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Development of a grilling and herbal steam device for Thai traditional medicine

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Abstract

This research focuses on developing a herbal grill and steamer for health enhancement. The objectives of this work are to construct and test the efficiency of the herbal grill and steamer that enhance the health of the Khao Na Tad Moo 12 community enterprise group, Lam Narai Subdistrict, Chai Badan District, Lop Buri Province, Thailand, which is located in the central region of Thailand. The research results found that the usage patterns of the herbal grill and steam machine consist of two patterns. Pattern 1 uses the herbal grill and steam machine twice for 15 minutes each, then sits and rests for 5 minutes, for a total of 35 minutes. Pattern 2 sets the temperature at 40 degrees Celsius and uses the herbal steam machine for a total of 20 minutes, once. Both patterns maintain a temperature of 37 to 46 degrees Celsius. The wooden floor of the grill machine is made from natural pine wood. It measures 90 centimeters wide, 195 centimeters long, and 67 centimeters high. The herbal steam tent is made of 10 mm stainless steel, 99 centimeters in diameter, and 110 centimeters high. The entrance is 54 centimeters wide. The results of the efficiency test of the herbal grill, Model 1, show an average maximum temperature of 43.83 degrees Celsius and an average minimum temperature of 39.00 degrees Celsius. Model 2 has an average maximum temperature of 41.97 degrees Celsius and an average minimum temperature of 39.00 degrees Celsius. The results of the efficiency test of the herbal steam tent, Model 1, show an average maximum temperature of 45.94 degrees Celsius and an average minimum temperature of 33.31 degrees Celsius. Model 2 has an average maximum temperature of 41.83 degrees Celsius and an average minimum temperature of 38.06 degrees Celsius.

Keywords: Efficiency, Grilling, and herbal steam device, Temperature control, Thai traditional medicine.

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1. Introduction

Thai Traditional Medicine (TTM), as defined by the Thai Traditional Medicine Profession Act B.E. 2556 (2013), encompasses the medical processes of examination, diagnosis, treatment, disease prevention, and the promotion and rehabilitation of human health. Among various TTM techniques, herbal steam therapy plays a significant role in both clinical and community-based applications. It is employed to treat illnesses, promote general well-being, and enhance physical appearance. Herbal steam therapy can be administered to both men and women and is traditionally delivered through steam rooms, herbal steam cabinets, or tent-style enclosures [1].

In Ban Khao Na Tat, Village No. 12, Lam Narai Subdistrict, Chai Badan District, Lopburi Province, Thailand, a variety of medicinal herbs have been identified, such as *Sterculia foetida* (jang), *butterfly pea*, *Andrographis paniculata*, *turmeric*, *aloe vera*, and *Indian gooseberry*, as shown in Figure 1 [2]. These herbs represent valuable local resources that can be transformed into economic opportunities for community members. The Ban Khao Na Tat Community Enterprise Group has adopted traditional and folk Thai medical practices to offer healthcare services involving diagnosis, treatment, disease prevention, and health promotion, integrating local wisdom and culturally rooted methods.

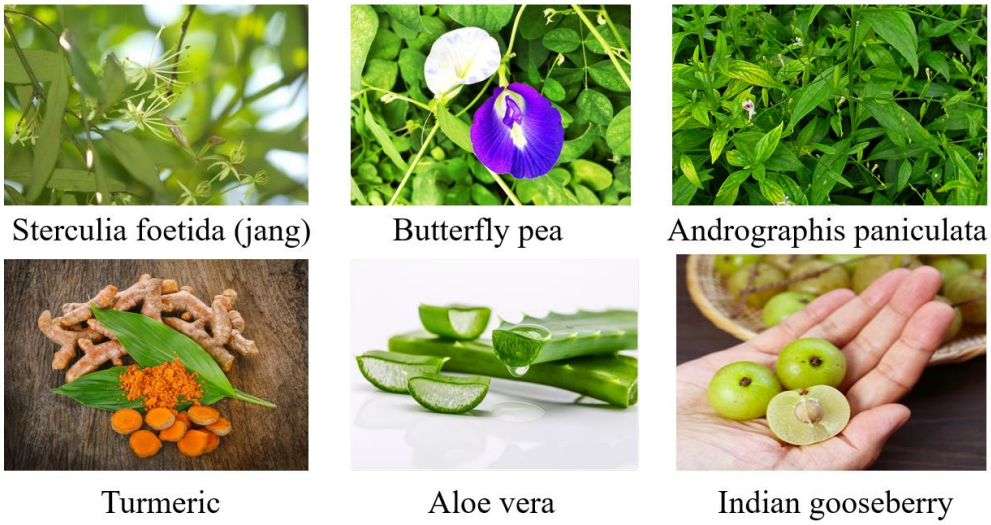

Figure 1.
Examples of herbs that have been applied in traditional Thai medicine [3-8].

One notable practice includes the use of jang leaves, which are heated through traditional roasting methods. Leaves are placed on a bamboo bed, covered with cloth, and heated from below using a charcoal stove. This practice, rooted in local wisdom, is believed to relieve blood stagnation, reduce muscular pain, and promote relaxation and physical vitality [9-11]. However, this technique often results in uneven heat distribution, which may pose risks to patient safety. The Ministry of Public Health prescribes that optimal temperatures for steaming, compressing, or roasting therapies should range between 37–46°C [12-14].

In light of these findings, the research team proposes the development of a smart herbal roasting and steaming machine specifically tailored for health promotion within the Ban Khao Na Tat community. The machine will ensure a consistent and safe internal temperature range of 37–46°C, while also allowing for the controlled release of herbal compounds at temperatures above 60°C. Furthermore, it will address the current lack of standardized temperature regulation and eliminate the need for constant manual supervision during use.

