Field Research for Production Method of Miang: Post–Fermented Tea in Thailand

Masanori HORIE1,†, Supatjaree RUENGSOMWONG2, Bhusita WANNISSORN2

1Health and Medical Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), 2217–14, Hayashi–Cho, Takamatsu, Kagawa 761–0301, Japan.
2Biodiversity Research Center, Thailand Institute of Scientific and Technological Research (TISTR), 35 Mu 3 Tambon Khlong Ha, Amphoe Khlong Luang, Pathum Thani 12120, Thailand.

"Miang" is a type of post–fermented tea in northern Thailand, which is produced by lactate fermentation. The fermentation process is similar to that of Awa–bancha, which is a type of Japanese post-fermented tea from Tokushima. However, the processing procedures for the Miang and Japanese post-fermented teas are different. Miang is classified into two types based on its fermentation period. Mian–Faat (stringent Miang) is produced after fermentation for several weeks to one month. Mian–Som (sour Miang) is produced after fermentation for several months. Additionally, a part of Miang production process includes fungal fermentation. In general, the leading process of Miang processing is lactate fermentation by lactic acid bacteria. Among the post–fermented teas, Miang has the highest production rate. However, most individual producers are small–scale produces. Although the basic procedure of Miang production is the same, certain details vary depending upon the production area and producers. Microbial control, particularly the control of lactic acid bacteria, in Miang production is extremely important for its stable and continuous production. However, in several cases, Miang production is based on individual experience. Recently, biodiversity of microorganisms was discovered. Therefore, understanding the Miang production in each production area is essential for the production of unique regional Miang.

Keywords: post–fermented tea, Miang, Lactobacillus sp., fungi

1. Introduction

Post–fermented tea is tea that has been fermented by microorganisms. There are three types of production methods pertaining to post fermented tea processing. They are aerobic fermentation by fungi, anaerobic fermentation by lactic acid bacteria, and their combination method. The area where post–fermentation tea is produced traditionally is limited to East Asia. Post–fermented tea is not always produced in its cultivation area. Generally, the post–fermented tea producing areas are tea cultivation areas and mountainous region. Post–fermented teas are produced in two areas: one is the area which encompasses four countries China (Yunnan), Myanmar, Laos, and Northern Thailand, and the other is Japan. Among these countries, traditional Japanese post–fermented teas are produced in the Shikoku Mountains (Ehime, Kochi, and Tokushima) and Asahi (Toyama), which is located at the foot of the Hida Mountains.

Although it is interesting that post–fermented teas are produced in mountainous regions, the reason behind this is unknown. A post–fermented tea produced in Northern Thailand is called 'Miang' is also produced in regions of Laos [1].

Miang is made from tea leaves (Camellia sinensis L. var. assamica), locally called the “Miang tree”, that are scattering grown in the forests of high mountainous areas in the northern provinces of Thailand such as Chiang Mai, Chiang Rai, Nan, Phrae, Mae Hong Son, Phayoa, and Lampang. Of these provinces, Chiang–Mai is the largest Miang plantation area whereas Nan is the main area for Miang production [2]. Additionally, Miang is also produced in parts of northern Laos [1]; here, the plantation area of Miang is mainly the same as the production area.

Essentially, Miang tea is consumed as a snack, and there are different ways of consuming it. Fermented tea leaves with suitable sizes are directly chewed. Occasionally, Miang is chewed with salt, ginger, or condiments (Fig. 1). Miang is rich in fiber, and thus residual fibers remain in the mouth after chewing. Usually, the
residual fibers are spat out. Alternatively, they are sometimes swallowed. Compared to Lahpet, which is eaten as a side dish in meals, Miang is consumed like a snack such as candies and gums.

At present, the tea tree for the production of Miang ("Miang tree") and coffee are important commercial plants. However, the consumption amount of Miang is decreasing as the population of young people who enjoy Miang has been decreasing. Understanding the fermentation mechanism is important to maintain the stable and continuous production of this unique post-fermented tea. The fermentation process, which is mainly related to the lactic acid bacteria, directly affects the flavor of Miang. Inappropriate fermentation may promote the growth of unwanted bacteria including pathogens and detract the flavor. For understanding the process of fermentation of Miang, we investigated the Miang production processes in various areas of northern Thailand from December 16 to December 23, 2019 (Fig. 2). Although there are several reports about Miang, situation around Miang is changing [1-4]. Herein, we have reported the current production processes of Miang from the field.

