Change of Iodine Number for Odors Absorbed Mangosteen Charcoal by Using Small-Scale Biomass Furnace

Donludee Jaisut, Jaroon Kangkhadwit, Ratiya Thuwapanichayanan, and Sudsaisin Kaewrueng

***Abstract*—** This research was study on change of iodine number on odors absorbed mangosteen charcoal by small scale biomass furnace which was controlled air ratio. 30 pieces of small mangosteen in the diameter of 5 - 6 cm were dried until the final moisture content (approximately 4% wet-basis) by small-scale biomass furnace. The initial moisture content was approximately 30% wet-basis. Inlet air values were designed to control combustion section and drying section. The iodine number followed by Thai Community Product Standard (TPCPS 180/2003) of samples was evaluated (at least 150 mg/g). The resulted showed that inlet and outlet air affected on change of drying time and samples quality. The recommendation of odors absorbed mangosteen charcoal production was control inlet air at combustion zone at 100%, drying zone 50% and outlet air 100%. The drying time was approximately 115 min and the iodine number was 155 mg/g.

***Keywords*—**Absorb, Biomass, Charcoal, Mangosteen

I. Introduction

IN Thailand, many agriculture commodities were exported to the world market such as rice, para rubber, vegetable, aquatic animal especially tropical fruit. Mangosteen was well-known as "The Queen of Tropical Fruits". The process of growing mangosteen has to reduce the number of mangosteen fruit by cut it off after blooming (4 – 5 weeks). The small mangosteen in the field is one of insect pest cause such as oriental fruit fly [1].

The production of odors absorbed charcoal was applied widely in a variety of materials such as corn, fruit, bamboo and by-product. Odors absorbed charcoal obtained from agricultural by-products had the advantage of offering an effective, low cost replacement for non-renewable coal-based, provided that they had similar or better adsorption efficiency [2]. The abundance and availability of agricultural by-products made them good sources of raw materials for odors absorbed charcoal production [3]. The widely use of alternative waste materials from agriculture for odors absorbed charcoal production had been found in the recent years ago [4,5]. The useful of the charcoal was not only for odors absorbed but also for decoration.

Recently, the charcoal furnace which made from tank (200 lite) was promoted widely in Thailand. The advantage of this technique was low cost. However, the drying time and quality of product were uncontrolled.

According to that, the purpose of this study was to study on the optimal combustion conditions for odors absorbed mangosteen charcoal production by using a small-scale biomass furnace. The qualities after processing were evaluated, such as physical property and iodine number, followed by Thai Community Product Standard (TCPS) [6].

II. Experimental

A. Raw Material

Fresh mangosteens in the diameters of 5 – 6 cm from Rayong Province, Thailand were shade – dried until the final moisture of 20% wet-basis before drying in the small-scale furnace. The wood from mangosteen tree in Rayong Province, Thailand was prepared in cylinder shape (7.8 x 12 cm) and used as a fuel in this experiment.

B. Experimental equipment

The schematic diagram of a batch small-scale furnace used in the present study showed in Fig. 1. The small-scale furnace used in this study, shown in Fig. 1 was rectangular in shape and had two functional sections: the heating chamber and drying chamber (with two compartments). The heating chamber had rectangular shape (638 x 523 x 164 mm) and air supply to by conventional air flow through pipes. The fuel compartment was within the combustion chamber, constructed of mild steel and fire brick. The heating chamber was separated from the drying chamber by a metal plate through which absorbed heat from the heating chamber was transferred to the drying chamber, (400 x 400 x 513 mm) by conduction. The drying chamber was constructed of mild steel plate and fire brick, and partitioned into two layers. Both layers had a rectangular mild steel tray for drying (Fig. 1). The inlet 1 in Fig.1 were used to control the airflow rate into fuel chamber whereas the inlet values 2 were used to control the airflow rate into drying chamber. The outlet value was at the top of furnace, was controlled by butterfly value. The temperature inside the chamber was measured by

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thermocouple type K, recorded by data logger ± 0.1ºC. The moisture content required after drying was approximately 8%wet-basis, as recommended by Thai Community Product Standard (TPCPS 180/2003). The percentage of air flow in this study was measured by adjusting the angle of ball value and butterfly value.