The machine will feature two main operational modes:

1. Preset mode at 37– 46°C for 15 minutes, used twice per session.
2. Custom mode, which allows temperature adjustments within 37–46°C for a duration of 10 to 30 minutes.

The system will be designed in accordance with the safety standards outlined by the Thai Ministry of Public Health, ensuring its suitability for use by community health enterprises and aligning traditional practices with modern technological advancements.

2. Literature Review

The research team conducted a comprehensive review of relevant theories and prior studies, and synthesized findings from ten selected research papers, as presented in Table 1.

Table 1.
Summary of relevant research.

References, Year	Short Summary
Phatai and Khongnak [15]	A study conducted at Phon Na Kaeo Hospital in Sakon Nakhon Province investigated the effects of herbal steaming therapy on patients with asthma. The objective was to assess the therapeutic outcomes of herbal steaming in asthmatic patients. The results indicated that 57.14% of patients reported no daytime wheezing prior to the therapy, which increased to 71.42% after undergoing herbal steaming. Regarding nighttime symptoms, 23.80% of patients did not require the use of inhaled bronchodilators before the therapy, which increased to 52.38% following the treatment.
Wannasri and Ketkaew [16]	Postpartum women often experience fatigue and musculoskeletal pain resulting from childbirth, along with limited sleep due to uterine contractions, perineal or surgical wound pain, breast engorgement, and the demands of breastfeeding. As such, postpartum health recovery is of great importance. One traditional care option widely practiced in Thailand is known as yu fai (postpartum heat therapy), a culturally inherited method believed to restore balance according to the traditional theory of bodily elements. This practice typically includes sitting or lying near a fire, herbal steam bathing, hot salt pot compresses, charcoal seat warming, massage, hot compress therapy, and dietary adjustments. Postpartum women may adapt these practices according to their family traditions and personal convenience. Today, Yu Fai can be accessed through public healthcare services or practiced independently at home to promote maternal health and recovery.
Kamfu and Parasill [17]	A Comparative Study on the Immediate Effects of Thai Herbal and Traditional Steam on Flexibility in Women Aged 30–45. This study compared the immediate effects of Thai herbal steam and traditional steam therapy on physical flexibility in women aged 30–45 with low to moderate flexibility. Twenty-nine participants were divided into two groups: herbal steam (n=15) and traditional steam (n=14). Both groups received a 30-minute steam session. Flexibility was assessed using the sit-and-reach test and shoulder girdle flexibility test before and after treatment. Results showed that both methods improved shoulder flexibility, with no significant difference between groups. However, the herbal steam group demonstrated greater improvement in lower back and hamstring flexibility compared to the traditional steam group.
Kamfu [18]	A Comparative Study of Thai Herbal Steam and Traditional Steam on Pain and Muscle Flexibility in Individuals with Lower Back Pain. This study aimed to compare the effects of Thai herbal steam and traditional steam therapy on pain levels and flexibility of the lower back and leg muscles in individuals with lower back pain. Thirty-five participants aged 35–60 years were divided into two groups: herbal steam (n=19) and traditional steam (n=16). Each participant received three steam sessions. Pain was assessed using a visual analog scale, and muscle flexibility was measured using the sit-and-reach test before and after the intervention. Results indicated significant reductions in pain and improvements in flexibility in both groups ($p < 0.05$). However, the herbal steam group showed significantly greater reductions in pain and greater gains in flexibility compared to the traditional steam group.
Nontakan [19]	Development of Public Herbal Steam Therapy for Health through Community Participation: A Case Study of Ban Nong Plapark, Ubon Ratchathani, Thailand. This study explored the development of public herbal steam therapy for health through community participation in Ban Nong Plapark, Khampai Subdistrict, Ubon Ratchathani, using an action research approach. The process included four phases: planning, implementation, observation, and reflection, with data collected through surveys and workshops involving 40 participants. The study found high levels of community involvement and led to the creation of the "SPAC" model for herbal steam therapy, which includes: 1) Service of sauna (S), 2) Participation (P), 3) Action plan (A), and 4) Continuous operation (C). This model emphasizes sustainable, community-driven health practices based on local knowledge.
Sukkaya and Kieopun [20]	Effectiveness of Thai Herbal Steam Therapy on COPD Patients at Wat Bots Hospital, Phitsanulok, Thailand. This study aimed to assess the effectiveness of a herbal steam therapy program on the health of COPD patients at Wat Bots Hospital, Phitsanulok. A quasi-experimental design was used with 56 participants, divided into an experimental group (28) and a control group (28). The experimental group underwent 15-minute herbal steam therapy twice daily, once a week for four weeks. Health outcomes were measured using the COPD Assessment Test (CAT). Results showed a significant reduction in CAT scores for the experimental group (from 4.71 to 2.25), with a significant difference compared to the control group ($p < 0.01$). The herbal steam therapy program effectively reduced symptoms of COPD. Further studies are recommended to explore long-term benefits and cost-effectiveness.
Srirattayawong [21]	Effect of Thai Herbal Steam Therapy on Blood Pressure in Hypertensive Patients. This study aimed to examine the effect of Thai herbal steam therapy and regular steam therapy on blood pressure in hypertensive patients. The sample consisted of 30 hypertensive patients, divided into two equal groups: a control group receiving regular steam therapy and an experimental group receiving Thai herbal steam therapy. Each session lasted 20 minutes, twice a week, for a total of 30 sessions. Blood pressure was measured before and after each session. Results showed a statistically significant reduction in systolic blood pressure in the experimental group after Thai herbal steam therapy (85.70

