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Case Report

Utilization of a Pressure Cooker for Homemade High-Temperature Sterilization of Rendang

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Abstract: This study aimed to analyze the impact of pressure cooker (presto) sterilization on the nutritional value and microbial content of rendang, a traditional Indonesian meat dish. The evaluated parameters included moisture content, ash content, fat content, protein content, and total plate count (TPC), measured before and after a 40-minute sterilization process. The results showed a moderate increase in moisture (from 32.66-37.67%) and fat content (from 29.86-32.01%), with slight decreases in ash (from 3.47-3.30%) and protein content (from 35.01-33.05%). The TPC was significantly reduced from 1.1×10^{8}-6.7×10^{4} CFU/g, indicating a 4-log reduction, which demonstrated the potential of pressure-cooking to lower microbial loads. Although the calculated F_0 value was only 0.17 that indicated well below the recommended threshold of 3 for commercial sterilization, no substantial degradation of nutritional quality was observed. Preliminary results indicated a possible presence of Clostridium botulinum in the sterilized samples; however, this finding required further verification through more specific microbial testing. These findings highlighted the practicality of pressure cooker sterilization as a low-cost and accessible method for small-scale or home-based food industries to improve product safety and extend shelf life. Nonetheless, further optimization, particularly in increasing sterilization duration and ensuring proper thermal processing, is necessary. Additional validation studies were recommended to confirm pathogen inactivation and to establish reliable safety standards for wider application.

Keywords: F0 Value, Pressure Cooker, Rendang, Sterilization

Introduction

Rendang is a traditional dish from Minangkabau, West Sumatra. Rendang is one of the most popular foods in the world. It was ranked as the world's most delicious food by CNN in 2011 and 2017 and was officially designated as one of Indonesia's national dishes by the Ministry of Tourism in 2018 (Maryetti *et al.*, 2011) Rendang is a processed food product made from meat, coconut milk, ground chili, galangal, garlic, lime leaves, shallots, lemongrass, turmeric leaves and spices (Gusnita, 2019). In recent years, there has been a notable rise in consumer demand for ready-to-eat rendang products that offer both practicality and convenience. Ready-to-eat foods, particularly those based on meat, have been extensively developed, featuring diverse nutritional profiles, ingredient compositions, and sensory attributes. However, meat products are highly susceptible to spoilage due to contamination by pathogenic bacteria such as *Listeria monocytogenes*, *Escherichia coli*, *Clostridium botulinum*, and *Salmonella* spp., which presents a significant challenge in the commercialization and market distribution of these products (Dharma, 2023). To ensure product safety and extend shelf life, the growth and presence of such microorganisms must be effectively controlled—one of the key methods being thermal sterilization (Ayeni *et al.*, 2022).

Sterilization is a key step in the food processing process that aims to ensure the product is safe for consumption and has a long shelf life. On a household scale, this high temperature and pressure is achieved using a pressure steamer, namely a pressure cooker with a temperature of 115-120°C and a pressure of 1 to 2

atmospheres (Sya'bani & Musyono, 2024). The sterilization degree was represented as an F value. The f value depends on the temperature of the process and the Z value (Temperature changer). Z value is connected with the resistance of microbes and their spores to heat. Microbial heat resistance is expressed as Thermal Death Time (TDT). TDT at 121^{o}C is used as a sterility reference and is expressed as F0 (Nurhikmat *et al.*, 2016).

Using a pressure cooker for home food sterilization is an effective method of preserving food by utilizing high temperature and pressure to kill harmful microorganisms, including pathogenic bacteria and spores. In this process, the concept of F_0 value—which represents the sterilization time equivalent to heating at 121°C is an important factor in determining the appropriate processing duration to ensure food safety without damaging food quality. The F_0 value is usually adjusted according to the type of food and the size of the packaging, where foods with high viscosity or in large containers require more time for the heat to penetrate the core of the product. By controlling the pressure and heating time in the pressure cooker according to the F_0 principle, home business owners can produce sterile food products that last a long time without preservatives, ensuring safe consumption while maintaining taste and nutrition. However, there is limited information regarding the F0 value for the utilization of pressure cookers for the homemade sterilization process. In this study, rendang was used as the research object since it needed to be sterilized before distribution. Rendang is known as long self-life food product.

