

Development and Study on Bamboo Charcoal Production

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Abstract -This work aims to report the success of the study on the development of bamboo biochar production and high quality bamboo charcoal. We have published designs of various types of charcoal-kilns that have been created and developed, including 1) “Iwasaki-Kitti Kiln” for learning basic charcoal production processes, which can produce various types of charcoal, cooking charcoal, grilling charcoal, high quality charcoal with a carbon purity higher than 80%. 2) “Khonmai Kiln” for producing bamboo biochar which is suitable for use in Nourish the soil. Pyrolysis process in which combustible gas is used as fuel to burn itself. This makes it possible to reduce the amount of toxic gases released into the atmosphere by more than 80%. 3) “Klongpain Kiln” for producing high quality bamboo charcoal, which is charcoal for health, such as using it to soak in water to make it alkaline, filter drinking water, absorb toxic gases, use as air filters, etc. Dissemination of knowledge and experience in the kilns development and production of bamboo charcoal to farmers who are interested in burning charcoal continuously since 2019 through a discussion group called “Kon-Puw-Than” in the LINE application, and transferring knowledge through writing the blog on www.gotoknow.org has made the target group of 234 farmers gain knowledge, understanding and see the importance of bamboo charcoal production in the community. Opening a center of bamboo charcoal development study center (BCDSC) for interested parties to visit, study and practice. There are interested people who come to visit. Study visits have been made to the site by 12 groups, totaling approximately 120 people.

Keywords: Bamboo charcoal, biochar, high quality charcoal, bamboo charcoal development study center

1. Introduction

Abroad, there is serious research to develop the production process and utilization of bamboo charcoal. Especially Japan (Hosokawa, 2005), China (Shenxue, 2004) and India (Chaturvedi, 2023). But in Thailand, bamboo charcoal has not been given much importance. With the outstanding physical properties of bamboo charcoal, which has pores smaller than 20 nanometers (microporous), it has 4 times more pores than normal wood, has 10 times more surface than normal wood charcoal, and is rich in minerals. Benefits (Dwivedi et al., 2014) result in applications in many different areas. For example, absorb toxic gases (Asada, 2002), trap heavy metals in water (Liu, 2012), soaking to adjust the pH-alkaline condition in water (Lensoni et al., 2023) and it is used in filtration of drinking water (Lin et al., 2017) etc. In addition, Using biochar to nourish the soil also has an direct effect on preserving and restoring the environment. Bamboo clumps with leaves 3-5 times thicker than normal trees can absorb more carbon dioxide from the atmosphere when turning wood into biochar. The carbon content in charcoal, which is more than 80%, is stored so that it does not return to carbon dioxide in the atmosphere.

The wisdom of Japanese bamboo charcoal production came to Thailand in 1999 when Mr. Daisuka Nagako, who had passed on the wisdom of burning charcoal for many generations. Collaborated with Mr. Kittilertlam, a resident of Nadi District, Prachinburi Province. There are many forests in the area. Build a large bamboo charcoal kiln with a capacity of 20 tons, producing bamboo charcoal at temperatures up to 1,000 degrees, which will make bamboo charcoal with a carbon purity higher than 80% (high quality bamboo charcoal) to be sold as an export product to Japan. Mr. Kittilertlam learned the process of burning charcoal from Mr. Daisuka. Later studied and developed health products from various types of bamboo charcoal under the Bantan brand. Able to create an income for the family of 70,000 - 100,000 baht per month. Academically The production of different types of bamboo charcoal has been studied to compare their moisture absorption ability. Studies have found that mixing bamboo charcoal into chicken feed makes eggshells thicker. Less damage to broken eggs Rattanawut (2014) and it was found that mixing finely ground bamboo charcoal into rice growing soil helps increase the efficiency of chemical fertilizers, resulting in higher yields. However, there is still a small amount of research on bamboo charcoal, compared to foreign countries, and most of it is just a laboratory experiment.

In the past, although bamboo charcoal has been produced and processed into various products and sold commercially in Thailand, there has been no dissemination of knowledge regarding the production process of high quality bamboo charcoal. There has not been any research and publication on the production process. Physical conditions inside the furnace. Most of the material published on social media is about common charcoal burning methods. This is only a basic principle step for the general charcoal production process. There has not been any published knowledge on the production and utilization of bamboo charcoal specifically. There is still no community of practice (Cooperative of Practice) that exchanges and shares experiences in producing bamboo

charcoal. As a result, bamboo charcoal is not yet popular for application in daily life. It is different from Japan, China, and Korea which have widely adopted it until it has become a way of life.