2. Types of Miang

Miang is classified into two types based on the fermentation period: “Miang–Faat,” which means astringent Miang, with several-weeks long fermentation period; and “Miang–Som,” which means sour Miang, with fermentation period extending over several months. Additionally, there are two types of fermentation methods used in Miang production. One is produced by only lactic acid fermentation by lactic acid bacteria. The other is produced by a two-step fermentation process; the tea leaves are first fermented by fungi, and subsequently, they are fermented anaerobically by lactic acid bacteria.

3. Basic production process of Miang

3.1 Overview

The process for Miang production always includes lactic acid fermentation. Tea leaves are fermented by lactic acid bacteria. Particularly, Lactobacillus spp. is involved in the fermentation of Miang [5-8]. However, Miang has low recognition in Japan. Although some investigations related to Miang are available, they mainly focus on the...
physiological activities of isolated lactic acid bacteria from Miang [9-11]; the details related to the processing of Miang are hardly known in Japan. There are two main methods for producing Miang, and the production methods differ according to the production area. Differences in the producing method may affect the microbiome, and thus, its flavor. Recently, Miang produced in some areas of northern Thailand is supported by the Thai Royal project. Additionally, Miang is also produced in modernized factories. Conversely, most of Miang is produced by traditional methods on a small scale. The taste of Miang depends on several factors, e.g. the producer, temperature, tea leaves, and fermentation period. Cavity and food poisoning pathogen prevention effect of lactic acid bacteria isolated from Miang is reported [12]. However, if fermentation is performed in an unsanitary environment, Miang may additionally include pathogens owing to uncontrollable fermentation. Thus, control of lactic acid fermentation during the processing of post-fermented teas is important.

3.2 Comparison of Miang and Japanese fermented tea

The closest Japanese post-fermented tea to Miang is the Awa-bancha, which is produced in Tokushima. However, there are also several differences between the Miang and the Japanese post-fermented tea (Table 1). Japanese post-fermented teas are produced using *Camellia sinensis* L. var. *sinensis*, mainly *Camellia sinensis* var. *sinensis* cv. Yabukita, and rarely, wild type (Yamacha). In contrast, Miang is produced using *Camellia sinensis* var. *assamica*. Japanese post-fermented teas are dried in the sun after fermentation. Dried leaves are extracted using boiled water and drunk in the same manner as green tea. Therefore, the viability of lactic acid bacteria included in the fermented tea leaves is drastically decreased owing to ultraviolet rays, decrease of water activity, and boiling water [13]. The probiotic effects by the viable lactic acid bacteria can hardly be expected in Japanese post-fermented teas. Alternatively, Miang is directly consumed without solar drying after fermentation. When we consume Miang, we also consume large number of viable bacteria and yeast. Planted Miang trees (*C. sinensis* var. *assamica*) can be seen on the mountains in Miang producing areas. In Miang producing areas, tea leaves are mainly used for Miang production, and hardly used for other products such as green tea and black tea. The plantation areas of the Miang tree show entirely different aspects compared to Japanese tea plantation fields. On viewing them for the first time, the Japanese author failed to recognize the trees as “Miang trees”. For Japanese post-fermented tea production, the matured hard leaves are harvested with branches and nuts in early summer. Alternatively, in many cases, young soft leaves are harvested and used for the fermentation of Miang. The leaves are harvested by hands or a finger knife. The harvesting technique of the leaves varies according to the producer. In various observed cases, part of the leaf,
### Table 1  Table Comparison of miang and Japanese postfermented teas production process between different production area.