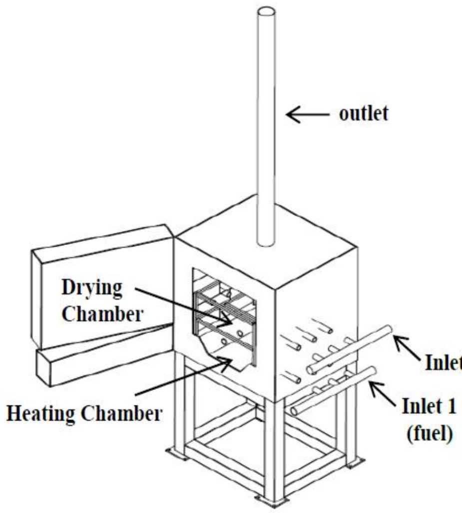

Fig. 1 A schematic diagram of a batch small-scale furnace.

C. Experimental setup

TABLE I
THE PERCENTAGE OF AIR FLOW TO SUPPORT COMBUSTION IN THE INITIAL TEST

Conditions	Percentage of air flow (%)		
	Inlet 1	Inlet 2	Outlet
A1	100	0	100
A2	50	0	100
A3	25	0	100
A4	100	0	50
A5	50	0	50
A6	25	0	50
A7	100	0	25
A8	50	0	25
A9	25	0	25

Samples of fresh mangosteen from Rayong Province were sundried adequately to reduce moisture content to about 20% dry basis before processing of odors absorbed durian charcoal. The 3 kg of wood was measured on a Trade Mark model TAN1, (15 kg ± 0.1 kg) and used as a fuel. The measured fuel consumption was introduced into the heating chamber and fired until the final moisture of the samples (4%wet-basis). The air supply to support combustion was evaluated into two parts. The initial measurement conditions were followed by Table I.

The result showed that the recommended condition from the Table I was A1. According that, the measurement in the second part was set up as the following in Table II:

TABLE II
THE PERCENTAGE OF AIR FLOW TO SUPPORT COMBUSTION IN THE FINAL TEST

Conditions	Percentage of air flow (%)		
	Inlet 1	Inlet 2	Outlet
B1	100	0	100
B2	100	100	100
B3	100	50	100
B4	100	25	100

Heat transfer from the heating compartment to the drying chamber was by conduction and radiation. Convective heat transfer within the combustion chamber was minimal and has no significant practical effect on heat transfer, thus it was assumed negligible. The drying chamber was insulated by a 119 mm fire brick in between inner wall and the outer casing to prevent heat loss. Three trial replication tests were performed for each sample and the average recorded. The time taken for each sample to produce completely was recorded against temperature rise in the drying chamber. Moisture content analysis was measured following by AOAC (2005) method. The sample was dried by Memmert hot air oven model UFE400 at the temperature of 70ºC for 72 hours.

D. Iodine Number Measurement

The iodine number of the odors absorbed mangosteen charcoal was measured according to ASTM D4607-94 (1999) [7]: (1) Transfer 0.5 g mangosteen charcoal to a clean, dry 250-ml Erlenmeyer flask equipped with a ground glass stopper. (2) Pipet 10 ml of 5 wt% hydrochloric acid solution into each flask containing durian charcoal. (3) Stopper each flask and swirl gently until the carbon is completely wetted. (4) Loosen the stoppers to vent the flasks, place on a hot plate in a fume hood, and bring the contents to a boil. Allow to boil gently for 30 ± 2 s to remove any sulfur which may interfere with the test results. (5) Remove the flasks from the hot plate and cool to room temperature. (6) Pipet 100 ml of 0.1 N iodine solution into each flask. Immediately stopper the flasks, and shake the contents vigorously for 30 ± 1 s. (7) Quickly filter each mixture by gravity through one sheet of folded filter paper (Whatman No. 2 V or equivalent) into a beaker. For each filtrate, use the first 20–30 ml to rinse a pipet. Discard the rinse portions. Use clean beakers to collect the remaining filtrates. (8) Mix each filtrate by swirling the beaker and pipet 50 ml of each filtrate into a clean 250-ml Erlenmeyer flask. (9) Titrate each filtrate with standardized 0.1 N sodium thiosulfate solution until the solution is a pale yellow. Add 2 ml of the starch indicator solution and continue the titration with sodium thiosulfate until one drop produces a colorless solution. (10) Record the volume of sodium thiosulfate used for determination of the amount of iodine adsorbed on to the carbon (mg/g).

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E. Moisture Analysis

Moisture analysis in this study was followed by ASTM D 2867-70. Put the grinded sample into a pre-dried tared weighting moisture can with lid, closed and weighted at once to the nearest 0.5 mg. The depth of the charcoal in the container must not excessed 1.25 cm. Removed the lid and placed the container and lid in a pre-heated forced circulation oven (at 150°C). Closed the oven and then dried for 3 hours. Opened the oven and closed the container quickly. Cooled in a desiccator to ambient temperature and weighted. The percentage of moisture content in dry-basis (M_d) was calculated in the following equation:

$$M_d(\%) = \frac{(w-d)}{d} \times 100$$

(1)

where

w = mass of original sample in gram, g

d = mass of dried sample in gram, g

III. Results And Discussions

A. Effect of air supply on physical change in odors absorbed mangosteen charcoal production

Table I showed the percentage of air supply to support combustion in the small-scale furnace at the initial test. The results showed that the volume of air supply affected on change of physical in odors absorbed mangosteen charcoal as shown in Table III.