Material and Methods

Material

Samples of packaged rendang were obtained from one of the local rendang production in Padang city. The experiment was conducted at the biochemical chemistry and agricultural products laboratory, microbiology laboratory, and faculty of agricultural technology andalas University, Padang.

Sterilization with Pressure Cooker

The sterilization process of rendang using a pressure cooker refers to the method commonly practiced by a local rendang producer in Padang, which involves a 40-minute sterilization period counted from the moment the pressure cooker begins to emit its characteristic sound. The procedure is as follows: the rendang, already packed in retort pouches, is inserted with a data logger to record temperature data throughout the sterilization process, with the tip of the data logger positioned inside the meat. After the packaging is sealed, the rendang pouches are placed and arranged inside the pressure cooker, which is then tightly closed. The stove is turned on and sterilization is carried out for 40 min, starting from the sound produced by the pressure cooker.

Moisture Content

The aluminum cup was cleaned of dirt and then dried in the oven for 30 min at 105^{o}C. Then, the cup was cooled in a desiccator for 15 min and the weight of the cup was weighed (W0). The sample is put into the cup as much as 3-5 g (W1). Then put the cup that contains the sample into the oven at 105^{o}C for 3-4 hours. Next, the cup was cooled in a desiccator for 30 min and then weighed. Reheated in the oven for 1 hour and weighed again until a constant weight is obtained (W2) (Wellyalina *et al.*, 2023):

$$\% \ MC = (W1 - (W2 - W0)) \ / W1 \times 100\%$$

Ash Content

The porcelain cup was dried in a furnace for 15 min, then cooled in a desiccator and weighed (W0). The sample was weighed as much as 5 g (W1) then put into the cup and burned on a hot plate until it did not smoke anymore, then put into the furnace until gray or white ash was obtained or until it reached a fixed weight. After the furnace, the cup was cooled in a desiccator and weighed (W2) (Syukri *et al.*, 2022):

$$\% \ AC = ((W2 - W0)) \ / \ ((W1 - W0)) \times 100\%$$

Fat Content

The fat flask was oven to 105^{o}C for 30 min, then cooled in a desiccator and weighed, then added hexane solvent as much as the capacity of the fat flask. Samples weighed as much as 3 g (W1) then wrapped using a thimble or filter paper are inserted into the soxhlet extraction tool. Furthermore, the condenser is installed above, and the fat flask is below. The tool is heated for 4 h or 15 times circulation. After that, the thimble is removed and the solvent is evaporated and collected. The fact that still contains a little solvent is put into a 100^{o}C oven until all the solvent evaporates, cooled in a desiccator for 30 min, and weighed (W2) (Wellyalina *et al.*, 2023):

$$\% \ Fat \ Content = W2/W1 \times 100\%$$

Protein Content

Protein content testing using the kjedahl method. The kjedahl method consists of three stages, namely dextruction, distillation, and titration. In the deconstruction stage, as much as 0.5 g of sample is put into the kjedahl flask, 1 g of selenium mix and 15 mL of concentrated H2SO4 are added. Then the kjedahl flask is installed in the deconstruction device and heated for 3 hours or until the mixture becomes clear and then cooled. Then the solution was transferred to a 100 mL volumetric flask and diluted with distilled water until the limit mark.

At the distillation stage, as much as 10 mL of the deconstruction solution was pipetted and put into a kjedahl flask that had been cleaned. Then 30 mL of 50% NaOH. The kjedahl flask is mounted on a distillation device and the distillate is collected in 10 mL of 3% boric acid solution and 3 drops of methyl red: methyl blue mixture indicator (3: 1). The tip of the distillation device must be submerged in boric acid solution. The distillation process lasts about 15 min or until the boric acid solution turns green. In the final stage of titration, the distilled solution is titrated with 0.02N HCL until the color of the solution changes from green to purplish red (Wellyalina *et al.*, 2023):

$$\%\,N = ((ml\,HCL\,Sample - ml\,HCL\,blanko) \times N\,HCL \times Fp \times 14,007)/(mg\,sample) \times 100\%$$

$$\%\ Protein = \%N \times Faktor\,covers\,protein\ (6,25)$$

Total Plate Count

Calculation of total plate numbers was carried out according to the Fardiaz method (Syukri *et al.*, 2024). In principle, the sample was diluted and then put into a petri dish aseptically. After leveling, the plates were incubated at 300C in an inverted position upside down for 48 h.

