Lemang cooker optimization

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Abstract. Lemang is popular in Indonesia, especially in western part of Indonesia. A traditional way to cook Lemang is both tedious and hazardous, thus a mechanization of some sort will help in Lemang production. This paper was intended to provide a design a Lemang cooker and its optimization through varying cooking temperature and cooking duration. The combined result of prior researches shows that for the operation of Lemang Cooker, the best setting was for cooking temperature set to 105°C and cooking duration set to be 90 minutes. The best setting will result in the production capacity of 1.44 kg/hr.

1. Introduction
Lemang is Indonesian indigenous cuisine native to Sumatra Island. It was made from gelatinous rice, and a mix of coconut milk and some spice, cooked traditionally inside bamboo stems and a little flame [1]. The process is not complex, but requiring a lot of effort to make sure the heat is spreading evenly throughout the bamboo stems so that the gelatinous rice mix will be cooked evenly. Bamboo stem used in Lemang cooking will also pose a difficulty of its own, since one would need to find the stem of the correct size and thickness of the wall. Lemang is usually enjoyed with another Indonesian cuisine, Rendang, which is also indigenous from Sumatera Island, though there is also a suspicion that Rendang is actually originated from India. Rendang is also enjoyed in any another location with Malay culture [2].

The cooking process of Lemang is also containing some smoke hazard, since the cooker will more likely to be exposed to smoke from the burning charcoal. Smoke is hazardous to human, and prone to cause direct irritation, asphyxiation induced by lack of oxygen and also poisoning by toxin absorption, while thermally, smoke could also causes burn on external and also internal parts of the body [3].

The weaknesses of Lemang cooking process can only be overcame by the use of machinery which replaces the need to turn Lemang every intervals of time and also diminish the exposure to smoke, hence, a need to design such machinery rises. We designed the Lemang cooker using heater element and steel cylinders to replace bamboo stems. In the operation of this Lemang cooker, we also need to measure the mechanical performance, the quality of the product and also economic analysis of the cooker’s operation. The cooker hence would also be optimized in the terms of cooking time and temperature so that the optimum settings can be determined.

This paper is organized into several parts to describe each process that has been undergone to design and optimize the Lemang cooker, the design of the cooker will be described in detail within the Lemang Cooker Design section, the optimization process for cooking temperature will be described in Cooking Temperature Optimization section and the optimization process for cooking duration will be...
described in Cooking Duration Optimization section. The whole result of optimization process will be discussed further in Result and Discussion section, including the comparison of different settings in the terms of product quality.

2. Materials and methods

2.1. Lemang cooker design

The design of Lemang cooker was done and reported by [4]. In construction of Lemang Cooker, Stainless Steel, Glasswool, aluminium, copper wires, screws and bolts were used. The cooker was painted to maintain aesthetics and to preserve exteriors of the cooker. The cooker then designed to mimic process of conventional Lemang cooking.

![Figure 1.](image)

(a) Lemang cooker dimensions. (b) Cooking tube dimensions.

The cooker was separated into 2 main parts, reactor and encasing. Basically, the construct of the reactor is a heating element as a core and surrounded by Glasswool to trap heat inside the cooker interior while distributing the heat evenly around the stainless steel encasing. The reactor designed to use three heaters with total of 900 w of power, which is controlled using dial thermostat calibrated to the maximum temperature of 120°C. The radius and height of reactor is 23.5 cm and 31.8 cm, respectively. Dimensions of the cooker can be seen as in Figure 1 (a). Most of the cooker metallic parts were made of stainless steel to ensure Lemang produced using the cooker to be free from rust. The reactor will be able to cook six cylindrical tubes at once which the dimensions of the tubes can be seen on Figure 1 (b).

