JOURNAL OF SUSTAINABLE MATERIALS PROCESSING AND MANAGEMENT
e-ISSN: 2821-2843

JSMPM

Vol. 4 No. 2 (2024) 24-30
https://publisher.uthm.edu.my/ojs/index.php/jsmpm

Safely Managed Barbeque Use of Charcoal as Traditional Renewable Energy

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DOI: https://doi.org/10.30880/jsmpm.2024.04.02.003

Article Info

Received: 22 July 2024
Accepted: 30 July 2024
Available online: 15 August 2024

Keywords

Charcoal, renewable energy, fire accident, firelighter

Abstract

While coal is a fossil fuel, traditional charcoal is an inherently renewable energy source. In addition to fuel, charcoal can also be used as a functional material such as adsorbents and catalysts. Charcoal is still used for heating in safe cooking situations, such as barbecues. However, in recent years in Japan, there have been many cases of barbecue fire accidents. This study is a case study in which the author experimented with charcoal (made from Malaysian mangroves) barbecue using a safe method within an established facility. Based on past fire incidents, the main causes are the ignition of liquid or fluid combustion aids, the spread of sparks by the wind, and insufficient trailing fire. In this case study, under calm wind conditions (artificially fanning at an appropriate level of strength), using a solid firelighter, and collecting used and extinguished charcoal ash in a metal container, these three points was found to be important for safety fire management in barbeque.

1. Introduction

Charcoal, a historical and traditional renewable energy material, is alkaline, and its properties vary depending on the species of wood used as raw material and the carbonization temperature. Charcoal is divided into cellulose charcoal and lignin charcoal based on its constituent components. Among these, cellulose charcoal is said to have high reactivity, good adsorption and combustibility. Although charcoal is not pure carbon, its main component is an amorphous carbon allotrope, and as an inorganic polymer/porous material, it has unknown attractive functions and room for research. Charcoal, wood vinegar, ash, and baked clay can be obtained, reducing energy and environmental issues. Biomass conversion technology and utility value conversion technology through charcoal burning can be a sustainable solution to food and environmental problems [1]. There are many unknowns about the wood carbonization process. However, for example, charcoal can be made from the original lignin and polysaccharides. The process of transforming into a part of the basic structure of graphene is not fully understood. Chemical composition of wood. The simple structure is probably formed through dehydration and decarboxylation reactions [2]. When all charcoal is used as fuel for home cooking, charcoal is for kitchen use. This will cover approximately 39% of energy consumption. Deer However, this cannot be said to be enough. Also, modern people. Considering the lifestyle, charcoal is used as daily fuel, especially at home. It is difficult to use it as a commercial fuel. As mentioned above, charcoal has a good shelf life and has a low yield per kg. Because the amount of heat is large, it can be potentially to be used as a fuel in "emergency" situations as opposed to "everyday" situations [3].

Charcoal is not only used as a fuel, but also exhibits adsorption performance that is equal to or better than activated carbon, depending on the preparation method and processing conditions. These materials have a large

specific surface area and are heat resistant, so they are considered. It is also used as a media carrier and is known to exhibit catalytic effects in oxidation, dehydration, dehydrogenation reactions, and reduction of nitrogen monoxide [4]. In combination with other materials, high-temperature charcoal with low electrical resistance is a promising material for shielding electromagnetic waves. Using it as a functional material is different from using it as a fuel, and the generation of greenhouse gases (carbon dioxide) can be suppressed. However, the carbonization (manufacturing process) also releases heat and wood gas, which poses challenges to the effective use of biomass [5].