2. Objectives

The main aim of this work is Putting science and technology to upgrading the ability to produce charcoal to be more efficient, reduce the release of toxic gases into the atmosphere. Create opportunities to produce charcoal yourself or create an additional career to improve the quality of life by operational objectives are as follows

1. To study and develop the production process of bio-bamboo charcoal and high quality bamboo charcoal.
2. To create a community of practitioners to disseminate and transfer knowledge and technology. Exchange knowledge of production experiences and utilization of bamboo charcoal.
3. To be a learning base for students, students or the public who are interested. Come practice bamboo charcoal production.

3. Target

The target group is Thai people who are interested throughout Thailand. Farmers in the “Khok Nong Na” network. Farmers who are practicing agriculture according to new theories, integrated agriculture, agroforestry, mixed farming, and those interested throughout Thailand. without limit in number. Currently, there are 234 people interested in following and exchanging knowledge via social media, covering 17 provinces, including Maha Sarakham, Buriram, Sa Kaeo, Yasothon, Kanchanaburi, Chiang Mai, Nakhon Ratchasima, Saraburi, Nakhon Si Thammarat, Nakhon Phanom, Khon Kaen, Kalasin, Uttaradit, Samut Prakan, Chonburi, Lopburi, Bangkok.

4. Academic services: Knowledge and technology

Throughout the process, Knowledge Management (KM) is used as tools research tools, creating participation. Emphasis is on building a community of practice (Cooperative of Practice: CoP), exchanging knowledge (sharing) and extracting lessons to get best practices (Best Practice) from those who are most successful in Thailand in bamboo charcoal production. In this case, it is Mr. Kitti Lertlam and he uses storytelling to summarize the charcoal burning experiment activity and the results of his own reflection on learning (Self-Reflection) published on the website and exchanged knowledge via social media. Exchange practical experiences (Show and Share) and constructing a center for development and study on bamboo charcoal production, to provide an opportunity for those interested to come and try it out by themselves.

5. Production of charcoal by iwasaki-kitti kiln: “Tung Krung Kiln”

A practice community of people interested in burning charcoal with “Tung Kraung Kiln” on the Line group named “Tung Kraung Kiln User Group” was created first. With Ajarn Kitti Lertlum sharing knowledge and understanding about burning charcoal. Later, to create a more open exchange of knowledge. Therefore, a community of practitioners of “charcoal burners” was created and the process of developing charcoal kilns began, and demonstrate and broadcast the events of each experiment on the channel “Khon Kon Khroo” on the YouTube website (Chai-ngam & Thamsaeng, 2021) summarize important knowledge in a journal at www.gotoknow.org, and notes of the LINE group in the form of storytelling, interested people who join the group later can learn on their own. In addition, during each experimental study If there is any interesting new discovery The researcher will post news updates via both the Line group and their own Facebook page.

After successfully developing a high quality bamboo charcoal kiln (Klongpain Kiln) and biochar kiln (Khonmai Kiln), so it is open to fellow members of the community of practitioners to come visit and learn how to produce bamboo charcoal on site. By opening it as a learning resource in the name “Bamboo Charcoal Development Study Center” (BCDSC) is located at Don Wiangchan Village, Tha Khon Yang Subdistrict, Kantharawichai District, Maha Sarakham Province. It provides an opportunity for students, university students, and interested persons to come for a field trip without any cost.

After continuous operation for 5 years, important products include: Basic knowledge in bamboo charcoal production, charcoal production using Iwasaki-Kitti Kiln, production of biochar using “Khonmai Kiln”, and production of high quality bamboo charcoal using “Klongpain Kiln”. Information media in the form of blogs, lesson transcripts, and video clips which are published on social media, and the BCDSC is open for interested people to come and learn. The important result is that network members who join in exchanging knowledge with each other. The number of members who applied their knowledge and developed it until they were successful create additional income.

