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Implementation of Overpressure-Retort Technology to Extend Shelf Life of Packaged Rendang Products in West Pasaman

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Abstract: *Rendang producers at the Rendang Bu Pit MSME face a short ambient shelf life due to the absence of thermal sterilization, which constrains distribution and undermines product consistency. This community service program aimed to implement overpressure retort sterilization to improve product quality and extend shelf life. Methods included partner engagement, training on retort principles, familiarization with critical parameters, installation and commissioning of the unit, temperature-distribution and heat-penetration tests, and pilot production runs. Implementation yielded actionable process control: sterilization of 250-g beef and clam rendang achieved commercial sterility ($F_o \geq 3$) in compliance with national requirements while preserving pouch integrity through overpressure cooling; the partner also initiated systematic cycle documentation and basic F_o calculations. These outcomes delineate a pathway to extend shelf life toward a six-month target at room temperature, strengthen production readiness, and broaden market access.*
Keywords*: Commercial sterilization; MSME; Rendang; Retort overpressure; West pasaman*

1. INTRODUCTION

The food processing sector is a principal contributor to the micro and small enterprise (MSE) structure in West Sumatra Province, accounting for 41.6% of the 87,884 total enterprises (Diana, 2021). One of the region's flagship products is rendang, widely acknowledged as a hallmark of Minangkabau culinary heritage, with several variants including beef, goat, chicken, lung, and egg rendang (Darmayanti et al., 2017). West Pasaman Regency is known for its distinctive clam rendang, which uses clams as the primary ingredient. The Sasak Ranah Pasisie District in West Pasaman is among the main sources of clams, which occur naturally in estuarine areas (Fitri & Gusnita, 2022). Nevertheless, the number of MSEs producing packaged clam rendang in this area remains low, indicating substantial potential for enterprise development to foster sustainable regional economic growth. Despite this potential, packaged rendang production in West Pasaman continues to face constraints, particularly the lack of sterilization technology, rendering product quality and food safety vulnerable and resulting in a short shelf life. As a meat-based product with a relatively high pH and moisture content sufficient to support microbial growth, rendang is highly susceptible to contamination if not subjected to adequate thermal processing (Frediansyah et al., 2017). Advances in food preservation have highlighted thermal treatments as a practical solution to meet consumer expectations for durable yet high-quality food products (Singh et al., 2018; Setiawan et al., 2025a).

The Rendang Bu Pit MSME produces several variants such as beef rendang, chicken rendang, and its flagship clam rendang. The partner still relies on traditional processing in which, after cooking, the product is immediately packed in standing pouches, without any post-packaging sterilization step. The products were packed in aluminum foil standing pouches immediately after cooking and exhibited a limited ambient shelf life of approximately 7 days, or up to 14 days under refrigerated storage. Potential contamination from the environment, personnel, and equipment elevates the risk of spoilage within days. Monthly production capacity was approximately 80 kg, supported by four workers, with distribution restricted mainly to the local West Pasaman area due to shelf-life constraints. Based on an initial needs assessment conducted through field observation and direct discussion with the partner MSME, several measurable baseline conditions were identified, as summarized in Table 1.

Vol. 6, No. 1 - Januari 2026, Hal. 323-329
DOI: 10.59395/altifani.v6i1.1036

Table 1. Needs analysis based on the partner's existing conditions

Parameter	Baseline Condition
Type of processing	Traditional cooking without post-packaging sterilization
Packaging sytem	Aluminum foil standing pouch
Ambient and refrigerated shelf life	7 and 14 days
Sterilization technology	Not available
Process control (F_o value)	Not measured
Distribution area	Local (West Pasaman and surrounding areas)

The absence of a sterilization step compromises product quality and safety during prolonged storage and distribution, resulting in a short shelf life and, consequently, limited market reach. Proper sterilization is fundamental to the production of meat products that remain safe and stable over prolonged storage periods. Consequently, thermal preservation approaches, particularly canning, must be conducted under rigorously controlled conditions to prevent quality deterioration and ensure food safety (Yang et al., 2022; Syukri et al., 2025). This condition constrains distribution and sales, which are largely confined to West Pasaman and parts of West Sumatra. From a marketing standpoint, the MSME has notable strengths, including attractive packaging design, a Business Identification Number (NIB), halal certification, and active promotion via Instagram and TikTok. In view of these conditions, the community service program aims to implement overpressure retort sterilization to enhance product quality and extend shelf life.

2. METHODS

The partner of this Community Partnership Empowerment Program, the Rendang Bu Pit enterprise, is located in Nagari Sasak, Sasak Ranah Pasisie Sub-district, West Pasaman. The methodology applied in this community service program comprises four principal stages, namely planning, implementation, evaluation, and sustainability.