Japan is heavily dependent on charcoal imports from Asian countries. The import of charcoal from China to Japan has been completely prohibited since 2004 for forest protection reasons. Charcoal consumption in Japan by use is decreasing year by year for fuel use, but for commercial and household use it is on the rise. This is due to the recent outdoor leisure boom and increased use in the restaurant industry. Other uses such as environmental purification are also increasing [6]. From the perspective of the sustainability of the supply of biological resources, biochar that uses unused agricultural biomass such as rice husks, rice straw, and pruned branches of fruit trees, as well as unused local biomass such as abandoned bamboo forests, is also being discussed. Its effect of soil carbon sequestration is expected [7]. On the other hand, in the business world, from the perspective of charcoal regenerating “mountain and forest ecosystems surrounding villages and farmland” (in Japanese language SATO-YAMA), attention is being focused on the benefits of charcoal production using thinned wood, carbon dioxide balance (when wood photosynthesis and charcoal combustion), and soil improvement [8]. Furthermore, from the perspective of carbon neutrality, underground storage of carbon in the form of charcoal or biochar has also been proposed [9].

The author has pointed out fires and countermeasures associated with new energies and materials; for example, investigations into the use of hydrogen fuel as a renewable energy source and fires [10], and flame-retardant measures for solar panel fires (difficult to extinguish with water) including the development of materials [11]. Even with charcoal as a traditional fuel, accidents related to carbon monoxide are at the top of the list. A careful reading of the (Japanese) Tokyo Fire Department's investigation into carbon monoxide poisoning accidents (related to charcoal) reveals that insufficient ventilation tends to be the most common cause [12]. For example, a tea ceremony class was being held in a closed tearoom when incomplete combustion of charcoal in the hearth released carbon monoxide, causing poisoning in all seven participants. There are also articles stating that the dangers of carbon monoxide were also pointed out in the days when charcoal buses were used as a power source, though they are no longer in use [13].

The current use of charcoal is as a heat source for cooking, and a typical example is an outdoor barbecue. A relatively recent example of a barbecue fire accident in Japan is the disinfectant-induced fire at a barbecue that occurred in 2023. This occurred when disinfectant alcohol was added to increase the heat, resulting in a fierce flame. Four men were burned, one of whom died, after the barbecue fire caught fire on their clothes [14]. Another fire occurred in 2024, when a fire broke out on the roof of an apartment building, burning tables and other items. It is believed that the fire spread from charcoal used in the barbecue. It is believed that the cause was charcoal that was temporarily placed to clean up after the barbecue and then caught fire after some time [15]. Based on this background, the purpose of this paper is to experiment with barbecue using charcoal using an established environment.

The purpose and novelty of this research, which is different from a simple hypothesis testing experiment or a literature review, is that the author and his colleagues actually practiced safe barbecue and the author compared it with past fire accident case studies to find out what and why it is safe (or dangerous). The approach is to show whether the situation was dangerous or not.

2. Methods

A common way to conduct research (writing a review paper) is to review past accident cases (administrative materials, literature, papers), extract knowledge, and discuss opinions. On the other hand, in experimental research, it is common to obtain data under specific experimental conditions and discuss hypothesis verification and numerical theoretical analysis. This paper takes the style of actually carrying out a safely managed barbecue and comparing and examining how the risks extracted from research on past accidents were avoided.

According to a protocol by Hoshifuru Gakkou Kumanoki (Shioya, Tochigi, Japan) [16], barbecue was carried out in the outdoor dedicated facility on July 20, 2024 (fine weather, gentle breeze). The charcoal (Natural Season; Komeri, Japan) [17] employed was made of Malaysian mangrove.

2.1 Materials and Equipment

In a purpose-built outdoor facility with a roof and concrete floor (Fig. 1a), charcoal (mangroves) and fire starters (compressed wood, hemp rope, newspaper) were placed in a metal fireplace and ignited with a lighter attached to an LPG cylinder (Fig. 2). The facility was surrounded by grassy ground, far from any other buildings except for

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the storehouse toilet, and had a water supply, a fire extinguisher, and a metal container for storing ash after use (Fig. 1b).