The physical of conditions A4 to A9 were not completely changed to charcoal after processing whereas A1 to A3 were changed. The results illustrated that the suitable volume of air flow at the outlet was 100% as shown in Table III (A1, A2 and A3). The decreasing of air volume at the inlet 1 affected on change of drying time. The drying times of A1, A2 and A3 were 146 min, 175 min and 204 min, respectively. However, the physical of A1 after processing was similar to the fresh mangosteen than A2 and A3. Therefore, the recommended condition at the initial test was A1.

Regarding to A1, the adjustment of air volume at inlet 2 was set up as shown in Table II. The drying times decreased when the air volume at inlet 2 increased. The physical of B2 and B4 was deformed. The maximum drying temperatures were average in the rage of 270°C - 314°C as shown in Fig. 2. The characteristics of the charcoals depend not only on the starting materials, but also on the carbonization system [8]. The heteroatoms, especially oxygen, had effect on the adsorbent-adsorbate interactions and the resulting adsorptive properties [9]. Regarding to that, the air supply to the furnace affected on change of iodine number in A1, A2, A3, B1 and B3 as shown in Fig. 3

TABLE III
PHYSICAL PROPERTY AND DRYING TIME OF TREATED SAMPLES AT THE INITIAL TEST

Conditions	Physical Property	Drying time (min)
A1		146
A2		175
A3		204
A4		N/A
A5		N/A
A6		N/A
A7		N/A
A8		N/A
A9		N/A

N/A means not available

TABLE IV
PHYSICAL PROPERTY AND DRYING TIME OF TREATED SAMPLES AT THE FINAL TEST

Conditions	Physical Property	Drying time (min)
B1		146
B2		N/A
B3		115
B4		N/A

N/A means not available

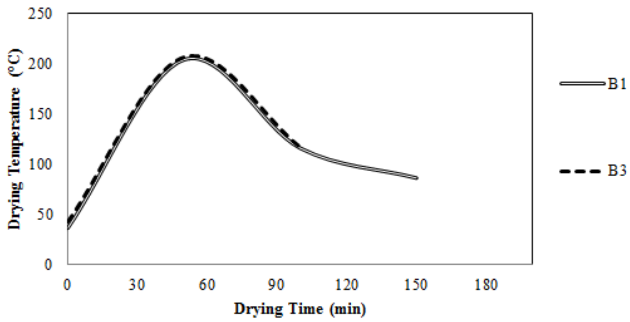

Fig. 2 Change of drying temperature during odors absorbed mangosteen charcoal production

B. *Effect of air supply on iodine number*

The iodine number was the mass of iodine in grams that was consumed by 100 grams of a chemical substance. The results in Fig. 3 showed that the iodine numbers of A1, A2, A3, B1 and B3 were 128, 94, 90, 100 and 155 mg/g, respectively. The minimum of iodine number followed by Thai Community Product Standard (TPCPS 180/2003) was 150 mg/g. Therefore, B3 was recommended.

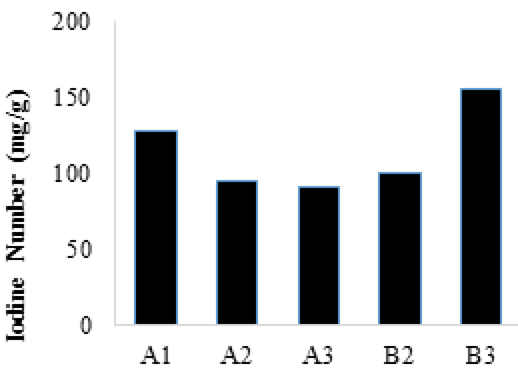

Fig. 3: Iodine number of treated samples

IV. Conclusion

According to the results, the volume of air supply affected on the change of physical property of odors absorbed mangosteen. The volume of air flow at outlet in this study was recommended at 100%. The physical of odors absorbed mangosteen remained in the original shape. The adjusting of air flow volume at inlet 2 affected on the drying time and iodine number. Therefore, the recommendation of odors absorbed mangosteen production in this study was adjusting the air flow volume at inlet 1 100%, inlet 2 50% and outlet 100%. The iodine number and the drying time were 155 mg/g and 115 min, respectively.

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