Physicochemical Properties and its Relations of Beef Rendang inside Retort Pouch Packaging in Various Temperature Storage Conditions

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Abstract. Physicochemical characterization for beef Rendang inside retort pouch packaging had been evaluated. The objective of this study was to know the effect of time, and temperature storage to the physical properties of beef Rendang includes interactions between them so it could be evaluated what properties were changed along storage. Commercially sterile beef Rendang products using sterilization process at a pressure of 1.3 bar for 40 minutes holding time with the lethality value (Fo) of 4.67-7.49 minutes were stored at three different temperatures (35, 45, and 55 °C). Moisture content, pH, and rancidity value (TBA) as physicochemical properties examined were observed for 6 weeks of storage. The results showed that the effects of three different temperatures and times storage had significant difference value of moisture content, pH, and TBA value. Moisture content, pH, and TBA value of beef Rendang were approximately in the amount of 38-42%; 5.15 – 5.38; and 0.12 – 0.27 mg malonaldehyde/kg sample respectively, along 6 weeks of storage.

1. Introduction

Rendang is a traditional food from West Sumatera Indonesia with generous amounts of different kinds of spices and ingredients including meat and coconut milk. The dried meat rendang cooking technique could prolong the food’s shelf life and also might be caused by the contribution of the spices used during the cooking process[1]. Rendang usually was packaged in a flexible pouch and sealed uses vacuum processing. In the present study, beef rendang in pouch packaging was sterilized after the
vacuum sealed processing for extending the shelf life of the product [2–4]. During the storage process, the temperature is one of the primary factors that effect in physicochemical properties of products. Lipid oxidation reaction effected in viscosity of oils rancid off flavors while cross-linking of polymers effected in loss of water-holding capacity [5]. The integrated effects of time and temperature on food products affect their color, flavor, and texture commonly referred to as quality.

Commercially sterile retort foods for ready to eat meal had been studied by many researchers such as pepper chicken [6] soy peas curry [7], milkfish [8], tuna in oil [9], black clam product [10], mushroom in brine [11], dairy dessert (kheer) [12], freshwater prawn in curry medium [13], egg-based product [14], Chettinad goat meat product [15], chopped mussel meat [16], and also samgyetang [17]. The effect of retort pouch processing to the physicochemical parameters had also examined by [18,19].

Many researchers were studied especially about physic-chemical properties of meat and retorted foods. Bindu et al. [10] were also studied about TBA value in black clam product in indigenous retort pouches. They found that TBA during the storage period, TBA value tends to increase and it was be expected that it caused by a product used which contained only solids, without a liquid medium. Processing of mushrooms in brine was also studied by Chandrasekar et al. [11], and they found that the pH value of the product was 5.75 and remained unchanged during 12 months storage time. Diaz et al. [18] evaluated the chemical composition, pH, water holding capacity, drip loss, color and texture of the meat of meat from capons and they found that those factors were significantly influenced by the age of the capons. The meat from the youngest animal showed higher pH than the older ones. pH value from muscle tissue in accordance with meat quality was in the range of 5.5-7.4 [20]. Ukekpe et al. [21] were also evaluated TBA value in selected fish harvested from Nigeria, and they reported that the Tilapia and catfishes with the value TBA of 6.60 and 8.00 mgMA/kg respectively have better quality within twelve hours of keeping, than elephant snout, Mud, and butterfishes. Kheer, as a traditional milk product of South East Asia, were examined the product quality such as F0 value, TBA value, reflectance value, and pH by Jha et al. [12]. According to their findings, for the product with F0 value of 12.4-14.8 minutes, the TBA value ranged 0.073-0.081 and the pH value reported were 6.04-6.10. Based on a study which had been reported by Karel [5] the remaining cause of deteriorations of foods stored at room temperature besides the microbial growth were physical changes and chemical reactions. Ma et al. [22] studied the effect of pressure and heat treatment on beef proteins, and they found that the concentration of soluble myofibrillar proteins increased from 0.273 mg/mL to 0.747 mg/mL of the meat proteins. According to Pasha et al. [23] the TBA value of rice polishing was affected (p<0.05) by storage period, the increasing value were reported when the storage period increased from 4 to 16 weeks. Pearson [24] found that most beef can be considered to be acceptable if the total volatile nitrogen (TVN) and TVN/FF (fat-free) figures were not exceeded 16.5 and 19.7 mg N/100g respectively. In his further study [25], peroxide values of most fresh samples were found in the range of 0.0-1.0 mequiv./kg (on the extracted fat). Study about the physicochemical deterioration and lipid oxidation were also done by Rahman et al. [26] which reported that as the increase of the freeze-thaw’s number, pH value of beef muscle affected by freeze-thaw cycles was decreased (p<0.05), free fatty acids value were increased (p<0.05) and TBARS value were also increased (p<0.05) significantly. The increase of TBA value inside the retort-pouched sauces was also reported to
increase during storage according to study had been done by Lee et al. [27], whereas the overall pH reported decreased.

