Evaluating the Food Properties of Canned Beef Rendang to Determine the Product Quality

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ABSTRACT

Canning is a common method for preserving food, but its application to traditional cuisine is a new concept for Indonesian small and medium enterprises (SMEs), which typically focus on freshly served dish. Several studies have shown that the use of this method has the potential to extend the durability and marketability of beef rendang. Therefore, this study aimed to evaluate the food properties (sensory, proximate, color, spectroscopy, and physiochemical) of canned beef rendang to its suitability for consumption. Canning was carried out using the sterilization method at a temperature of 121^{0}C and pressure of 0.7-0.9 bar. The sensory test of the canned product obtained was performed using a questionnaire, exploring various properties, including appearance, color, taste, aroma, and texture, while the proximate analysis was conducted by PT Saraswanti Indo Genetech laboratory. The color analysis was measured with a chromameter Konica Minolta CM-5 using the petri dish method, while the spectroscopy analysis was performed with an FTIR instrument from Brucker Vertex-80 using the ATR technique. Subsequently, moisture content was statistically analyzed using one-way and two-way ANOVA with a 95% confidence level. The sensory test results of canned beef rendang showed a 4.52 rating on a maximum scale of 5. The sterilization value (F0) was 3.819 minutes, which met the BPOM requirement of >3 minutes. The findings showed that the proximate analysis was consistent with the SNI standard, while the spectroscopy analysis indicated an unchanged functional group compared to the initial condition. The canned product was reported to have an increased trend of moisture content, but the range did not exceed the permissible limit of 60%. In addition, the pH and TBA value obtained were 5.745-5.315 and 0.1859-0.3195 mg/kg, respectively. The normal pH range of canned beef was typically 5.3-5.7, indicating that the value recorded met the established standard. Meanwhile, the TBA range obtained was significantly lower than the value of spoiled beef at 1.8 mg/kg. Based on these results, canned beef rendang was edible and safe for consumption.

Keywords: Canned beef rendang; proximate test; physicochemical analysis; sensory evaluation; traditional cuisine

INTRODUCTION

Canning is an extensively used method for extending the preservation period of various food product (Homayouni et al., 2015). Although canned food product, such as mackerel and sardines are widely available in markets around the world (Garcia et al., 2019; Weremfo et al., 2020), canning traditional cuisine is a new concept for Indonesian small and medium enterprises (SMEs), which focuses on freshly served dish. However, there is an increasing opportunity for traditional cuisine to gain a larger market share due to the growing demand (Pascual & Ludevese-Pascual, 2018). For instance, visitors often prefer to buy signature dish when traveling, and locals who settle in other regions travel with their hometown cuisine. In recent

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times, when food security has become a major concern due to the COVID-19 outbreak (Elsahoryi et al., 2020; Olaimat et al., 2022), canned food product can serve as an alternative for individuals who are unable to dine in at restaurants. Therefore, canning traditional cuisine has the potential to extend durability and marketability, leading to the economic growth of SME.

Gudeg is the first traditional cuisine to be successfully canned by Indonesian Institute of Sciences (LIPI) and has also been integrated into National Research Innovation Agency (BRIN). Canned Gudeg is currently available nationwide with a shelf life of more than a year. In addition, this represents a significant improvement compared to traditional Gudeg, which typically has a maximum shelf life of 3 days and has never been expected to extend beyond this period. Several reports have shown that the discovery of canning has influenced the orientation of SMEs to increase their business prospects (Nurhikmat & Hendrix, 2016). Following the commercial success of canned Gudeg, several studies have also been carried out on canning beef rendang. In line with previous reports, beef rendang is an ethnic dish from Sumatra Island, which is widely known for its authentic and delightful seasoning (Fajri et al., 2013; Rini et al., 2016). The successful canning of this dish has been reported to have the potential to increase its distribution across the country. Compared to pouch and vacuum plastics, canning packaging provides various advantages, such as increased rigidness and decreased food damage during transportation.

According to previous reports, beef rendang is categorized as a low-acid food, which has the potential to be affected by *Clostridium Botulinum* hazard. To ensure its safety and extend the shelf life, the sterilization method is often required for a minimum of 3 minutes at 250 °F (121.1 °C) (F_0 3) (Featherstone, 2015; Stojanović et al., 2021). Several variables, such as temperature, pH, water content, and the presence of metal ions have also been reported to have the potential to influence the shelf life (Singh & Singh, 2005). However, the sterilization method can change food properties, such as sensory characteristics, nutritional value, and physicochemical attributes (Igual & Martínez-Monzó, 2022). This indicates that the process has a detrimental impact on the quality of the product and suitability for consumption in terms of nutrition and safety.