	± 0.27, $p < 0.05$). The average blood pressure decrease in the herbal steam group was greater than in the regular steam group. The study suggests that Thai herbal steam therapy can effectively lower blood pressure and should be promoted as an alternative treatment for hypertensive patients, especially in the early stages, as part of Thai traditional medicine practices.
Siriprasert and Konghin [22]	Development of an Automatic Body Temperature Measurement Device with Line Notification. This study aimed to develop an automatic body temperature measurement system to avoid close contact with individuals or high-risk groups potentially infected with COVID-19. The system consists of three components: 1) GY-906 Infrared Temperature Sensor, 2) Arduino ESP32-CAM camera, and 3) Arduino Wi-Fi ESP8266 microcontroller, which sends temperature data and notifications via the Line application. The system was tested on 10 participants (7 male, 3 female), measuring body temperatures ranging from 30°C to 40°C with an error margin of ± 3.05%. The system successfully transmitted data and images via the Line every 3 seconds. The infrared sensor's effective measurement range was within 10 cm, and the test required a Wi-Fi signal to operate.
Susetyo, et al. [23]	Herbal Medicine Goes Digital: IoT for Automatic Temperature and Humidity Monitoring. This article aims to demonstrate the use of the Internet of Things (IoT) in businesses by installing sensor devices for continuous and automated environmental monitoring. Prior to IoT implementation, environmental checks relied on inconsistent manual inspections. In the herbal and pharmaceutical industry, monitoring temperature and humidity is crucial. The DHT11 and DHT22 sensors, used with the ESP32 microcontroller, facilitate real-time temperature monitoring. Data collected is stored in a MySQL database and displayed on a web dashboard built with HTML and PHP. This article compares the performance of both sensors and discusses potential applications in organizations. Implementing IoT transforms the monitoring process from manual to automated, enabling continuous data collection for further analysis. Results indicate that IoT integration enhances efficiency and accuracy in environmental monitoring.
Harianto, et al. [24]	Development and Evaluation of a Temperature and Humidity Control Unit Based on ESP32 for Textile Storage. Temperature and humidity measurement in textile storage is crucial for maintaining product quality and ensuring optimal conditions. This study focuses on the development of a temperature and humidity control unit using the ESP32 microcontroller, evaluated through black-box testing. The ESP32-based system provides a scalable, energy-efficient solution for climate control, offering precise environmental monitoring through built-in Wi-Fi and Bluetooth for affordable connectivity. Its advanced real-time data processing and compatibility with multiple sensors make it ideal for cost-effective, large-scale use in textile storage environments. The experimental approach involved controlling temperature and humidity as independent variables, with proper storage conditions as the dependent variable. DHT21 sensors, the ESP32 microcontroller, and relays were used as control components. Software was developed in Arduino IDE to manage temperature and humidity, and after validation, the program was uploaded to the ESP32 for black-box testing. Results confirmed the system's effective control of environmental conditions.

3. Methodology

The research on the development of a herbal steaming and grilling device for health promotion among the Ban Khao Na Tat community enterprise group was conducted in three sequential phases, as outlined below.

- A study on the needs and preferences regarding the design of a herbal steaming and grilling device for health promotion among the Ban Khao Na Tat community enterprise group
- The development of a herbal steaming and grilling device for health promotion among the Ban Khao Na Tat community enterprise group.

An evaluation of the efficiency of the herbal steaming and grilling device developed for health promotion among the Ban Khao Na Tat community enterprise group, Village No. 12.

3.1. A study of the design requirements for a herbal steaming and grilling device to promote health among the Ban Khao Na Tat Community Enterprise Group.

The study of the herbal steaming and grilling device design for health promotion among the Ban Khao Na Tat Community Enterprise Group revealed that both the herbal grill and steam tent required manual operation and preparation by service providers. For the grilling process, charcoal must be placed into the stove and heated until it reaches a sufficient temperature. Once ready, the service recipient lies down on a bamboo bed above the heat source.

For the herbal steam tent, water is poured into a boiling pot, along with selected herbs. The pot is then placed inside the tent and heated until the water reaches a boiling point and releases herbal steam. However, the system does not allow for precise temperature control according to the operator's preferences.

Time monitoring for both the grilling and steaming processes relies on the service provider, who must manually track time using a wall clock or wristwatch and manage the operation steps accordingly. Safety supervision also depends on the service provider's direct observation. Once the scheduled time is completed, the system must be manually turned off by the operator.

In terms of design, the charcoal stove is located directly beneath the bamboo bed, while the herbal steam pot is situated under the seating area inside the tent. This configuration presents potential electrical safety risks due to the proximity of the power supply to moisture, as water is a strong conductor of electricity and may cause electric leakage inside the tent.

Service users are responsible for observing the temperature both on the grill and inside the herbal steam tent. They must also monitor usage time and ensure all operational steps are followed. The operator is required to prepare the room for use by cleaning the grilling area, beneath the bamboo bed, and the interior and exterior surfaces of the steam tent.

Each use begins with lighting the charcoal stove for grilling and boiling water in the herbal steam pot. Afterward, the switch on the steam boiler is turned on, and the service time is monitored. The setup process and equipment configuration are illustrated in Figure 2 (Grilling Device) and Figure 3 (Herbal Steam Tent).

Figure 2.
Traditional Herbal Grilling Device.

Figure 3.
Traditional Herbal Steam Tent.

Based on Figures 2 and 3, the study of the usage patterns of the herbal grilling device and herbal steam tent used by the Ban Khao Na Tat Community Enterprise Group revealed a traditional operational process. The herbal grill operates by igniting charcoal in the stove, covering the bamboo bed with a layer of unbleached cotton cloth, followed by the placement of crinum leaves and Jang leaves, and finally covering them with another layer of unbleached cotton cloth. The herbal steam tent functions by filling the boiling pot with water, adding herbs, plugging in the power source, and activating the steaming function via the control button on the boiler. The user must also monitor the usage time for both the grill and the steam tent. These traditional usage methods were examined and later compared with the improved model of the herbal steaming and grilling device developed by the researcher, as presented in Table 2.

Table 2.
Study of the Usage Pattern of the Herbal Grilling and Steaming Device for Health Promotion in the Ban Khao Na Tat Community Enterprise Group.