2.1 Planning Stage

The planning stage involved an initial needs assessment through field observation and direct discussion with the partner MSME to identify production constraints, technological gaps, and site readiness. Baseline conditions, including the absence of sterilization technology, limited shelf life, and restricted distribution capacity, were used to design an appropriate community service intervention based on overpressure retort sterilization. This stage also included program socialization and alignment of partner production capacity with the selected technology.

2.2 Implementation Stage (Technology Transfer and Training)

The implementation stage comprised training and hands-on activities related to overpressure retort sterilization. The partner received theoretical instruction on sterilization principles, followed by installation, commissioning, and trial operation of the retort unit. The effectiveness of the sterilization process was assessed through temperature-distribution and heat-penetration tests using a data logger, and thermal adequacy (F_o) was calculated following the method of Setiawan et al. (2023).

2.3 Evaluation Stage

Evaluation focused on periodic field assessments conducted by the team, monthly real-time shelf-life monitoring to track improvements in product longevity, and the partner's ability to independently operate the sterilization process using an overpressure retort.

2.4 Sustainability Stage

The sustainability stage focused on ensuring the continued application of overpressure retort sterilization after program completion. This was achieved through strengthening partner capacity for independent operation. Periodic communication and limited technical assistance from the community service team were planned to support troubleshooting and to facilitate future regulatory processes, including preparation for BPOM licensing.

The partner's involvement in the community service activities was manifested through several forms of active participation, including:

Vol. 6, No. 1 - Januari 2026, Hal. 323-329
DOI: 10.59395/altifani.v6i1.1036

a. facilitating the provision of a location for the implementation of the entire series of activities
b. allocating time to coordinate and engage in discussions with the implementation team during the process of identifying and determining priority problems
c. fully participating in all planned stages of the activities
d. implementing sterilization technology in the production process, including the use of the provided equipment and maintaining consistency in the application of quality assurance practices
e. regularly providing information regarding business development and challenges encountered during program implementation.

3. RESULTS AND DISCUSSION

The series of community partnership empowerment activities was conducted from May to November 2025 in Nagari Sasak, Sasak Ranah Pasisie Sub-district, West Pasaman. An initial survey indicated that the MSME employs four workers who support production from raw-material preparation through packaging. Current output is approximately 80 kg per month across all product types, with the largest proportion being clam rendang, produced once weekly. The production process includes raw-material preparation, boiling and peeling for clam, followed by washing, spice preparation, and rendang cooking for 6–8 hours. After cooling, products are packaged in aluminum-foil standing pouches and stored under refrigeration until distribution. The principal constraint lies in production: reliance on traditional methods without a sterilization step results in a short shelf life for rendang. The intervention provided by the program team comprised training followed by hands-on implementation of sterilization technology using a retort system.

3.1 Training on Overpressure Retort Sterilization and Calculation of Sterilization Process Parameters

This training focused on introducing the steam–air overpressure retort technology to the partner. Instruction covered sterilization principles comprising three core stages: venting, to remove air and ensure a homogeneous steam environment; holding time at the target sterilization temperature to achieve the required thermal lethality; and cooling, to reduce temperature in a controlled manner. In addition, the overpressure system, by applying counter-pressure is essential to preserve the integrity of flexible packaging, particularly pouches, preventing deformation during cooling. Beyond these fundamentals, participants were introduced to key components, including temperature sensors, pressure gauges, safety valves, and the cooling system. The introduction emphasized the food-safety rationale, especially the prevention of *Clostridium botulinum*, which is the principal objective in sterilizing hermetically sealed low-acid foods (Jimenez et al., 2023). Accordingly, the partner gained an understanding that adoption of retort sterilization can extend product shelf life when integrated into production. Moreover, operators were trained to use a data logger to monitor temperature distribution and heat penetration and to calculate thermal adequacy (F_o) in accordance with BPOM requirements. Following the training sessions, the partner was able to independently operate the retort system during trial production runs under minimal supervision. Thus, the training not only introduced a new technology but also equipped the partner with practical skills to support independent and sustainable application of sterilization in packaged rendang production.

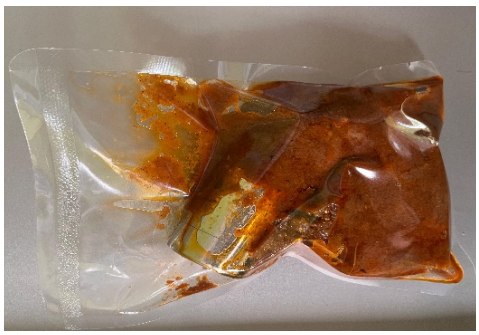
Vol. 6, No. 1 - Januari 2026, Hal. 323-329
DOI: 10.59395/altifani.v6i1.1036