| Production area | Production steps | Thailand (Miang) | Japan |
|-----------------|------------------|----------------|-------|
|                 |                  | Doi Sakad      | Naka, Kamikatsu |
| Harvesting step |                  | Ban Pa Miang   | Miyoshi |
| Type of leaves  |                  | Doi Lang       | Otoyo |
|                 | 1. Type of leaves| only whole mature leaves | only whole mature leaves |
|                 | 1.1. Type of leaves | only whole leaves | only whole mature leaves |
|                 | 1.2. Placing technique | Bare hand | Chopper and scissors |
|                 | 2. Steaming process | tied in a bundle with bamboo strip | Wash with flowing water |
|                 | 2.1. Preparation of fresh leaves | vapor from boiling water by earthen wood oven | Remove foreign matters |
|                 | 2.2. Containers | Wooden container | Metal basket or without container |
|                 | 2.3. Heat method | vapor from boiling water by earthen wood oven | Metal steamer |
|                 | 2.4. Time for steaming | 1-2h | Several hours |
|                 | 2.5. Time for cooling down | overnight | Several hours, subsequently the leaves are kneaded |
| Fungal growing step | 3.1. incubation period | 2-3 days | No information |
|                 | 3.2. Washing | Yes | No |
|                 | 3.3. Soaking in water | 2 days | No |
| Anaerobic fermentation | 4.1. Solution used | Water containing picking salt | No water added |
|                 | 4.2. Container | Plastic bag in a plastic container | Plastic bag in a large plastic bucket |
|                 | 4.3. Fermentation time | > 15 days for sour miang | 2-3 months or longer for sour miang |
|                 | 4.4. Solar drying | No | No |
|                 | 4.5. Preparation of miang ready for sale | Already in a bundle (handful size) | Already in a bubble (handful size) |
| Product distributed | 5. Product distributed | Phrae, Lampang, and Mae Hong Son | Naka, Kamakatsu, and Miyoshi, Tokushima |
| Product season  | 6. Product season | year-round | Summer and sometimes Spring |

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approximately two-thirds, was cut. According to the interview with the producers, if the whole leaf is harvested, the Miang tree becomes enfeebled. Conversely, in some cases, the whole leaf was harvested. The procedure of leaf-harvesting depends on the producer’s experience and regional traditions. Tea leaves can again be harvested 2–3 months after a harvest. Generally, Japanese post-fermented teas are produced in summer, i.e., July and August. In contrast, Miang is produced throughout the year. We visited the Miang producing village in December, and observed the processing of Miang and how Miang was sold in the local market.

3.3 Basic Miang production process

Basic Miang production process is shown in Figure 3. The tea leaves are harvested early in the morning (6–8 am) till late afternoon (4–5 pm). Harvested tea leaves are bundled using bamboo bands or the leaves are put in a net and steamed. The steaming process makes the tea leaves soft and inactivates the enzymes. Time of steaming is approximately 1–2 h. After steaming, the steamed leaves are cooled to room temperature. Next, the tea leaves are bundled by a new bamboo band and squashed into plastic bag in a plastic container, glazed earthen jar, or bamboo basket. In the processing of the Japanese post-fermented tea Awa-bancha, sometimes lactic acid fermentation is performed in a large wooden tank. However, we did not observe such large wooden tanks in Miang processing. The plastic bag into which the tea-leaves bundle was stuffed is deflated and closed tightly. Lactic acid bacteria are grown in the plastic bag under anaerobic condition. Similar to Japanese post-fermented teas, artificial starter bacteria are not used in Miang production. After tea leaves are fermented for several weeks to months, Miang production reaches completion. Additionally, there is another type of Miang that is produced by a two-step fermentation process. The teas leaves are fermented by fungi and then lactic acid fermentation is performed. Among the Japanese post-fermented teas, Goishi-cha and Ishizuchi-kurocha are produced by two-step fermentation using fungi and lactic acid bacteria. However, process of fungus fermentation between the Miang and Japanese post-fermented teas is different.