Usage Pattern of the Herbal Grilling and Steaming Device: A Data Analysis	**Usage Pattern of the Herbal Grilling and Steaming Device Developed by the Researcher**
1. Usage Pattern of the Herbal Grilling and Steaming Device	1. Usage Pattern of the Herbal Grilling and Steaming Device
1.1 The herbal grilling and steaming device is used twice, each session lasting 15 minutes with a 5-minute rest in between. During the first session, the service provider is responsible for monitoring the time spent using the device, while the service recipient must control the temperature independently. After 15 minutes, the service provider will notify the recipient and instruct them to rest for 5 minutes, based on the time indicated by a clock. Once the rest period is over, the service provider will inform the recipient to resume using the device for the second session, which also lasts 15 minutes. At the end of the second session, the service provider will notify the recipient that the total usage time has reached 30 minutes.	1.1 Press the option to select Mode 1 and then press to start the operation. The control circuit will begin managing the operation of the herbal grilling and steaming device, which is used in two sessions of 15 minutes each, with a 5-minute rest in between. During the first session, the device will operate for 15 minutes. After 15 minutes, an alert signal will sound, and the service recipient must exit the device to rest outside for 5 minutes. Once the alert signal sounds again, the recipient must re-enter the herbal grilling and steaming device for the second session. This second session also lasts 15 minutes, and after 10 minutes, the alert signal will sound again. The recipient must then exit the device and the steam tent once the set time is complete. 1.2 Press to select Mode 2. The service provider must set the desired temperature, ranging from 37°C to 46°C, and set the operation time, ranging from 1 minute to 30 minutes. Once the settings are configured, press to start the operation. The control circuit will then begin managing the operation of the herbal grilling and steaming device.
2. The internal safety system for the users of the herbal grilling and steaming device requires the service provider to monitor and observe the service recipient throughout the process.	2. There is an automatic internal safety system for the service provider of the herbal grilling and steaming device, which is activated when any malfunction is detected.

3.2. Method of Developing the Herbal Grilling and Steaming Device for Health Promotion in the Ban Khao Na Tat Community Enterprise Group

The development of the herbal grilling and steaming device for health promotion in the Ban Khao Na Tat Community Enterprise Group, Village No. 12, consists of two main components: the design and construction of the herbal grilling and steaming device. The process of designing and constructing the device involves two parts: the design and construction of the herbal grilling and steaming device itself, and the design and construction of the temperature control system within the device.

3.2.1. Design and Construction of the Herbal Grilling and Steaming Device

Design and Construction of the Herbal Grilling and Steaming Device Using the Regulations of the Ministry of Public Health: The design and construction of the grilling device followed the operational requirements, resulting in the design and installation of a sensor on the top of the grilling device, as shown in Figure 4.

Figure 4.
Installation of the Sensor on the Top of the Grilling Device.

The design and construction of the grilling device followed the established usage specifications. The design resulted in the installation of a temperature sensor at the top, positioned at the center of the grilling device, to measure the operating temperature during use.

The design and construction of the herbal steam tent were made from 10mm stainless steel, with a diameter of 99 centimeters and a height of 110 centimeters. The front of the tent includes an entrance with a width of 54 centimeters. The result of the design and construction of the herbal steam tent involved using a lip-stop fabric to cover the structure, allowing for the maintenance of the internal temperature within the steam tent.

On the side, there is a space for installing a stainless steel pipe to transfer steam from the boiler into the tent, providing steam to regulate the internal temperature of the herbal steam tent. The pipe has a height of 36.5 centimeters and a diameter of 3 centimeters. To ensure safety regarding the electrical system used in the control of the herbal steam tent, the electrical supply system for the herbal boiler will be installed externally, as shown in Figure 5.

Figure 5.
Installation of the Control System.

As shown in Figure 5, the installation of the control system on the side is separated from the main structure of the steam tent and positioned at a distance that allows both the service provider and the service recipient to easily view it. Additionally, the system is designed for easy mobility.

3.2.2. Design and Construction of the Control System for the Herbal Grilling and Steaming Device

The design and construction of the control system for the herbal grilling and steaming device began with the use of heating coils, sensors, solid-state relays, optocouplers [25], microcontrollers, Arduino programming, and LCD screens [26]. These components were integrated to design and construct the control system for the herbal grilling and steaming device. The results of the design and construction of the control system are shown in Figures 6 and 7.