With 24 cm effective length and 5 cm of diameter, each cooking tube will be able to contain approximately 195.65 g of gelatinous rice, 117.5 ml of coconut milk and 117.5 ml of water. In total, the cooker will be able to cook a total of 1173.9 g of gelatinous rice at a time. Initially, cooking temperature was set to 100°C and cooking duration was set to 90 minutes. The average weight of cooked Lemang was 2.13 kg, thus the cooking capacity was 1.42 kg/hr. Figure 2 displays the actual picture of the cooker.
The quality of Lemang produced using the cooker was then measured using organoleptic test with the scale as seen on Table 1. The parameters measured were colour, shape, flavour, taste and texture, which as a result having average score of 2.9 (like), 3.1 (like), 2.9 (like), 3.3 (like), 3.5 (like), respectively.

Table 1. Hedonic scale of organoleptic test [5].

| Hedonic Scale  | Numeric Scale |
|----------------|---------------|
| Strongly Dislike | 1             |
| Dislike        | 2             |
| Like           | 3             |
| Strongly Like  | 4             |

2.2. Cooking temperature optimization

Grains, rice in particular, is affected by several factors on its qualitative parameters, especially flavour, where the taste itself is a result of interaction between chemical reaction, cooking temperature, concentration, where the rise and decline of cooking temperature will affect mostly in sweet and salty taste [6]. The flavour itself is a result of interaction between type of wrappings and also amount of coconut milk used, when cooked in the right temperature, it will result in a unique flavour [7]. Therefore, an optimization of cooking temperature in Lemang Cooker is needed. The research was reported in Sinaga’s work [8] using temperatures of 95°C, 100°C and 105°C which henceforth referred as T1, T2 and T3 respectively, while other settings such as cooking duration and Lemang ingredients were hold on the same value as in Risanta’s work [4].

The quality parameters observed were flavour, taste and texture, using organoleptic test with the same scale as seen on Table 1. The parameters from each levels of temperatures then compared using Duncan Multiple Range Test (DMRT) to see how each levels of temperatures performs differently or indifferently.

The results show that in terms of flavour, T1 with average score of 3.03 performs differently than T2, with average score of 3.80 and T3 with average score of 4.03, and there is no difference of performance between T2 and T3. Qualitatively, T2 and T3 were strongly liked, and T1 was liked.

The results show that in terms of taste, T1 with average score of 2.86 performs differently than T2, with average score of 3.66 and T3 with average score of 3.70, and there is no difference of performance between T2 and T3. Qualitatively, T2 and T3 were strongly liked, and T1 was liked.

Lastly, the results show that in terms of texture, T1 with average score of 2.10 performs differently than T2, with average score of 3.96 and T3 with average score of 4.03, and there is no difference of performance between T2 and T3. Qualitatively, T2 and T3 were strongly liked, and T1 was disliked.

The combined organoleptic scores are as seen on Table 2.
Table 2. Average organoleptic scores on variable cooking temperature.

| Temperature  | Flavour   | Taste   | Texture  |
|--------------|-----------|---------|----------|
| T1 (95°C)    | 3.03 a,A  | 2.86 a,A| 2.10 a,A |
| T2 (100°C)   | 3.80 b,B  | 3.66 b,B| 3.96 b,B |
| T3 (105°C)   | 4.03 b,B  | 3.70 b,B| 4.03 b,B |

*a,b : DMRT using 0.05 significance; A, B : DMRT using 0.1 significance

However, since the only change was in the temperature, there is no significant change in effective capacity of the cooker, which was 1.44 kg/hr. It can be concluded that the best result in terms of flavour, taste and texture was T3 which was cooking temperature of 105°C.

2.3. Cooking duration optimization

Based on previous works of [4] and [8], it was concluded that the best cooking temperature was 105°C. Since the cooking duration used was 90 minutes, it was suspected to be suboptimal, since a lesser cooking duration is suspected to be able to increase productivity of the cooker and longer duration is suspected to be able to enhance the qualitative parameters of Lemang produced by the cooker, thus, another research conducted by [9]. In his research, [9] inspects the effect of various cooking duration to qualitative parameters of Lemang produced by the cooker, while keeping temperature settings according to [8]’s work and other settings of the research the same.