(a) **(b)**

Fig. 1 *(a) Outdoor facility; (b) Fire extinguisher (red box) and metal ash containers*

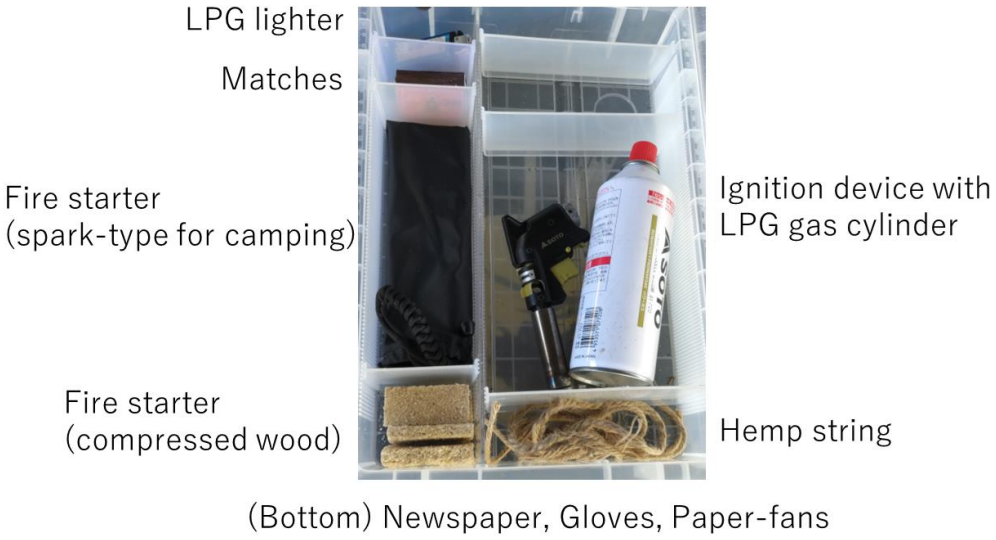

Fig. 2 *Tool kit for lighting charcoal for barbecue*

2.2 Procedure for Starting a Fire

Charcoal pieces were arranged in a metal furnace without a ignition agent (Fig. 3a), and the fire was ignited with a lighter equipped with an LPG gas cylinder. After burning for a while, ignition was observed on the surface of the charcoal (Fig. 3b).

(a) **(b)**

Fig. 3 *(a) Arranged charcoal before ignition; (b) Fire ignition with LPG gas cylinder*

2.3 Weakening the Fire and Re-Igniting

Charcoal pieces were arranged in a metal furnace without an ignition agent, and the fire was ignited with a light. After a while, the fire died down and stopped spreading. So, the experimenters changed the arrangement of the pieces of charcoal, added a fire starter (pieces of compressed wood and twine) inside, and lit it again with an LPG lighter (Fig. 4a). The compressed wood pieces were ignited, but fail. Hence, the twine was ignited and the flame was spread to the compressed wood pieces and then to the charcoal. In addition, the force of the fire was increased by blowing air using a manual paper-fan (Fig. 4b). This was done more efficiently using a small electric blower fan (Fig. 4c), and after a while the fire spread throughout the charcoal.

(a) **(b)** **(c)**

Fig. 4 *(a) Re-igniting using an igniter; (b) Air blowing by a paper-fan; (c) Air blowing by a fan*

2.4 Barbecue Cooking Use and Post-Processing of Charcoal

After the charcoal fire steadily emitted a weak flame (as it reached a certain temperature and emitted far-infrared rays), the stage of grilling the meat and zucchini on a wire rack (Fig. 5a) lasted about two hours. After using the barbecue, the charcoal changed from unburned black to white after burning, but some spark remained inside (Fig. 5b). After extinguishing the fire, the remaining charcoal and ashes were stored in a designated metal container (Fig. 1b).

(a) **(b)**

Fig. 5 *(a) Grilling zucchini on a wire rack using charcoal; (b) After using a barbecue, the charcoal changes from unburned black to white after burning, but some spark remains inside*

3. Results and Discussion

3.1 Comparison Study with Fire Accident Cases

The Tokyo Fire Department's case study website introduces the types of causes of fires during barbecues [18].