2. Methods

2.1. Materials
Beef Rendang was one of traditional food from Indonesia. Beef meat, coconut milk, and traditional Indonesian spices and herbs were heated together while stirred until they got dried continuously. In this research, beef Rendang was bought from Uni Upik Restaurant in Yogyakarta.

2.2. Preparation of beef Rendang retort pouch
Beef Rendang as the sample of this research then packaged inside retort pouch by weighing preparation which had been developed by previous research [2] through preparing 60 grams of meats and 60 grams of dressing. The size of the pouch was 18 cm x 13 cm. Rendang inside retort pouch then was thermally processed using Zon Gon Horizontal Retort Machine according to sterilization method for flexible packaging which had been registered in Indonesian patent document number of P00201708373. In this research, it was chosen the retort pressure of 1.3 bar hold for 40 minutes to sterilize the samples. When it had sterilized, the samples were quarantine for 2 weeks to assure samples in stable condition achieving commercially sterile. In order to study the reaction rate, samples were stored at three different temperatures inside incubators, which were 35, 45, and 55 °C.

2.3. Commercially sterile measurement in the slowest heating zone
The requirement of a commercially sterile product was stated by US-FDA to accomplish the 12D process [28]. To check the adequacy of the thermal process, Fo meter probe was mounted with the system of the sample and pouch exactly on its slowest heating zone (SHZ). The vessel was then turned on together with the data logger. Fo result then was printed on thermo-paper.

2.4. Physicochemical properties measurements
Physicochemical properties parameters which observed in this study were moisture content, pH, and rancidity value based on TBA (thiobarbituric acid reactive substance). Those three parameters were examined every week for 6 weeks and the initial week was also measured. Moisture content determined gravimetrically; pH value was measured using pH meter brand Eutech PC 700, Thermo Scientific, II, USA; whether the TBA value was derived using a spectrophotometer and Tarladgis’s method [29].

2.5. Statistical Analysis
Value of moisture content, pH, and TBA was evaluated statistically using SPSS 16.0 version. Univariate Analysis of Variance test was used in this study, accompanied by Duncan Multiple Range Test for Post-Hoc when the value was significantly different.

3. Result and Discussions

3.1. Fo value of Beef Rendang
According to the previous study which had been registered in the patent document mentioned above, sterilization process using a pressure of 1.3 bar for 40 minutes holding time was chosen for the thermal process of flexible package pouch, especially for beef Rendang. The sterilization Fo value was found
approximately in the range of 4.225-8.795 minutes; the value was varied sometimes in large value range according to quality control or might be caused by different scenarios occurs along the process. Fo value was insufficient to an amount close to 2.54 minutes as the requirement of 12D thermally processes for low acid food to reach commercially sterile product by the thermal death time of \textit{Clostridium botulinum} [28].

3.2. \textit{Statistical analysis for moisture content, pH, and TBA value}

To study the behavior of each parameter and interactions between them, the univariate analysis of variance study for moisture content, pH, and TBA value was displayed in Table 1.

| Properties Factors | Sig. (Moisture content) | Sig. (pH value) | Sig. (TBA value) |
|--------------------|------------------------|----------------|-----------------|
| Temperature storage| *                      |                | 0.011*          |
| Time storage       | *                      | *              | 0.04*           |
| Temperature*Time storage | *                  | *              | 0.825 ns        |

(*') differ significantly, (ns) not significant
(Significance level used: 0.05)

Post-Hoc test for each factor was displayed in Table 2, 3, and 4 and explained below in sections.

| Time storage (weeks) | Moisture content (%) | Temperature storage (°C) | Moisture content (%) |
|---------------------|----------------------|--------------------------|----------------------|
| 1                   | 39.116±0.923a        | 35                       | 39.798±1.104a        |
| 2                   | 40.335±0.973bc       |                          |                      |
| 3                   | 40.237±0.920b        | 45                       | 40.251±0.741b        |
| 4                   | 40.946±0.851b        |                          |                      |
| 5                   | 39.951±0.642b        | 55                       | 40.648±1.156c        |
| 6                   | 40.807±1.086cd       |                          |                      |

*Same column having similar superscript did not differ significantly
(Significance level used: 0.05)

| Time storage (weeks) | pH value | Temperature storage (°C) | pH value |
|---------------------|----------|--------------------------|----------|
| 1                   | 5.303±0.017d | 35                       | 5.331±0.029c |
| 2                   | 5.312±0.046d |                          |          |
| 3                   | 5.279±0.040bc | 45                       | 5.282±0.028b |
| 4                   | 5.290±0.050c |                          |          |
| 5                   | 5.226±0.060a | 55                       | 5.230±0.052a |
| 6                   | 5.276±0.073b |                          |          |