3.4. Where does lactic acid bacteria associated with fermentation of Miang come from?

Lactic acid bacteria, particularly, Lactobacillus spp. is the main contributors of Miang fermentation [6, 14]. However, we do not know their origin. The question whether they live on the tea leaf arises. The surface of the tea leaves is covered by and it is an unsuitable environment for Lactobacillus sp. because they are facultative anaerobes. In fact, in the case of Japanese post-fer-

![Fig. 3](Image)
mented tea, Ishizuchi-kurocha, Lactobacillus sp. were not found on the tea leaves [13]. Additionally, tea leaves are steamed after harvest. Lactobacillus sp. do not form spores. Viable bacteria count on the leaves may decrease remarkably during steaming. Living bacteria cannot be found on steamed leaves in Japanese post-fermented tea [13, 15]. In many cases of Miang processing, steamed tea leaves are cooling down overnight at room temperature. The tea leaves are kept on the floor. The possibility of Lactobacillus sp. as airborne microorganisms is also raised. Lactobacillus sp. grow drastically during fermentation. Finally, Miang including several amounts of living Lactobacillus sp. associated with Miang fermentation are selected based on certain factors such as temperature, anaerobic condition, and tea contents. Tannin is an important factor responsible for the selection of Lactobacillus sp. However, Lactobacillus sp. isolated from Miang exhibited tannin tolerance [8, 16]. Thus, the origin of Lactobacillus sp. associated to Miang fermentation remains unknown. This is an interesting problem that warrants further investigation.

4. Miang production in Thailand

4.1 Miang in Nan Province

Nan province is an area on the border of Laos. Miang in this area is produced by the two-step fermentation process using fungi and lactic acid bacteria. Miang trees for harvesting leaves are grown on the slopes of mountains (Fig. 4). For Miang production, only the leaves are harvested; however, unreachable high leaves are harvested by cutting the branch with a billhook. In this area, both soft young leaves and hard mature leaves are used for production of Miang. During this investigation, it was observed that only in Doi Sakad in the Nan province the branches were lopped off the “Miang tree”. Harvested tea leaves are bundled by bamboo bands and steamed. The steamed leaves are then spread on a plastic sheet and cooled down overnight at room temperature. The leaves are bundled by a new bamboo band again and fermented using fungi for 2–3 days at room temperature in a plastic bag. After fungal fermentation, the bundled leaves are washed with water and they are soaked in

(A) View of village. “Miang tree” is also grown at beside of house. (B) Plantation of miang tree (Camellia sinensis var. assamica). (C) Leaf of “Miang tree”.

Fig. 4 Miang production in Nan Province.
water for 2 days. Next, the tea leaves are completely soaked into saltwater in a plastic bag closed tightly using a rubber band. Submerged fermentation process takes place anaerobically at room temperature for at least 15 days. Some of this sour Miang tea leaves were sold to the middleman while some were consumed within the families.

We ate some of the sour Miang. It most closely tasted like aged “Nukazuke” (Furuzuke) which is Japanese vegetables pickled made by lactic acid fermented rice-bran paste but are not the same. The unique acid taste and flavor of Miang may be loved or hated. It is difficult for beginners to swallow residual fibers.

4.2 Miang in Lampang Province
We visited Ban Pa Miang, Lampang Province. This area is an appealing Miang production region known as “Miang Village”. Several “Miang trees” are grown in the mountains behind the village. Two thirds of the leaves are harvested. Harvested leaves are steamed in a wood-fired oven that is placed inside a house. Wooden container is filled with tea leaves. The bottom of the container has a hole, and the leaves are supported with a reticulately knitted bamboo. A pan is placed with water in the oven. The bottom of the pan is heated by firewood and steam is formed. (Fig. 5). The container is placed on the wood-fired oven and the leaves are steamed. After steaming, the leaves are cooled and then the leaves are bundled again by a bamboo band. The bundled leaves are filled into plastic bags in the plastic container or big glazed earthen jar. Next, the leaves are submerged in water and lactate fermentation is performed. Salt is not added for fermentation. Fermentation periods are approximately 1 month for Miang-Faat, and 2-3 months for Miang-Som. Miang produced in this area is consumed in the local area. Additionally, Miang is exported to Laos. It is strange that Miang is exported to far Laos, not Myanmar where the border is close. This may be because there is another post-fermented tea, called Lahpetso, in Myanmar. Miang is also consumed in Laos. Therefore, destination for export of the Miang may be Laos.