- [Case 1] Fire where clothing ignited due to adding ignition agent.
- [Case 2] Fire caused by strong winds blowing away charcoal in a stone oven.
- [Case 3] Fire caused by fuel alcohol splashing onto charcoal.
- [Case 4] Fire caused by storing charcoal that had not completely extinguished.

Furthermore, The Tokyo Fire Department listed the following points as points to prevent fires.

- [Countermeasure 1] Once the fire is lit, never add more igniting agent.
- [Countermeasure 2] Never use rubbing alcohol as a fire starter.

- [Countermeasure 3] Do not use rubbing alcohol near fire.
- [Countermeasure 4] Do not go near fire immediately after using rubbing alcohol on yourself.
- [Countermeasure 5] Prepare a water bucket or damp cloth to extinguish the fire immediately.
- [Countermeasure 6] When discarding used charcoal, soak it thoroughly in tap water before throwing it away.

A similar warning was issued on the recent website of the Otsu City Fire Department [19], so it is an almost universal content.

- [Danger O-1] Avoid doing this near flammable materials. There is a danger that sparks may fly and ignite nearby flammable objects.
- [Danger O-2] If the wind is strong, the firepower may increase more than expected, and the sparks may fly far away.
- [Danger O-3] Be careful about clothing catching fire! There have also been incidents where clothing has caught fire from bonfires or barbecues, resulting in burns.
- [Countermeasure O-1] Check your surroundings and choose a large area with no flammable materials.
- [Countermeasure O-2] Check the wind direction and strength in the weather forecast and consider canceling on days with strong winds.
- [Countermeasure O-3] Remember that you are dealing with fire. Be especially careful not to let the hem or sleeves meet fire. Be sure to have a fire extinguisher and a bucket of water ready so you can extinguish the fire immediately in case of an emergency.

Comparing the safety and potential risks of this experiment with the four cases in Tokyo, it became clear that a safe method had been established as follows: (1) Although more igniting agent was added, the flames were not strong enough to ignite the person's clothing (short sleeves, pants, and gloves). (2) The metal furnace was deep enough. The weather was windy, and even though an electric fan was used, it was small, and due to the nature of the charcoal, it did not cause any sparks. (3) The dangers of adding alcohol to fuel became widely known after a fire accident. Since the igniter is a compressed piece of wood (solid), vaporization and ignition of clothes are unlikely to occur. (4) Make sure that the fire is completely extinguished using water, etc., and do not store used charcoal or ash in a place or container that contains flammable materials. Table 1 summarizes the comparison.

Table 1 *Comparison of predominantly dangerous items or circumstances in the previous fire accidents [14,15, 18-20] and present protocol [16]*

	Previous accidents	Present protocol
Added firelighters	Liquid or gels	Solid
Alcohol firelighters	Used	No
Ignition of cloths	Happened	No
Strong wind weather	(Potentially, yes)	No (except for hand fans)
Surrounding environment	(Potentially, flammable)	Outdoor concrete floor
Fire extinguisher	(Potentially, equipped)	Equipped
Extinguishing at end	(Potentially, insufficient)	Metal container

3.2 Ignition Agent

Since the memory of a fatal fire accident in which disinfectant alcohol was used as an igniter to intensify the fire is still fresh, further consideration about the igniter will be discussed here. Considering the accident situation, the Sakai City Fire Department has issued the following warning regarding fires caused by adding igniting agents to barbecues [20]. Accidents where a jelly-like fire starter was added to increase the firepower caused the fire starter to fly off, causing clothing to catch fire and causing injuries, and accidents where rubbing alcohol was added, causing the fire to spread rapidly, resulting in casualties. is also happening. Many of the ingredients in jelly-like fire starters are highly volatile and combustible, such as methyl alcohol, and when lit, they produce a blue-white flame, making it difficult to see the flames on sunny days, so don't worry about what you're wearing. There is a risk of catching fire.