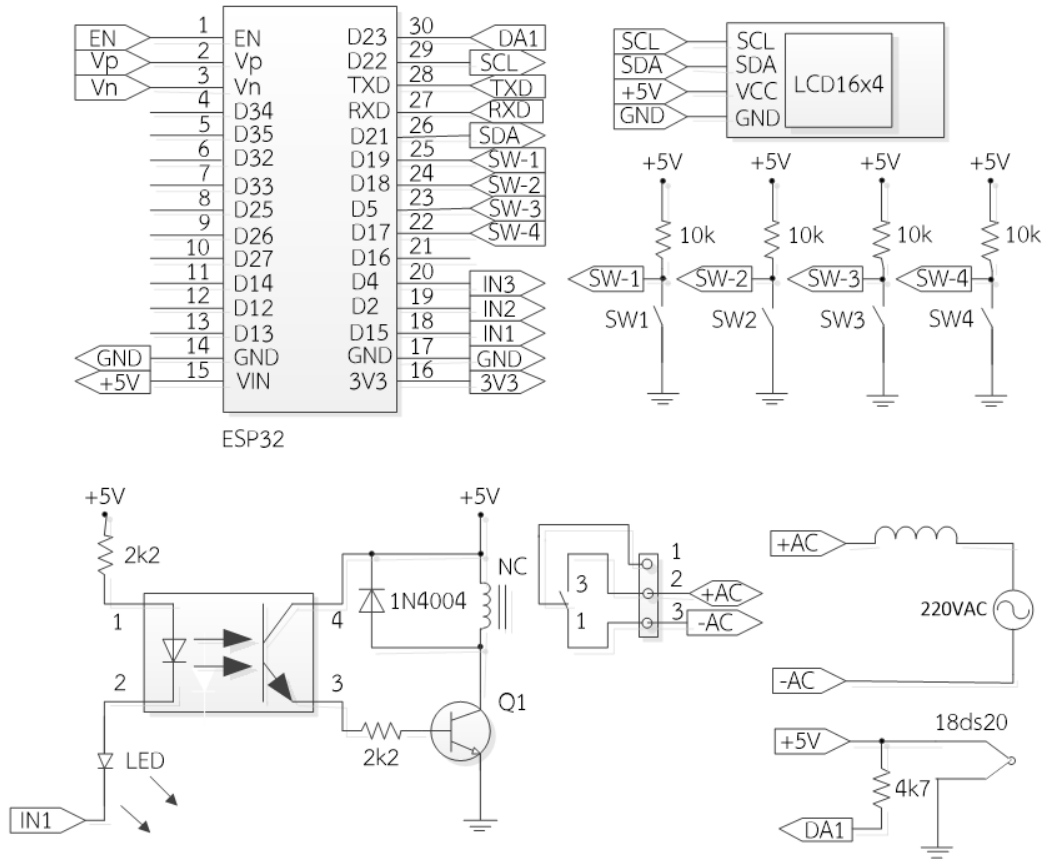

Figure 6.
Circuit Diagram of a Herbal Steam Boiler.

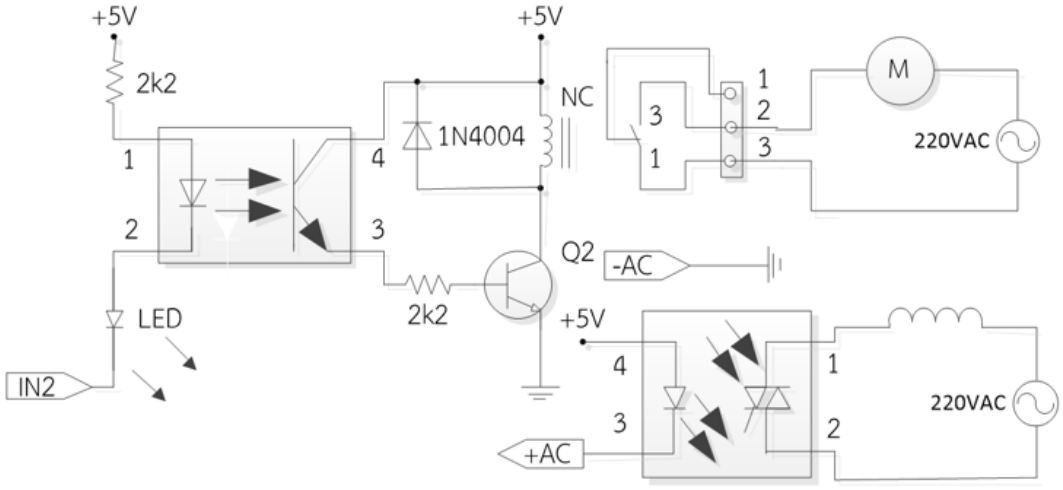

Figure 7.
Electrical Circuit of a Herbal Grilling Bed Heating.

As shown in Figure **7**, the control system of the herbal grilling and steaming device can control the operation of the grilling device starting from the ESP32 [27, 28], which sends a logic signal of 0 from pin IN1, causing the PC817 optocoupler to complete the circuit. This results in biasing the base of the transistor, activating relay circuit 1, which switches the contacts to the opposite position from the original. This action connects pin 1 with pin 3, allowing current to flow from the 5-volt power supply at the output of the PC817 optocoupler [29]. The current flows from pin 4 to pin 3 and passes through the base of the transistor, biasing it to activate the transistor, which in turn activates the relay. The magnetic field generated pulls the relay contacts to the opposite position, connecting pin 1 to pin 3, thereby powering the herbal steam boiler.

For the grilling device, when the relay contacts switch to the opposite position from the original, with pin 1 connected to pin 3, current from the 5-volt power supply flows through the input stage at pin 4 to pin 3 of the solid-state relay and through the relay contacts between pins 3 and 1, completing the circuit to ground. This powers the grilling coil.

Subsequently, the ESP32 sends a logic signal of 0 to pin IN2, which activates the PC817 optocoupler to complete the circuit. This causes biasing of the base of the transistor, activating relay circuit 2. The output connected to the 220 VAC power supply for the fan motor is then powered on. An 18ds20 sensor is used to read the temperature inside the grilling

device, sending the temperature data to the microcontroller for display on the LCD screen. Once the temperature reaches 39°C, the system begins operation. When the internal temperature reaches 46°C, the circuit is cut off by sending a logic signal of 1 from pin IN1. When the internal temperature drops to 37°C, the circuit restarts until the operating time is completed, as shown in Figure 8.

Figure 8.
Display of the Grilling Device's Operation.

For the herbal steam dome, the operation of the herbal steam dome is controlled starting from the ESP32, which sends a logic signal of 0 from pin IN1**.** This triggers the PC817 optocoupler to complete the circuit, causing biasing at the base of the transistor and activating relay circuit 1. This switches the relay contacts to the opposite position from the original, connecting pin 1 to pin 3, thus initiating the heating coil to start functioning and allowing steam to flow into the herbal steam dome. The system utilizes the **18**ds**20** sensor to read the temperature inside the herbal steam dome and sends the temperature data to the microcontroller for display on the LCD screen. Once the temperature reaches 39°C, the herbal steam dome begins operation until the internal temperature reaches 46°C. At this point, the circuit is disconnected by sending a logic signal of **1** from pin IN**1.** When the internal temperature drops to 37°C, the system restarts and continues until the operation time for the herbal steam dome is completed, as shown in Figure 9**.**

Figure 9.
Display of the Herbal Steam Dome's Operation.