6. Basic knowledge of charcoal production

Most people understand that charcoal refers to charcoal, a black material used as a fuel for heating. Including cooking charcoal and grilling charcoal only. But in fact, wood charcoal can be classified into many types according to the purpose of production, including biochar which is used for nourishing the soil, high quality charcoal or healthy charcoal. High quality charcoal is defined as a high purity of carbon, more than 80% (fixed carbon) and a remaining volatile matter value of less than 10%. Each type of charcoal must be produced using different methods. The maximum temperature is different and different heating rates. This work has developed and designed two type of charcoal kilns. One is for producing bamboo biochar. It's called “Khonmai Kiln”, another is for producing high quality bamboo charcoal. It's called “Klongpain Kiln” [16]. By studying

the temperature changes inside the kiln throughout the charcoal production process, 3 factors that affect the characteristics and quantity of charcoal yield are as follows.

1. Raw materials: suitable bamboo for producing charcoal must be very old bamboo. The age of the bamboo stem should be more than 4 years. Bamboo stems such as “Pai Siang Prai” or “Pai Liang” (*Bambusa Multiplex*), “Pai Sang Mon” (*Dendrocalamus sericeus Munro*) etc. These kind of bamboo are suitable for producing high quality bamboo charcoal. As for edible bamboo, such as “Pai Tong” (*Dendrocalamus asper*), “Pai Bong” (*Bambusa*), “Pai Kim Sung” (*Bambusa beecheyana Munro*) etc. They are suitable to be used to produce biochar. To produce high quality bamboo charcoal using the “Klongpain Kiln”, the bamboo should be dried in the shade for about 2-3 months. For the production of biochar, the wood should be dried completely before putting it in the kiln. In addition, how to arrange bamboo and its position in the kiln affects the quality of that piece of bamboo charcoal, which will be heated differently.

2. Temperature: when the raw material is heated to 100 degrees, water will be expelled from the wood cells until it dries. Then, when the wood accumulates heat until it reaches a temperature of 270 degrees, the wood will begin to decompose, releasing flammable gases and liquids. The remainder will turn into charcoal at a temperature of 400 degrees. When heated further, the amount of volatile matter remaining in the charcoal will become less and less and will decrease rapidly at a temperature of 800 degrees until lower than 10%, while the amount of fixed carbon will increase when the temperature in charcoal production increases. Therefore, to produce high quality bamboo charcoal, it must be burned at a temperature above 800 degrees.

3. Temperature rate or firing process: in addition to the style of the charcoal kiln, the sequence of steps or method of firing that affects the rate of temperature increase inside the kiln. It will affect the appearance and quality of the charcoal obtained. The fast heating rate results in a large pore size, cavities, and cracks form inside the charcoal. A slow heating rate will cause the charcoal to have small pores, no internal cavities or cracks, makes strong charcoal. There is a loud sound when tapped against a solid object. Those who have no experience in making charcoal should start learning how to burn charcoal with a Iwasaki-Kitti Kiln. The first designer was Dr. Masato Iwasaki. Later, Ajarn Kitti Lertlum modified the front of the kiln to make it easier to burn charcoal. It has the form and size as shown in Figure 1, and those interested can make it themselves with materials that can be purchased locally at an inexpensive price. The kiln is divided into 4 parts: the front of the kiln, the fuel room, the charcoal drying room, and the chimney. The front of the kiln opens into a rectangular opening measuring 20x30 square centimeters for storing firewood and 10x15 square centimeters. For air vent, the fuel room uses a steel tank with a diameter of 60 centimeters and a length of 45 centimeters. The charcoal drying chamber is 90 centimeters long with a chord-shaped heat opening at the top, 10 centimeters high. The top opens into a large opening measuring 30 x 50 square centimeters. For packing wood to be burned into charcoal. At the bottom behind the kiln, a 10 centimeter diameter hole is drilled, connected to a chimney of the same size. The mouth of the chimney is 15 centimeters higher than the back of the kiln.

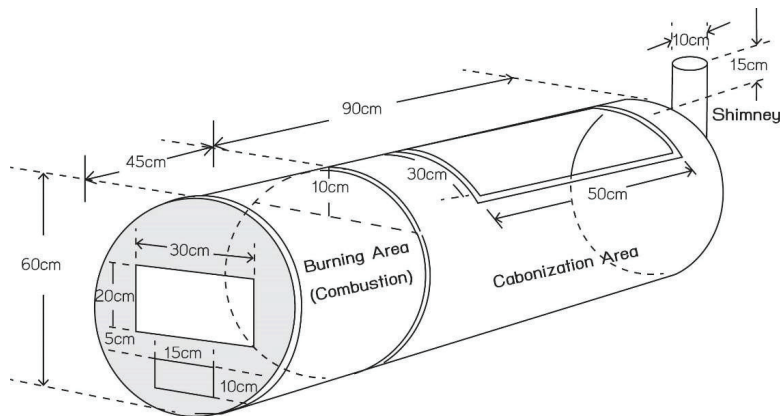


Figure 1. Diagram of Iwasaki-Kitti Kiln or “Tao Tung Kraung”