Volatile liquids of flammable substances (disinfecting alcohol, which is the cause of accidents, is more volatile and dangerous than normal fuel alcohol) and gel-like substances (fluid and can splash onto people or clothing) In addition to fire igniters (such as those used in this experiment), solid fire igniters made of wax-containing compressed wood fibers (Fig. 6) are also popular, as was the case in this experiment. One

commercially available product claims that a single piece of wood can burn for about 10 min. Even with wood fibers, it is necessary to generate flammable gas components by heating, as in the general combustion of wood. However, by including wax, an improvement has been added that is advantageous for ignition at low temperatures.

According to a police analysis of combustion accelerants in arson cases [21], ethanol, triethylamine, ethylene glycol, triethanolamine, diisopropylamine, 2,4-dihydroxybenzophenone, triethanolamine bromide, polyethylene glycol (oligomer), rhodamine B, etc. were identified in the ignition agents. Two types of ignition agents are commercially available in Japan: solid ignition agents (limited amount of use) made of wood blocks soaked in kerosene or paraffin, and gel ignition agents (amount of use can be adjusted) whose main component is methanol. The latter includes thickeners that make the agent gel and color additives that increase the visibility of the flame. These generally include volatile and flammable substances. From a criminal investigation perspective, amine decomposition products are important.

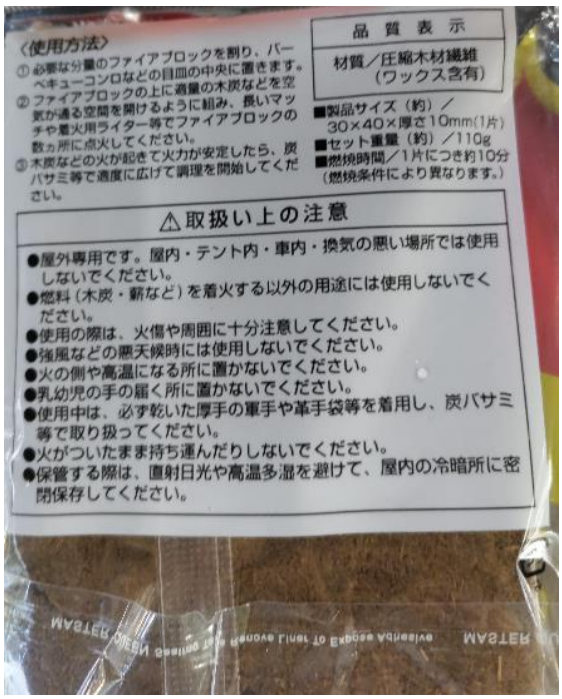

Fig. 6 *Wax-containing compressed wood fiber igniters (commercially available, different from the one used in this experiment)*

4. Conclusion

In this way, according to comparison with the previous cases, these three points, under calm wind conditions, using a solid firelighter (special woods), and keeping extinguished charcoal ash in a metal container, were found to be important for safe barbeque against fire accidents. To release carbon dioxide by burning carbon fixed by photosynthesis, we focused on traditional charcoal, which can be considered a renewable energy source from a carbon-neutral perspective and compared accidents in Japan and safe usage methods. Charcoal also has the potential to play a new role as a functional material. The charcoal logs used in this study were mangroves from Malaysia. Appropriately sized pieces of charcoal were ignited with an ignition agent or air blown and used for grilling barbecues in outdoor facilities for about two hours, with no problems in terms of heat or odor. By handling it properly, it was possible to use it safely without the risk of carbon monoxide poisoning, excessive burning of ignition agents, or re-ignition after extinguishing. It is thought that it is important to avoid inappropriate use and to understand the properties of the materials contained in it.

Acknowledgement

The author would like to thank all the friends of the St. Joseph Nursery School (Shibuya, Tokyo, Japan) Alumni Association.

Conflict of Interest

There is no conflict of interests regarding the publication of the paper.

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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