Three levels of duration were inspected within the research, 80 minutes, 90 minutes and 100 minutes, respectively referenced as D1, D2 and D3 (originally are T1, T2 and T3 within [9]’s work). To measure the effect of various duration on qualitative parameter an organoleptic test was conducted, based on the same scale with previous researches [5]. Qualitative parameters observed is also identical to [8]’s work, which are flavour, taste and texture. The result of organoleptic test is as can be seen on Table 3.

Table 3. Average organoleptic scores on variable cooking duration.

| Duration   | Flavour | Taste    | Texture   |
|------------|---------|----------|-----------|
| D1 (80 mins) | 3.433   | 3.033 a,A| 3.167 a,A |
| D2 (90 mins) | 3.567 a | 3.500 a,A| 3.400 a,A |
| D3 (100 mins)| 4.033 b | 3.700 b,B| 4.033 b,B |

*a, b : DMRT using 0.05 significance; A, B : DMRT using 0.1 significance

In terms of flavour, the duration of D1 with score of 3.433 and D2 with score of 3.567 are not significantly different, while D3 with score of 4.033 differs significantly with both D1 and D2. Qualitatively, D3 with duration of 100 minutes is strongly liked, while both D1 and D2 were liked.

In terms of taste, the duration of D1 with score of 3.033 and D2 with score of 3.500 are not significantly different, while D3 with score of 3.700 differs significantly with both D1 and D2. Qualitatively, the products of all duration settings do not differ, since all of them fall into the category of liked.

In terms of texture, the duration of D1 with score of 3.167 and D2 with score of 3.400 are not significantly different, while D3 with score of 4.033 differs significantly with both D1 and D2. Qualitatively, D3 with duration of 100 minutes is strongly liked, while both D1 and D2 were liked. In overall, the preferred products are the ones cooked with cooking duration of 100 minutes based on the results of organoleptic test.
3. Results and discussion
A comparison of best results was done between [4,8,9] researches referred as R1, R2 and R3 respectively, as can be seen on Table 4. Each column represents the best result of the research, except in R1, since there is no variation of cooking temperature or duration. In R2, results were taken from cooking temperature T3 while in R3, results were taken from cooking duration D3.

| Qualitative Parameter | Research |
|-----------------------|----------|
|                       | Risanta  (R1) | Sinaga (R2) | Manalu (R3) |
| Flavour               | 2.9      | 4.03   | 4.033   |
| Taste                 | 3.3      | 3.7    | 3.7     |
| Texture               | 3.5      | 4.03   | 4.033   |

Since the research was conducted as a further optimization of the previous research chronologically, it is much more sensible to compare the results using Paired Sample T-Test to see if there is change of means after a modification was done to the Lemang cooker. Thus, the comparison was done between R1 and R2, and also between R2 and R3 since R3 in principle was also a modification of the cooking duration using the best temperature in R2. The results then compared further using Paired Sample T-Test, which can be seen on Table 5.

| Pairs       | 2-tailed | 1-tailed |
|-------------|----------|----------|
| R1 and R2   | 0.02984097 | 0.01492048 |
| R2 and R3   | 0.99040169 | 0.49520085 |

The pairs R1 and R2 p-value shows that there is actually an improvement when different temperature is used in cooking Lemang, which is T3, where the pairs R2 and R3 p-value shows that there is no improvement when various cooking duration was used. Thus, it is recommended to only change the cooking temperature to 105°C and keeping cooking duration as 90 minutes.

4. Conclusions
The combined result of prior researches shows that for the operation of Lemang Cooker, the best setting was for cooking temperature set to 105°C and cooking duration set to be 90 minutes. The best setting will result in the production capacity of 1.44 kg/hr. The research can be explored more in terms of other parameters such as materials of the machine and Lemang recipe used in this machine’s operation.

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