Evaluation of Clostridium Botulinum

A total of 37.54 g of Reinforced Clostridial Medium (RCM) was weighed and dissolved in 240 mL of distilled water. Additionally, 45 mL of physiological saline solution was placed into a glass tube and covered with cotton and aluminum foil. Another 9 mL of physiological saline solution was dispensed into a test tube and similarly sealed with cotton and aluminum foil. Petri dishes were also prepared. All materials were then sterilized using an autoclave. Next, 5 g of the sample was weighed and transferred into the glass tube containing 45 mL of sterilized physiological saline solution, followed by vortexing to ensure homogeneity. From this mixture, 1 mL was taken and transferred into a test tube containing 9 mL of sterilized physiological saline solution, then vortexed. This serial dilution process was repeated until a 10^{-3} dilution was achieved. At the final dilution, 1 mL of the solution was transferred into a sterile Petri dish, followed by the addition of a sterile medium. The Petri dish was gently swirled in a figure-eight motion to evenly distribute the contents, then wrapped with plastic film and incubated at 30°C for 7 days (Gessler & Böhnel, 2006).

Organoleptic Test

Organoleptic testing was carried out on color, flavor, texture, appearance, and taste. The samples that have been coded are randomly tested by semi-trained panelists. The tests are carried out sensory (organoleptic) which is determined based on a hedonic scale of 1-5 on color, flavor, texture, appearance, and taste. Scale number 5 indicated very like and scale number 1 indicated dislike (Ruiz-Capillas & Herrero, 2021; Syukri *et al.*, 2024; Rini *et al.*, 2024). The data were statistically analyzed using Analysis of Variance (ANOVA)

Results and Discussion

Samples of packaged rendang before and after sterilization using a pressure cooker were tested for nutritional value. The test results can be seen in Figure (1). Based on Figure (1), the water content of rendang obtained before sterilization was 32.66% and after sterilization, it was 37.67%. This value is in accordance with the quality standards in the Indonesia National Standard (SNI) the maximum water content for meat rendang is 57%.

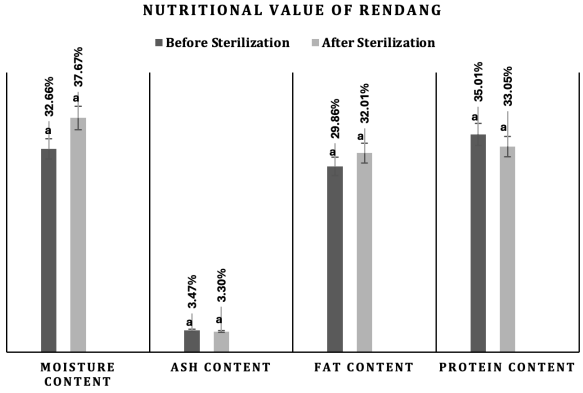

Fig. 1: Nutritional value of Rendang before and after sterilization using a pressure cooker

The increase in moisture content after sterilization is due to the increase in temperature in the product during sterilization. The relative humidity of the surrounding air (Ganogpichayagrai & Suksaard, 2020) influences the moisture content of a product. This is in line with the opinion of Arpah (Zielińska *et al.*, 2020), which states that food ingredients before and after processing are hygroscopic, which can absorb water from the surrounding air and vice versa, releasing some of the water they contain into the air.

Based on Figure (1), the ash content of rendang obtained before sterilization was 3.47% and after sterilization, it was 3.30%. This value is in accordance with the quality standards in SNI; the maximum ash content for meat rendang is 5%(Ganogpichayagrai & Suksaard, 2020). The determination of ash content is related to the mineral content in a material. The amount and type of minerals or ash contained in the material are influenced by the type of material itself and the method of ignition used. When a material undergoes a combustion process, the organic components are burned off, while the inorganic components remain as ash. Thus, ash is the residue that results from the complete combustion of a material in a furnace. In general, about 96 percent of the composition of foodstuffs consists of organic components and water, while the rest are mineral elements (Syukri *et al.*, 2023).