The method of producing charcoal with a half-barrel kiln can be divided into 7 steps, including 1) preparing the wood, 2) arranging the wood into the kiln, 3) drying the wood, and 4) collecting the wood vinegar, 5) charcoal production for the desired charcoal, 6) turning off the kiln and 7) turning on the kiln. The firing time will affect the maximum temperature of the furnace. The heating rate is related to the size of the air chamber. The process that takes place inside the oven can be divided into 4 phases: 1) hydration, 2) pyrolysis, wood decomposition with heat, 3) carbonization, and 4) purify the charcoal (Gasification). Each step has different thermal chemical reactions and different products. The conventional wisdom about the processes inside the kiln, are conducting by observing the color of the smoke. During the humidification process, the smoke will be cloudy white. During the decomposition of wood, the smoke will be white with a yellow tint. When the wood turns into charcoal, it will be bluish white. And when it is more pure from the remaining volatile substances in the charcoal, the smoke will become clearer until it is colorless.

7. Bamboo Charcoal Production by “Khonmai Kiln”

The kiln used to produce biochar that was developed is called a “Khonmai Kiln” and is cylindrical. It has a capacity of approximately 500 liters, diameter 60 centimeters, length 1.8 meters, placed on a clay base to retain heat, width 1 meter, length 2 meters, and height 60 centimeters (as shown in Figure 2). Bamboo used for producing biochar must be completely dry. Cut to a length of approximately 70 - 80 centimeters. The quantity of Kim Sung Bamboo that fills the kiln is equal to 60 kilograms, yielding 20 kilograms of charcoal. The lid-opening has a pipe to carry the combustible gas produced from the pyrolysis process. Let it flow down and let it ignite at the bottom of the kiln to burn and heat the kiln, and to eliminate flammable toxic gases from flowing back into the atmosphere, such as methane, carbon monoxide, etc. The kiln is located on a base made of clay to reduce heat loss, which will lead to wastage of fuel wood. Used for heating before the wood emits flammable gases and burns itself.

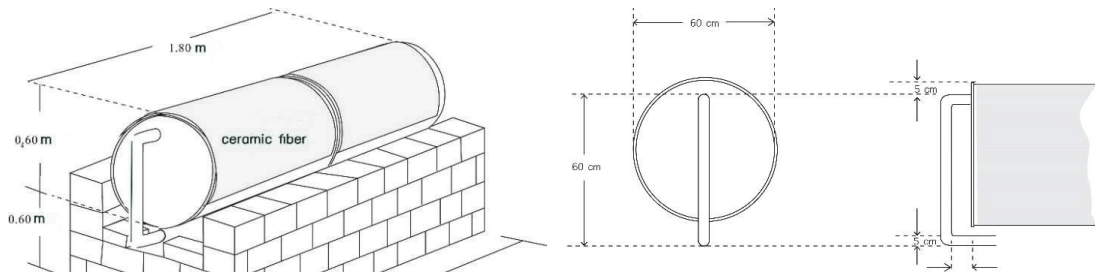


Figure 2 Diagram of “Khonmai Kiln”

The process of producing charcoal with a “log kiln” after filling the kiln with wood is only 3 steps: 1) turning off the kiln, 2) burning, and 3) turning on the kiln. When turning off the kiln, be careful not to leave any holes along the edge of the kiln cover. When starting the kiln, you must add fuel wood so that the heat is not interrupted until the kiln has released enough gas to heat itself. This process takes approximately 30 minutes. After that, for approximately 90 minutes, the gases released from the wood in the kiln will burn themselves until they are completely gone and then extinguished. Turning on the kiln is possible only when the temperature drops to room temperature. Normally, you have to leave it to cool on its own for about 6-8 hours.

8. Bamboo Charcoal Production by “Klongpain Kiln”

The high-quality bamboo charcoal production kiln developed is called the “Klongpain kiln”. It has a capacity of 333 liters, a diameter of 66 centimeters, a length of 99 centimeters, and the kiln is raised 150 centimeters above the floor. The chimney and heat pipe have a diameter of 10 centimeters (as shown in the Figure 3). The amount of farmed bamboo that fills the kiln is 100 kilograms. It can produce 10 kilograms of high quality charcoal at a time. Bamboo charcoal that has a carbon purity value higher than 80 percent (fixed carbon value greater than 80%) is called “high quality bamboo charcoal” and can be used for consumption as health charcoal.