Mon Ngo is located within several hours driving distance from Chiang Mai. Some stores and home-stays are located along the mountain stream. Miang is produced in some houses at Banlao patina community, Mon Ngo by support of “Mon Ngo” Royal project Development Center, Chaing Mai province. “Miang trees” are grown on the mountain behind the village. Young leaves are harvested. Harvested leaves are bundled with bamboo bands or collected in a net bag and the leaves are assembled in the house which has oven. The leaves are steamed on the wood-fired oven with a pan with water. Steamed leaves are spread on the floor and cooled overnight at room temperature. Next morning, the cooled tea leaves are bundled again by bamboo bands, and fermented for 1 month or more to obtain Miang-Faat. Water is not added to the leaves for the fermentation. The fermentation was performed only in a plastic bag, it did not use plastic container (Fig.8). In another way, banana leaves are overlaid on the plastic bag in the bamboo basket, and the tea leaves are stuffed. In this case, tea leaves are covered by banana leaves that are not sterilized. There is a possibility that lactic acid bacteria from the leaves of the banana may contribute towards the fermentation.

4.3 Miang in Chaing Mai Province
We visited two Miang production places in Chaing Mai Province. Doi Lang is located in the mountains near the Myanmar border. Doi Lang has a great view and houses are built along a road in a ridge. “Miang trees” are planted on the slope around the house (Fig. 6). Two thirds of the young leaves are harvested. According to producer’s interview, if the whole leaf is cut, the “Miang tree” becomes enfeebled. Harvested tea leaves are steamed. In addition to the common steam procedure that places the container on the oven directly, we observed another steam procedure in this area. The container into which the tea leaves are stuffed is separated from the wood-fired oven. Water is boiled on the oven and steam is sent to the container put on the side of the oven by a hose (Fig. 7). This procedure does not require moving the container onto the oven. Additionally, boiled water is not contaminated by falling droplet from container. Both steam procedures use firewood as fuel. Cooled leaves are bundled again by bamboo bands and fermented in plastic bags in plastic containers or big glazed jars. Water and/or salt are not added to the leaves for fermentation in this area. Fermentation period is approximately 1 month for Miang-Faat, and 2-3 months for Miang-Som. Miang produced in this area is consumed in the local area. Additionally, Miang is exported to Laos. It is strange that Miang is exported to far Laos, not Myanmar where the border is close. This may be because there is another post-fermented tea, called Lahpetso, in Myanmar. Miang is also consumed in Laos. Therefore, destination for export of the Miang may be Laos.

Suree Factory is located near Doi Lang, Chaing Mai province. This factory is supported by King Mongkut’s
(A) View of village. "Miang tree" is grown at mountain behind of village. (B) "Miang tree" (C) Earthen wood oven (D) Bottom of wooden container for steaming. (E), (F) Tea leaves in the wooden container. (G), (H), Fermentation process of miang (I) Squashed tea leaves in plastic container for fermentation.

Fig. 5 Miang production in Lampang Province.
(A) View of village. "Miang tree" is grown at mountain behind of village. (B) "Miang tree" (C) Finger knife and harvested fresh tea leaves. (D) Two thirds of the young leaves are harvested. (E), (F) Harvested tea leaves. (G) Tea leaves in HDPE container for steaming. (H) Bottom of HDPE container for steaming. (I) Tea leaves after steaming. (J), (K) Fermentation process of Miang.