From Figures 8 and 9, it is observed that the operation of the control system for the grilling device and the herbal steam dome displays the control results on the LCD screen. The system operation is managed by the microcontroller, which controls the functioning of the system.

4. Results and Discussion

The research findings are divided into two main sections: (1) the evaluation of the performance of the herbal roasting device developed to promote the health of the Ban Khao Na community enterprise group, and (2) the performance assessment of the herbal steam generator designed for the same purpose. Each case study consists of two operational models, detailed as follows:

4.1. Performance Evaluation of the Herbal Roasting Device for Health Promotion in the Ban Khao Na Community Enterprise Group

4.1.1. Performance Evaluation of the Herbal Roasting Device for Health Promotion in the Ban Khao Na Community Enterprise Group – Model 1

In Model 1, the system control procedure for the herbal roasting device involved conducting two roasting sessions, each lasting 15 minutes. After completing each session, users were instructed to rest for 5 minutes. Therefore, the total duration for one full herbal roasting cycle was 35 minutes. This procedure was repeated ten times.

During operation, the maximum recorded temperature reached 45.75°C, while the minimum was 39.00°C. The average maximum temperature was 43.83°C, and the average minimum temperature remained at 39.00°C. These temperature variations over time are illustrated in the temperature-time graph presented in Figure 10.

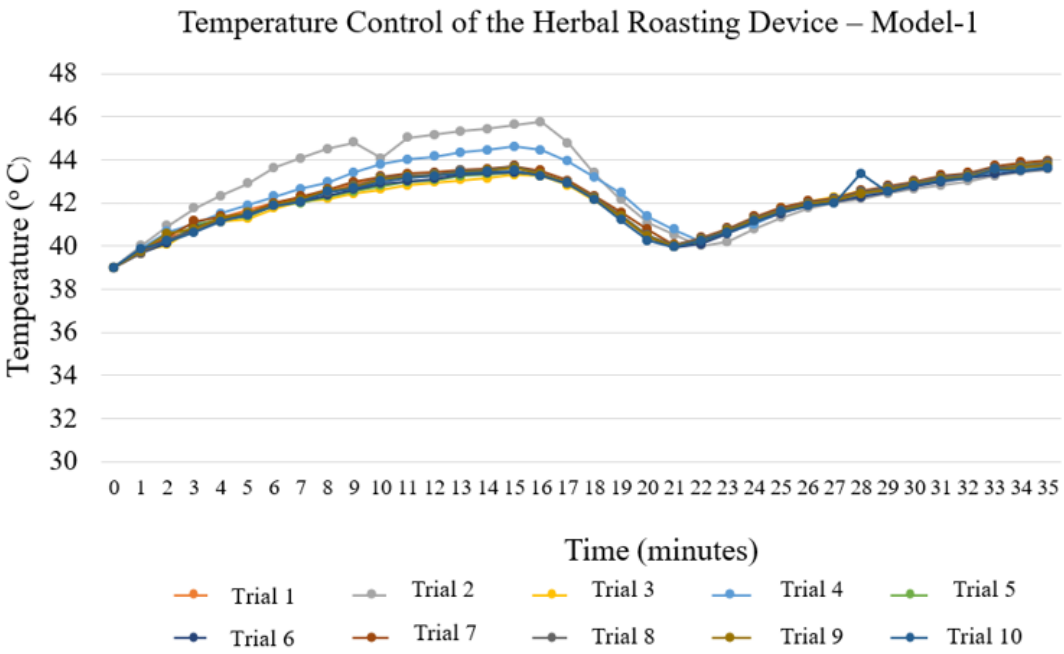

Figure 10.
Temperature Control of the Herbal Roasting Device – Model **1.**

Performance Evaluation of the Herbal Roasting Device for Health Promotion in the Ban Khao Na Community Enterprise Group – Model 2

In Model 2, the operation of the herbal roasting device involved a single roasting session lasting 20 minutes per cycle. This procedure was repeated ten times, resulting in a total roasting time of 20 minutes per session. The temperature data collected during the sessions was used to generate a temperature-time relationship graph, as illustrated in Figure 11.

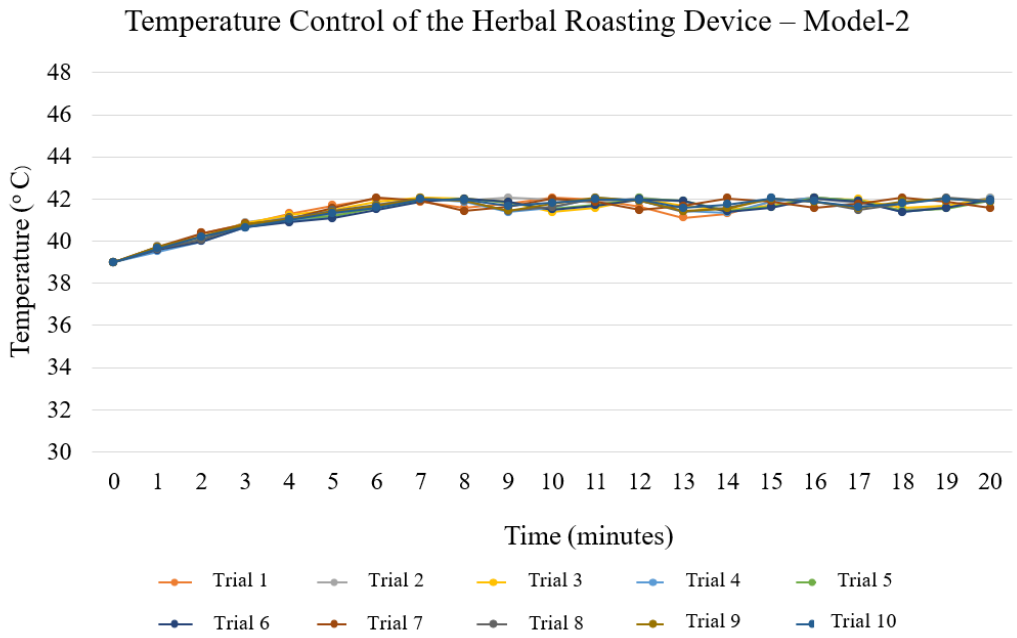

Figure 11.
Temperature Control of the Herbal Roasting Device – Model 2.