In response to these challenges, several studies exploring the physicochemical, sensory, and proximate properties of food product have been carried out to assess their performance (Apriyani et al., 2022; Gómez-Limia et al., 2022; Martínez & Carballo, 2021; Otunola & Afolayan, 2018; Ozyurt & Ötles, 2016). Considering the potential of traditional food to be widely distributed in larger markets, efforts are been made to explore their canning (Kusumaningrum et al., 2021; Nurhayati et al., 2017; A Nurhikmat et al., 2021; Pascual & Ludevese-Pascual, 2018). For example, a previous study examined the physicochemical properties of beef rendang in retort pouch packaging (Praharasti et al., 2019). Therefore, this study aimed to evaluate the sensory, color, proximate, spectroscopy, and physicochemical characteristics of canned beef rendang to determine its suitability for consumption. This evaluation was carried out to examine the qualities of beef rendang after canning, consumer acceptance, and fulfillment of food safety criteria.

METHODS

Materials

The samples comprised the traditional cuisine of beef rendang produced by SME 'Pabos' from Gunungkidul as displayed in Figure 1. The main ingredient was beef with a very thick sauce made from authentic local spices, including galangal, ginger, shallots, garlic, turmeric leaves, bay leaves, lime leaves, lemongrass, nutmeg, clove, cinnamon, coconut milk, and red chilies (Fajri et al., 2013). In addition, the processing of rendang typically required approximately 6-7 hours to get softened meat and the typical brownish color on the seasoning, which gave a distinctive taste and aroma (Rini et al., 2016). For the analysis, beef was prepared in fully cooked form (100% cooked).

Figure 1. The Canned product of beef rendang from SME Pabos

Canning Process

The dish was canned in the packaging laboratory of BRIN using the sterilization method. The first step was sterilization of the can (dimensions: 300 mm height and

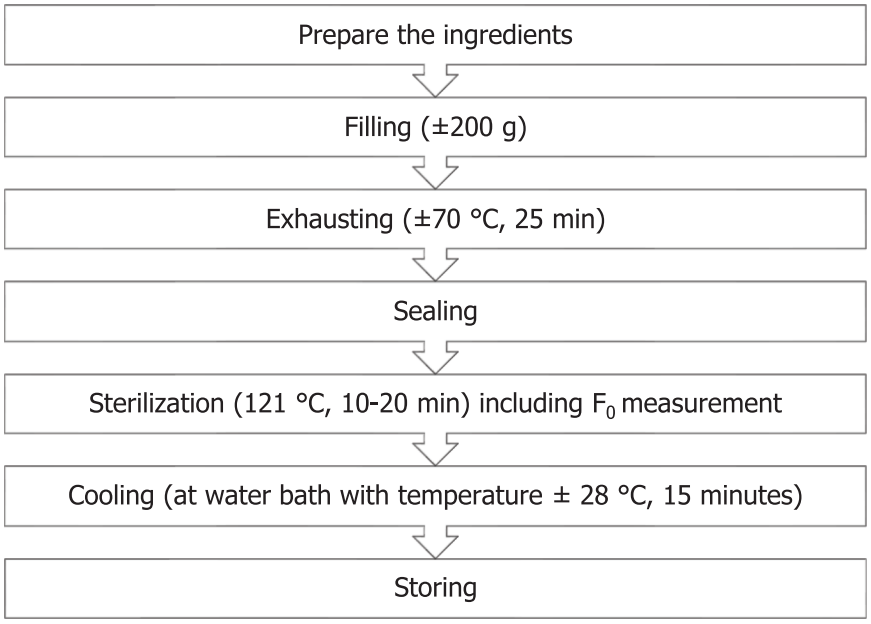


Figure 2. Canning procedures of food product

205 mm diameter) in an autoclave. The process was then continued by filling the can with ±200 g of the dish (±80 g of the meat, ±120 g paste sauce). Subsequently, exhausting was carried out by heating the filled can for approximately 25 minutes to achieve 70 °C of product temperature and push out the air from the filled can, followed by sealing. The main process was sterilization of the sealed can at a temperature of 121 °C with different pressures of 0.7-0.9 bar for 20-30 minutes in an autoclave. The canned product was then cooled down in a water bath at a temperature of 27 °C. The canning procedures were carried out based on a guiding document from the United States Department of Agriculture (USDA) (Brennand, 1995). The instruments specifications included Varin double seamer machine, ZonGon horizontal retort machine with a hot steam source from the boiler, data logger ELLAB CTF9004, and thermocouple Cu/CuNi (DC-input 1.2A, 12V, T -100 - 350 °C with accuracy of 0.1 °C, Tref 121.1 °C and Z 10 °C). The canning procedures of food product are presented in Figure 2.