Based on Figure (1), the fat content obtained before sterilization was 29.86%, and after sterilization was 32.01%. Fat content after sterilization increased because, during the sterilization process, the rendang underwent re-cooking. This situation caused oil absorption into the meat, which caused the fat content of the meat to increase; the cooking process will evaporate water and then be replaced by the oil used, causing fat to increase. High temperatures and long cooking times can also be the result of heat transfer that occurs during cooking. The heat transfer results in the mass transfer of oil into the sample and meat water in the form of water vapor that moves from the sample to the surface of the sample (Fiana *et al.*, 2024).

Based on Figure (1), the protein content obtained before sterilization was 35.01%, and after sterilization was 33.05%. This figure is in accordance with the quality standards in SNI; the protein standard for meat rendang is a minimum of 16%. The low protein content in rendang after sterilization is related to microbial growth because microbes require nutrients such as protein for growth. Proteolytic bacteria will hydrolyze the protein in rendang. Bacteria can break down complex molecules and organic substances such as polysaccharides, fats, and proteins into simpler units. This initial breakdown can occur due to the excretion of extracellular enzymes that are closely related to the process of food decay (Syukri *et al.*, 2023).

Figure (2) shows that after sterilization using a pressure cooker, the microbes contained in the rendang packaging decreased by 4-Log from the total microbes before sterilization of $1.1x10^9$ to $6.7x10^4$ after sterilization.

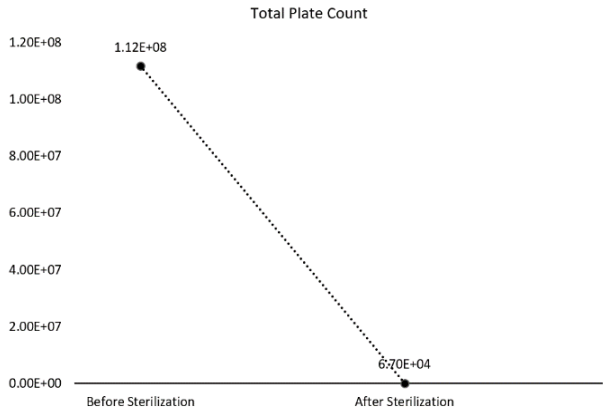

Fig. 2: Total plate count of rending

These results are in line with the purpose of the sterilization process, which is a process that aims to destroy all microbes and their spores. A sterilization degree is achieved when the coolest part of the product receives sufficient heat to kill the microbes. Sterilization degrees are generally expressed in terms of the F value, which is the time in minutes at 121°C required to kill microbes. This F value is influenced by the process temperature and the Z value, which is the change in temperature that causes a 1 log or 10^n decrease in the number of microbes (Nurhikmat *et al.*, 2016).

Although Figure (3) shows a significant reduction in the microbial count after sterilization, indicating that the process effectively decreased the total plate count and improved microbiological safety, the testing for Clostridium botulinum in rendang packaging revealed the presence of these microbes both before and after sterilization. The results are presented in Figure (4). These findings suggest that sterilization using a pressure cooker is not sufficient to eliminate Clostridium botulinum spores.

The sterilization process is designed to kill all thermophile microbes capable of forming spores. *Clostridium botulinum*, in both its vegetative and spore forms, is heat resistant. The vegetative form is more easily destroyed using moist heat at temperatures below 100°C, while the spores tend to be more resistant to heat treatment. Standard sterilization should be performed at 121°C for 3 minutes and is commonly referred to as F0 3 or botulinum cook[20].

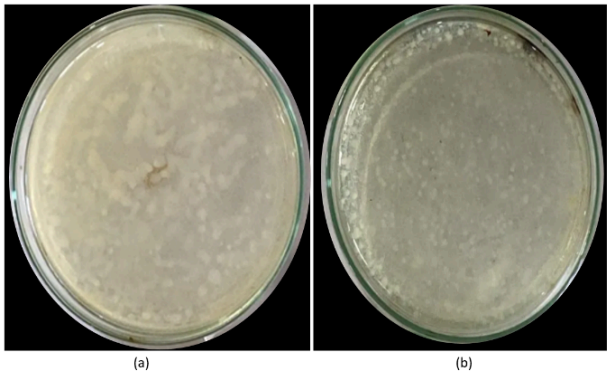

Fig. 3: (a) Total Plate Count Before Sterilization, (b) Total Plate Count After Sterilization