4.1.2. Performance Evaluation of the Herbal Steam Chamber for Health Promotion in the Ban Khao Na Tat Community Enterprise – Model 1

The performance evaluation of the herbal steam chamber for health promotion in the Ban Khao Na Tat Community Enterprise, Village No. 12, under Model 1, involved a steaming process consisting of two sessions, each lasting 15 minutes. After completing each 15-minute session, participants took a 5-minute rest. The total duration for each steaming cycle was

35 minutes, and the procedure was repeated 10 times. The collected data were used to generate a temperature-time relationship graph, as illustrated in Figure 12.

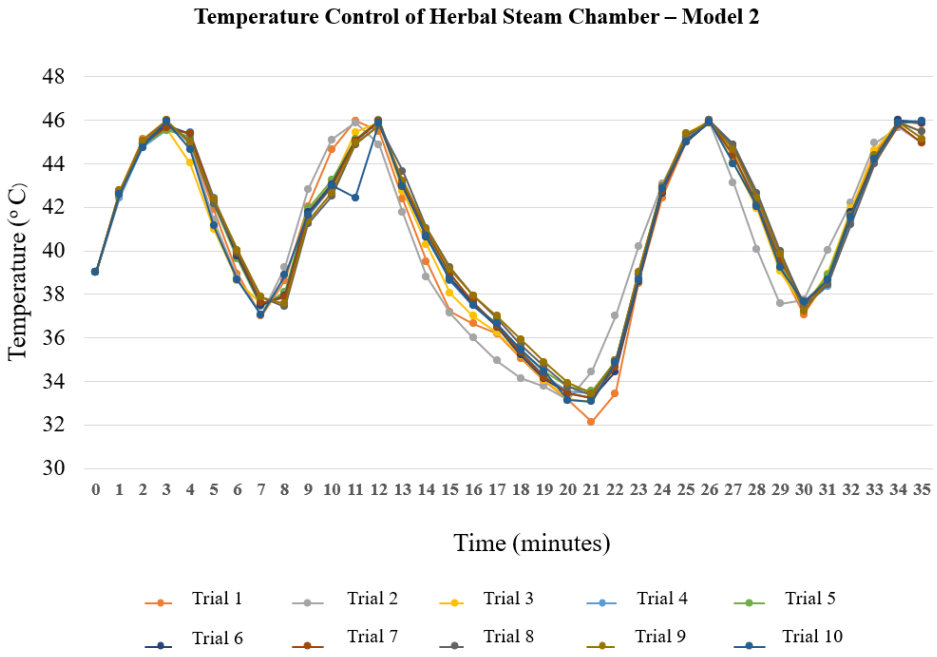

Figure 12.
Temperature Control of Herbal Steam Chamber – Model **1.**

4.1.3. Performance Evaluation of the Herbal Steam Chamber for Health Promotion in the Ban Khao Na Tat Community Enterprise – Model 2

In Model 2, the performance evaluation of the herbal steam chamber for health promotion in the Ban Khao Na Tat Community Enterprise involved a single 20-minute herbal steaming session per cycle. Each session was conducted 10 times, with the total streaming time being 20 minutes per session. The temperature-time relationship data collected during the process were used to generate a graphical representation, as shown in Figure 13.