Fig. 6 Miang production in Doi Lang, Chaing Mai Province.
University of Technology, Thonburi, with the financial support from the Thai Research Fund. Here, we can observe Miang production under well controlled fermentation in the factory (Fig. 9). Basically, the tea leaves are bought from the leaf pickers. Additionally, “Miang trees” are also grown in adjacent farms to provide leaves for the factory. Whole leaves are harvested and used for fermentation. Water for steaming of tea leaves is sent by a pipeline from the mountains and the water is passed through activated carbon, filter, and manganese before use. The tea leaves are steamed in a boiler with firewood. The steam is sent to tea leaves stuffed container via a pipeline from the boiler. After the tea leaves are cooled down, the leaves are fermented in a container with plastic bag. Fermentation period is approximately 2–3 months and sometimes 1 year. Water is not added for the fermentation process. Fermented tea leaves weigh approximately 500 g and are bundled again with bamboo bands by staff who wear disposable caps and gloves. The bundled Miang is packed with nitrogen gas in another packing factory. Then they are sold. We observed that Miang is produced in a sanitary environment and the fermentation is well-controlled in the factory.
(A) Harvested fresh tea leaves. (B) Wooden container for steaming. (C) Bottom of wooden container. (D) Tea leaves in wooden container for steaming. (E) Bundled tea leaves for fermentation after steaming. (F), (G), (H), (I), (J) Tea leaves are stuffed in bamboo bucket with plastic bag and banana leaves.

Fig. 8 Miang production in Mon Ngo, Chaing Mai Province.
5. Conclusion

Currently, Miang is produced in several areas of northern Thailand. Although the basic procedure of Miang production is the same, each region differs in terms of certain details. Miang of Nan Province is produced by a unique two-step fermentation procedure. This fungal fermentation changes the amino acids and sugar contents and influences the subsequent lactate fermentation. The most influencing factor on lactate fermentation, therefore, on the flavor of Miang may be the addition of water and/or salt. Tea leaves are submerged in salty water in Nan Province. In Lampang Province, the tea leaves are submerged in water without salt. Alternatively, lactate fermentation in Chiang Mai Province is performed without water. Thus, the difference in the procedures of Miang production in among different areas is of interest. We expect that the interaction between the procedure
and microbiomes of Miang will be elucidated in future studies. Additionally, the association between Miang and the Japanese post-fermented teas is also of interest. Further studies in this regard will contribute towards the development of post-fermented teas including Miang and Japanese post fermented teas.

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タイ王国の後発酵茶「ミャン」の製法調査
堀江祐範1,†, Supatjaree RUENGSOMWONG2, Bhusita WANNISSORN2

1国立研究開発法人産業技術総合研究所, 健康医工学研究部門
2タイ科学技術研究所 (TISTR)

後発酵茶は、茶葉を微生物（乳酸菌や真菌）により発酵させた茶で、日本やタイなどで伝統的に製造されている。このうち、日本では、四国山地および富山県において伝統的に製造されている。一方の生産地であるタイでは、後発酵茶はミャンとよぶ。ミャンはタイ北部で生産され、消費地も大部分は北部である。筆者は、2019年12月に、タイ王国北部のナーン県、ランパーン県およびチェンマイ県において、ミャン製造の現場を見る機会を得た（Fig. 2）。

ミャンは発酵期間によって2種類に区別される。発酵期間が数週間のものは、Miаng-Faat（Astringent Miаng）とよぶ。これに対して、数ヶ月の乳酸発酵を行うものは、Miаng-Sом（Sour Miаng）とよぶ。また、製造方法の面からは、乳酸発酵のみで製造するタイプと、乳酸発酵の前に真菌による発酵を行うタイプがある。

ミャンは製造工程には乳酸発酵を含み、茶葉を乳酸発酵することで製造する。この乳酸発酵には、Lactobacillus属乳酸菌が関与している。ミャンは基本的な発酵様式を類似するものの、相違点も多い。

日本の後発酵茶が発酵後の茶葉を天日乾燥し、熱湯で淹れた「茶」を飲用するのに対し、ミャンは発酵後の茶葉をそのまま食する。日本の発酵茶では、原料となるチャは中国変種（Camellia sinensis var. sinensis）を用いる。これに対して、ミャンの原料として用いられるチャは、アッサム変種（Camellia sinensis var. assamica）である。初夏に硬化した葉を用いる日本の後発酵茶とは対照的に、ミャンには柔らかい若葉のみを用いる。また、日本の後発酵茶の製造時期は製造に適した茶葉を収穫する7月~8月に限られるが、ミャンの製造は年間を通して行われる。

日本の製造方法は、ミャンの製造方法と大きく異なる。ミャンの製造方法の地域差は、発酵に関与する乳酸菌の選択に影響し、風味の違いに結びつけると考えられる。