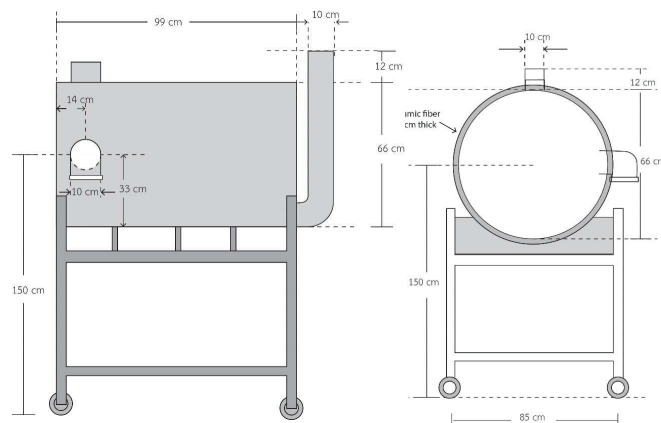


Figure 3 Diagram of “Klongpain Kiln”

9. Reflection of Cooperative of Practice “Khon Paw Than”

Currently, there are 234 members of the community of practitioners in the LINE group “Khon Burn Charcoal.” The following are some of the members’ answers when surveying their opinions on the benefits of exchanging knowledge in the group. “I got to know friends who burn charcoal from all over.” “I learned about various techniques and techniques for burning charcoal.” “I learned academic information about burning charcoal from many academics in the LINE room.” “It is a public space that gives me the opportunity to present charcoal burning in a form that I am interested in and am currently experimenting with.” “It is a LINE room that gathers important knowledge and ideas about charcoal burning. It’s like an online library where we can go back and look at knowledge at any time.” “Knowledge with reference sources. It’s not an empty article. On the internet, you have to do it yourself and filter it yourself, thus reducing confusion in consuming information. and there was clarity from the people in the group.” “There was a desire to experiment with burning charcoal for one’s own use. From seeing the example”. “Exchanged knowledge with members of the group” “Learned how charcoal has qualities different from charcoal that is commonly traded” “Created jobs, created careers, created income, created wisdom. Think of innovation Use charcoal to nourish the soil, reduce expenses, create income, be a person who uses charcoal,” etc. It can be seen that using Line groups to communicate and exchange knowledge Make members have knowledge and understanding and able to convey knowledge and understanding about the production and utilization of bamboo charcoal well.

10. Bamboo Charcoal Development Study Center (BCDSC)

Establishment of the Bamboo Charcoal Development Study Center Its main objective is to serve as a learning base for students, students, or the public who are interested. Came to study and practice bamboo charcoal production. and open to farmers or interested persons Come visit or study on the production of various types of bamboo charcoal. Located at Sanon Na Khwan Khao. Ban Don Wiangchan, Tha Khon Yang Subdistrict, Kantharawichai District, Maha Sarakham Province There is a charcoal burning house, size 10x12 square meters, with a drum kiln, log kiln, and charcoal grinder. and charcoal briquette making machine It is in use and ready to demonstrate to visiting groups. Since 2021, there have been 12 groups of visitors, totaling approximately 120 people.



Figure 4 Bamboo Charcoal Development Study Center (BCDSC)

11. Conclusion

The production and utilization of bamboo charcoal in Thailand is still low. Starting to learn about charcoal production should start with using a shellac tank kiln, which can produce charcoal of various qualities, from cooking charcoal, grilling charcoal, to high quality charcoal. The developed drum kiln can produce high quality bamboo charcoal that is used for health purposes. Approximately 10 kilograms per time. The charcoal production process in Thailand mainly involves burning cooking charcoal in large clay kilns that release large quantities of toxic gases into the atmosphere. The log kiln developed can reduce the release of such toxic gases by more than 80%. It can produce approximately 20 kilograms of biochar at a time. If 1 ton of charcoal is used to nourish the soil, it is equivalent to storing carbon in the soil. Helps prevent the generation of more than 3 tons of carbon dioxide. Building a community of practice on social media With the line group “People Burning Charcoal”, changes have already occurred. A number of members were able to apply the knowledge gained and develop additional careers. Create additional income for yourself.

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