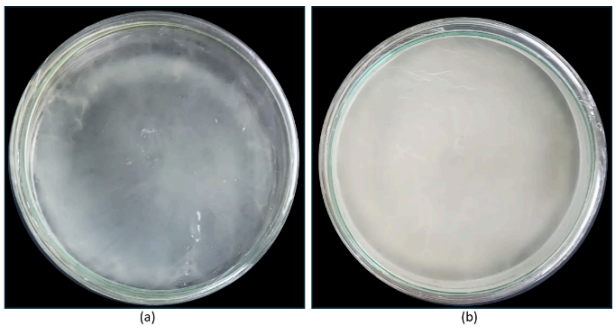

Fig. 4: Clostridium Test on Rendang (a) Before Sterilization, (b) After Sterilization

After calculating the value of the heat adequacy number, the F0 value of 0.17 was obtained, which did not meet the standard for the heat adequacy number of 3. The temperature during sterilization can be seen in Figure (5).

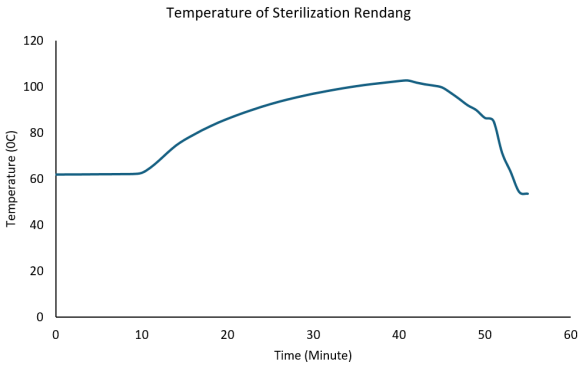

Fig. 5: Temperature of sterilization rendang using pressure cooker

The adequacy of the sterilization process is assessed based on the F_0 value, a parameter that represents the cumulative lethal effect of heat on microorganisms during thermal processing. The F_0 value is calculated from the relationship between time, temperature, and lethality rate. To ensure the inactivation of *Clostridium botulinum*, a pathogenic microorganism known for its high heat resistance, treatment at 121.1°C for 0.21 min is required, with a Z-value of 10°C. This Z-value indicates that a temperature change of ±10°C alters the time required to achieve an equivalent lethal effect. Thus, the minimum adequate F_0 value to ensure safety is approximately 2.52 min (Heshmati *et al.*, 2013).

In sterilization processes using a pressure cooker for 40 min, where the time is measured starting from the audible sound of the appliance (indicating that a certain pressure and temperature have been reached), the resulting F_0 value does not yet meet the required standards. A suboptimal F_0 value implies the potential presence of pathogenic microorganisms, including *C. botulinum* spores, which can survive under insufficient heat treatment. Consequently, this poses a significant risk of microbial contamination, and botulism and compromises food safety. Therefore, strict control over the parameters of temperature, time, and pressure during the sterilization process is essential to ensure the appropriate level of lethality and the overall safety of the final product. The adequacy of the sterilization process using a pressure cooker can be achieved by extending the sterilization time. According to research by Surur (2023), adequate sterilization using a pressure cooker for chicken rending can be achieved through 80 minutes of processing (Surur *et al.*, 2023)

Similarly, a previous study found that sterilization adequacy can be reached with 83 min of processing (Lubis *et al.*, 2024).

Based on organoleptic tests on rendang before and after sterilization in terms of texture, aroma, and taste, panelists preferred rendang after sterilization. In terms of color and appearance, panelists preferred rendang before sterilization. The spider web of rendang before and after sterilization can be seen in Figure (6). Panelists preferred the texture, taste, and aroma of the sterilized rendang samples because sterilization using presto helps soften the texture of the meat. This is because, during sterilization, presto rendang is cooked at high temperature and pressure. When the temperature of the water in the presto gets higher, more water vapor is produced and the vapor pressure becomes higher (Nurhikmat *et al.*, 2016).

