils on Aspergillus spore germination, growth and mycotoxin production: A potential source of botanical food preservative,” *Asian Pac. J. Trop. Biomed.*, vol. 4, no. Suppl 1, pp. S373–S381, 2014, doi: 10.12980/APJTB.4.2014C857.
32. H. Mukhoyaroh, “Pengaruh Jenis Kedelai, Waktu dan Suhu Pemeraman Terhadap Kandungan Protein Tempe Kedelai,” *Florea*, vol. 2, no. 2, pp. 47–51, 2015.
33. O. B. Assaraf and N. Orion, “Development of System Thinking Skills in the Context of Earth System Education,” *J. Res. Sci. Teach.*, vol. 42, no. 5, pp. 518–560, 2005, doi: 10.1002/tea.20061.
34. Y. Uyatmi, E. Inoriah, and M. Marwanto, “Pematahan Dormansi Benih Kebiul (Caesalphinia bonduc L.) dengan Berbagai Metode,” *Akta Agrosia*, vol. 19, no. 2, pp. 147–156, 2016, doi: 10.31186/aa.19.2.147-156.
35. A. De Angelis, L. Gasco, G. Parisi, and P. P. Danieli, “A multipurpose leguminous plant for the mediterranean countries: Leucaena leucocephala as an alternative protein source: a review,” *Animals*, vol. 11, no. 8, pp. 1–16, 2021, doi: 10.3390/ani11082230.

36. J. A. Ferreira, P. R. Lennartsson, and M. J. Taherzadeh, "Production of Ethanol and Biomass from Thin Stillage Using Food-Grade Zygomycetes and Ascomycetes Filamentous Fungi," *energies*, vol. 7, pp. 3872–3885, 2014