Figure 1. Training on sterilization technology at the MSME partner

3.2 Application of Sterilization Technology to MSME Products

The subsequent stage of the program involved implementing sterilization technology within the partner's production line. The process began with using the retort to measure temperature distribution and heat penetration via a data logger, followed by the corresponding calculations and trial runs using the partner's packaged rendang. These activities generated temperature-distribution and heat-penetration datasets to inform production settings. Differences in heating media can result in variations in the rate of heat transfer during the sterilization process (Zhu et al., 2022). Trial results showed that sterilization of 250-g beef and clam rendang achieved $F_o \geq 3$, thereby meeting BPOM requirements. In accordance with BPOM Regulation No. 27/2021, low-acid foods packed in cans or hermetically sealed flexible pouches intended for ambient storage must undergo commercial sterilization to a minimum lethality equivalent to $F_o \geq 3$ minutes (BPOM, 2021). Beyond its primary goal of extending shelf life, retort processing can also improve nutritional profiles, particularly protein digestibility which may be tailored to specific dietary needs (Lee & Shin, 2023).

Moreover, use of an overpressure retort demonstrated that the flexible pouches remained intact throughout sterilization. This outcome reflects the counter-pressure applied to prevent package damage; deformation typically occurs during cooling and can be mitigated by supplying compressed air during the cooling phase (Mosna & Vignali, 2015). Overpressure retorting is thus well suited to the partner's flexible-pouch format, preventing package failures that would otherwise cause losses. The activity simultaneously transferred technical skills: the partner began operating the retort according to procedures, conducting basic F_o calculations from data-logger traces under supervision, and understanding sterilization parameters to ensure food safety in line with BPOM standards. Theoretically, sterilized rendang can remain stable for up to six months at room temperature; accordingly, the partner is expected to achieve a longer shelf life, enabling broader distribution and marketing and, ultimately, increased revenue. To fully achieve food-safety objectives, sterilization must be complemented by good processed-food production practices through the application of Good Manufacturing Practices (GMP) at all stages (Setiawan et al., 2025b).



Vol. 6, No. 1 - Januari 2026, Hal. 323-329
DOI: 10.59395/altifani.v6i1.1036

Figure 2. Implementation of sterilization technology for MSME products and calculation of the sterilization value.

Overall, the partner's empowerment level before and after the community service program is presented in Table 2.

Table2. Partner empowerment level

Targeted Empowerment Level	Condition Before Program Implementation	Condition After Program Implementation
Improved partner knowledge of sterilization technology (general).	• No sterilization process in place. • Limited knowledge of sterilization technology.	• Sterilization applied in the production process. • Operators able to run the sterilization process in accordance with the procedure.
Improved partner knowledge of sterilization process parameters (general).	• Lack of understanding of sterilization parameters (temperature distribution, heat penetration). • No product F_o value available.	• Able to perform basic lethality (F_o) calculations using a data logger. • Achieved $F_o \geq 3$ for beef and clam rendang, meeting BPOM requirements.
Short shelf life; rapid product spoilage.	• Shelf life: 7 days at ambient temperature; 14 days under refrigeration.	• Extended shelf life toward a six-month target.

This community service initiative not only delivered training on retort technology but also supplied equipment, an overpressure retort together with a data logger constituting the essential package for conducting sterilization. The provision of this equipment is expected to enable the partner to consistently produce packaged rendang that is safe and compliant with food safety regulations.

3.3 Evaluation and Sustainability

The evaluation of the community service program was conducted using a performance-based approach. Partner capacity improvement was assessed through direct observation of the partner's ability to independently operate the overpressure retort and basic calculation of thermal adequacy (F_o value). The partner was able to carry out sterilization cycles independently with minimal technical assistance, achieving an F_o value ≥ 3 for both beef and clam rendang, in compliance with BPOM requirements for commercial sterilization of low-acid foods. Program evaluation was also conducted through real-time storage tests to verify the stability of organoleptic quality, microbiological status, and overall product safety throughout the targeted six-month shelf life. Program sustainability was supported by the availability of a sterilization process guideline booklet and retort operation manual developed by the community service team, planned routine maintenance of the equipment, and laboratory testing of the products to fulfill future BPOM distribution permit requirements.

4. CONCLUSION

The implementation of overpressure retort technology at the Rendang Bu Pit MSME has strengthened product safety and production readiness. The program integrated equipment provision and theoretical training with instrumented testing, enabling the enterprise to meet commercial sterility requirements while preserving package integrity during cooling, an essential advantage of

Vol. 6, No. 1 - Januari 2026, Hal. 323-329
DOI: 10.59395/altifani.v6i1.1036

overpressure retorting for flexible packs. The intervention also enhanced operator capability, supported routine documentation, and established a pathway to extend shelf life from a seven-day ambient baseline toward a six-month target at room temperature, thereby expanding distribution beyond local markets. Nevertheless, continued real-time shelf-life verification (microbiological, chemical, and sensory) must be conducted to substantiate the six-month claim, alongside completion of regulatory pathways (e.g., BPOM licensing).

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Vol. 6, No. 1 - Januari 2026, Hal. 323-329
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