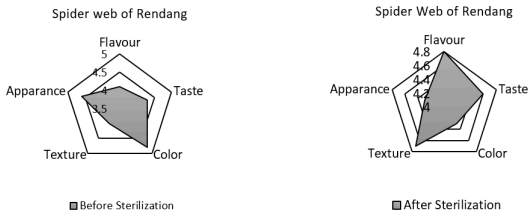

Fig. 6: Organoleptic test on rendang

Sterilization is a critical process in ensuring the microbiological safety of products, particularly in the food and pharmaceutical industries. Two common methods include the use of retort (industrial autoclave) and the pressure cooker (presto). Both rely on the principle of steam heating under pressure, typically reaching 121°C at 15 psi, which is sufficient to eliminate microorganisms, including heat-resistant bacterial spores. Retort systems are widely used in industrial settings due to their precise temperature and pressure control, as well as integrated monitoring systems such as thermocouples and data loggers, which allow scientific validation through F_0 values and D-values (Holdsworth & Simpson, 2007). This enables retort sterilization to comply with food safety standards established by agencies such as the FDA and BPOM (Indonesia Standard). In contrast, pressure cookers are more commonly used in household applications or preliminary research settings. While they can reach similar thermal conditions, their limitations in process control and monitoring make accurate scientific validation difficult. The absence of precise recording mechanisms means that sterilization processes using a pressure cooker are less consistent and less reproducible (Gould, 2013). Therefore, although sterilization using a pressure cooker is technically possible, it is only suitable for small-scale applications and is not recommended for commercial production unless supported by additional validation tools such as thermocouples or biological indicators (Rangsantham *et al.*, 2024). From a future perspective, pressure cookers present a promising low-cost alternative for sterilization, particularly for small laboratories, early-stage research, and micro or home-based food businesses. As interest in home-processed and locally packaged foods continues to grow, there is an increasing demand for affordable yet safe sterilization solutions. Future innovation could involve the modification of

pressure cookers to include digital temperature sensors, pressure data loggers, or simple biological indicators to improve process reliability. Additionally, scientific studies may focus on applying thermal kinetic models or temperature simulation techniques within pressure cookers to predict microbial inactivation effectively. This approach aligns with the trend of democratizing food processing technology, extending access to sterilization methods across broader communities, especially in rural areas. With proper training and education in sterilization validation, pressure cookers have the potential to become adaptive and inclusive sterilization tools, empowering small-scale producers and supporting food safety and export potential in small and medium-sized enterprises (Syukri *et al.*, 2024).

Conclusion

Based on the tests and measurements conducted in this study, it can be concluded that the sterilization process using a pressure cooker (presto) was effective in reducing microbial content in packaged rendang, achieving a 4-log reduction in total plate count. Importantly, the nutritional quality of the rendang, as reflected by the relatively stable levels of moisture, fat, protein, and ash, remained largely intact, indicating that the method did not significantly degrade its key nutritional components. However, despite the reduction in microbial load, the process did not meet the thermal lethality requirements typically used to define effective sterilization. The calculated F_0 value of 0.17 was substantially lower than the minimum standard of 3, indicating insufficient heat treatment. Furthermore, although preliminary results suggested the possible presence of Clostridium botulinum in the sterilized samples, this finding requires further verification using more specific microbiological testing methods. Therefore, while pressure cooker sterilization presents a practical and accessible method for microbial reduction in home or small-scale food production, it cannot yet be considered a fully reliable sterilization method for ensuring food safety, particularly in relation to spore-forming pathogens. Further research and process optimization, including extended processing times and thermal validation, are necessary to ensure complete microbial inactivation and compliance with food safety standards.

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Author's Contributions

Daimon Syukri: Conceptualization and wrote the manuscript.

Rini: Research Supervisor and reviewed the manuscript.

Risa Meutia Fiana: Data Curation and Laboratory Administration.

Jonrinaldi: Project Administration.

Ratni Prima Lita: Project Administration.

Quratul Aisyah: Formal analysis.

Hiyang Hidayati Sukma: Experimental Resources.

Yasmin Azzahra: Sampling and laboratory analysis.

Aurelia Amaliyah Tarumiyo: Sampling and laboratory analysis.

Deden Dermawan: Project Administration.

Ethics

The authors declare that there are no ethical issues associated with the conduct or publication of this manuscript.

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