*Same column having similar superscript did not differ significantly
(Significance level used: 0.05)
Table 4. TBA value in various time and temperature storages

| Time storage (weeks) | TBA value (mg malonaldehyde/kg sample) | Temperature storage (°C) | TBA value     |
|----------------------|----------------------------------------|--------------------------|---------------|
| 1                    | 0.240±0.070\textsuperscript{a}         | 35                       | 0.233±0.071\textsuperscript{a} |
| 2                    | 0.186±0.056\textsuperscript{abc}       | 45                       | 0.172±0.057\textsuperscript{a} |
| 3                    | 0.219±0.098\textsuperscript{bc}        | 45                       | 0.172±0.057\textsuperscript{a} |
| 4                    | 0.201±0.060\textsuperscript{abc}       | 55                       | 0.176±0.068\textsuperscript{b} |
| 5                    | 0.145±0.044\textsuperscript{a}         | 55                       |               |
| 6                    | 0.172±0.049\textsuperscript{ab}        | 55                       |               |

*Same column having similar superscript did not differ significantly (Significance level used: 0.05)

3.3. Moisture content

Freshly beef Rendang in this research was in the amount of 39% (wb). Changes in moisture content were shown in Figure 1 compared with the initial condition. It could be seen that the moisture content was decreased as the sterilization effect, but during storage time the values were increased.

![Figure 1. Moisture content during storage](image)

According to a statistic test, it showed that the probability was <0.05. It can be concluded that the three temperature storage had significant difference value of moisture content. The higher temperature storage, moisture content value tends to increase. For storage, the time parameter could be seen that the probability value was <0.05. The different time of storage gave a different value of moisture content, significantly. Moisture content value of the first week was the lowest of all. In the interaction test between temperature and time of storage, the probability was <0.05, means that those many interactions gave significant different moisture content value.

3.4. pH value

Statistic test for pH value showed that the probability was <0.05. It can be concluded that the three times storage had significant difference value of pH value. The longer storage time pH value tends to
decrease. For storage, the temperature parameter could be seen that the probability value was <0.05. The different temperature of storage gave a different value of pH, significantly. The higher temperature storage, pH value tends to decrease. In the interaction test between temperature and time of storage, the probability was >0.05; it means that those many interactions gave significant different pH value.

From Figure 2 above, it is shown that the pH value a ranged between 5.15-5.38 during 6 weeks of storage. Those results were in line with a study from Methayasa [30] which found that the pH value of Bali Beef and Wagyu Beef were in the range between 5.41-5.85. It also had a similar result which was specifically mentioned also by Weglarz that meat obtained from cows had pH values above 5.8 [31]. According to G. Feiner, pH values of meat and meat product were generally between 4.6 (raw fermented salami) and 6.4 [32].

3.5. TBA value
In this research, thiobarbituric acid (TBA) was used to measure rancid level from week to week using Tarladgis equation [29] and to investigate the effect of storage temperature of Rendang. Figure 3 shows the rancidity value of ready-to-eat Rendang in flexible retort pouch during storage time.

According to a statistic test, it showed that the probability was 0.011 (<0.05). It can be concluded that the three-temperature storage had significant difference value of TBA. The higher the temperature, the lower the TBA value will be. For storage, time parameter could be seen that the probability value was 0.04 (<0.05). The different time of storage gave a different value of TBA, significantly. The more time it stored, TBA value tends to decrease. In the interaction test between temperature and time of storage, the probability was 0.825 (>0.05). It means that those many interactions did not give significant different TBA value. Meat products contain the high level of unsaturated fatty acids which can easily become rancid over time in storage due to lipid oxidation reaction [5,33].

Figure 2. pH value during storage
From Figure 3, we could see that TBA value has fluctuated. One of the reason had been stated before that the red color formed in TBA test might also be part of the reaction from the reagent with other aldehydes which formed by the breakdown of the non-fat components in food, and this may interfere with the result [34]. When TBA test been done, all samples were centrifuged together but their red colors were not read at one time. The lag time of reading between samples made the visually intensities red color changed, different from the sample which read at the same time. According to the result studied by [34], the TBA result values of beef meat ranged between 0.1 to 2.2 depending on the storage condition. For spoiled beef, TBA amount was 1.8 according to the study reported by [24]. In this research TBA values varied from 0.12-0.27, close to those value reported by [34].

4. Conclusions

Temperature difference gave significant difference moisture content. The higher the temperature, moisture content tends to increase. Different time storage gave significant different moisture content. The longer storage time, the higher moisture content will be. The interaction between temperature and time storage was significantly different. Moisture content values for Beef Rendang was approximately in the amount of 38-42%.

Different time storage gave a significant difference in pH value. The longer storage times, pH value tends to decrease. The different temperature of storage gave significant different pH value. The higher temperature storage, the lower pH value. The interaction between time and temperature storage to pH value was significantly different, pH values for Beef Rendang were approximately in the amount of 5.15-5.38.

The three temperatures storage gave significant difference value of TBA (sig. 0.011). The higher the temperature, the lower the TBA value will be. Different storage time gave significant different TBA value (sig. 0.04). The longer it stored, TBA value tends to decrease. The interaction between temperature and time to the value of TBA had no significant difference (sig. 0.825). TBA values for Beef Rendang were approximately in the amount of 0.12-0.27 mg malonaldehyde/kg sample.
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