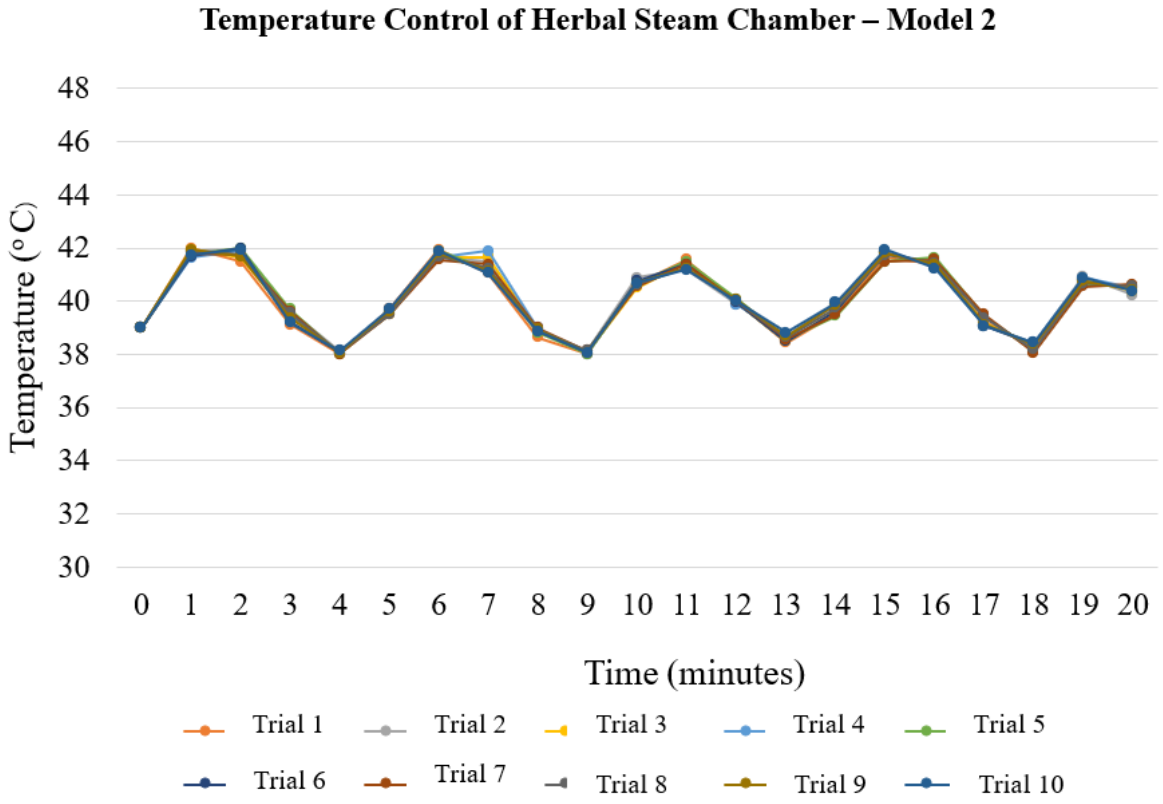

Figure 13.
Temperature Control of Herbal Steam Chamber – Model 2.

The study aimed to evaluate the performance of two herbal health promotion devices: the herbal grilling machine and the herbal steam chamber, developed for the Ban Khao Na Tat Community Enterprise. The experiments were designed to test two operational models for each device in terms of temperature control, duration, and consistency across multiple sessions.

For the herbal grilling machine, Model 1 involved two 15-minute grilling sessions with a 5-minute rest period in between, totaling 35 minutes per session across 10 trials. Temperature readings indicated a maximum of 45.75°C, a minimum of 39.00°C, with an average maximum temperature of 43.83°C. This suggests that the system could maintain a stable and appropriate thermal environment conducive to herbal grilling. In Model 2, a single 20-minute session per trial was used across 10 trials. This model was more time-efficient, though the absence of a rest period might influence user comfort and thermal saturation of the herbs.

The herbal steam chamber was tested similarly. In Model 1, two 15-minute steaming sessions were separated by a 5-minute rest, totaling 35 minutes. The data showed consistent temperature behavior, supporting the system's capability in maintaining suitable steaming conditions. In Model 2, a single 20-minute continuous session was performed, which may be more practical for time-limited applications, although prolonged exposure without breaks could potentially cause discomfort or overheating in certain individuals.

Overall, both devices demonstrated effective temperature regulation, and both models of operation were viable depending on user needs and context. Model 1, with its integrated rest periods, might be more suitable for users requiring gradual exposure, especially for therapeutic applications. Model 2 offers a quicker alternative and is better suited for routine health practices where time constraints are a concern.

These findings suggest that the integration of locally developed herbal equipment, when properly engineered and tested, can support community health initiatives, promote the use of Thai traditional medicine, and enhance the practical application of local wisdom through smart and scalable solutions.

5. Conclusion

The construction of the herbal roasting and steaming machine for the Khao Na Tad Moo 12 Community Enterprise Group in Lam Narai Subdistrict, Chai Badan District, Lop Buri Province, located in the central region of Thailand, has successfully met the objectives of the research. The herbal roasting unit was fabricated using a steel frame, with dimensions of 90 cm in width, 195 cm in length, and 67 cm in height. An air-blowing fan, with a blade width of 30 cm, was installed at one end to facilitate air circulation. Side compartments, each measuring 20 cm in width and 25 cm in length, were provided for placing herbal leaves such as Bai Jang and Bai Plap Plueng. Handles for opening and closing the herbal compartments measured 11 cm in width and 1 cm in thickness. The top section, made from imported pine wood, measured 2.54 cm × 2.54 cm in cross-section and was slotted with 5 mm gaps to allow the passage of steam.

The herbal steam dome was constructed from stainless steel with a thickness of 10 mm, a diameter of 99 cm, and a height of 110 cm. The front access opening measured 54 cm in width and was surrounded by a ripstop fabric enclosure to contain the steam from the boiler. A stainless steel pipe, with a height of 36.5 cm and a diameter of 3 cm, was installed on the side to channel steam from the boiler into the dome, thereby maintaining the internal temperature. For safety, the control system—comprising heating coils, a hot air blower, a boiler, sensors, a microcontroller, Arduino-based programming, and an LCD display—was installed separately from the dome in a visible and easily accessible location.

Performance testing of the machine was conducted with the objective of promoting community health in the Khao Na Tad Moo 12 enterprise group. In the first operating mode for the herbal roasting system, the process was repeated 10 times, each consisting of two 15-minute roasting sessions separated by a 5-minute rest, totaling 35 minutes per session. The highest temperature recorded was 45.75°C, the lowest was 39.00°C, with an average maximum of 43.83°C and an average minimum of 39.00°C. In the second mode, a single 20-minute roasting session was performed 10 times, yielding a maximum temperature of 42.06°C, a minimum of 39.00°C, with average maximum and minimum temperatures of 41.97°C and 39.00°C, respectively.

For the herbal steam dome, the first mode consisted of two 15-minute steaming sessions separated by a 5-minute rest, also repeated 10 times, totaling 35 minutes per session. The dome was activated at 39°C, with a recorded maximum temperature of 46.00°C, a minimum of 32.13°C, and average maximum and minimum temperatures of 45.94°C and 33.31°C, respectively. The second mode involved a single 20-minute steaming session at a preset temperature of 40°C, repeated 10 times. During operation, the highest temperature was 42.00°C, the lowest 38.00°C, with average maximum and minimum temperatures of 41.83°C and 38.06°C, respectively. These results confirm that the machine effectively operates within the intended thermal parameters and meets the goals of supporting health promotion within the community through the use of traditional herbal treatments.

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