Product Storage

After the canning process, the product was stored at a room temperature of 30 °C for sensory, color,

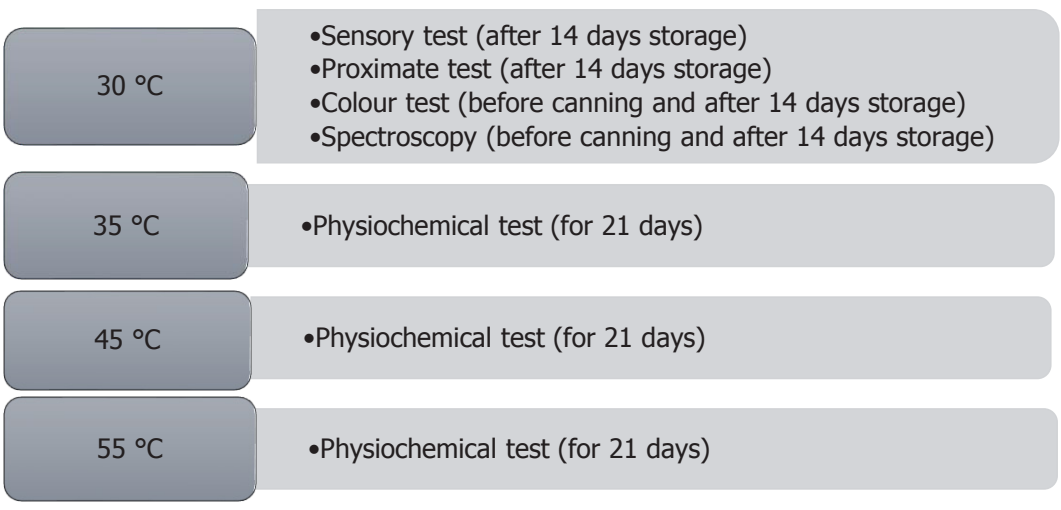


Figure 3. The sample storage temperature with the analysis

and spectroscopy analysis. In addition, the product was kept at temperatures of 35 °C, 45 °C, and 55 °C for physiochemical test. Storage at accelerated temperatures was carried out to predict the shelf life of canned beef rendang for future assessment. The sensory test could be performed after the quarantine period of 14 days to ensure human safety when conducting the test. This period was associated with the incubation time of *Clostridium botulinum* bacteria (Chatham-Stephens et al., 2017; Witoonpanich et al., 2010). When the canned product did not swell during quarantine, the sensory test was conducted. This was because the proper condition of the can confirmed the success of the canning process without defects caused by the presence of microbial activities. Meanwhile, the physiochemical test could be conducted during the 14-day quarantine period or more since the test was unrelated to human reaction. The storage time duration for the physiochemical test was carried out for 21 days to obtain 3 weeks replication. The diagram of the samples' storage temperature related to its analysis is presented in Figure 3.

F_0 Measurement and Proximate Analysis

During F_0 measurement, the F_0 probe was mounted with the system in 1 canned product sampling. The probe was placed on its slowest heating zone (SHZ) or approximately at the canter of the canned dimension. The measurement of F_0 was then performed during the sterilization of the canned product, and the result was displayed on the computer afterward to ensure the process obtained sufficient heat. The samples for proximate analysis were sent to a certified laboratory of PT Saraswanti Indo Genetech (SIG) and tested. According to the procedure, measurements were carried out 3 times to obtain optimal results.

Sensory Evaluation

Sensory tests were carried out based on several parameters using a questionnaire form (Szakály et al., 2012). The parameters for evaluation included (a) aroma, (b) taste, (c) texture, (d) color, and (e) overall appearance (Saguy & Dana, 2003). The sensory panelists were divided into 2 teams, consisting of 2 individuals to obtain an objective assessment (Ares & Varela, 2017). The first team comprised experts from BRIN, while the other team consisted of individuals from the SME Pabos. The panelists rated the parameters on a scale of 1 to 5, with descriptions of very dislike, dislike, ordinary, like, and very like, respectively. In addition, a column to fill a comment or remark from panelists was provided to obtain detailed description of the food product after being canned.

Color Analysis

Color analysis was performed with Chromameter Konica Minolta using the petri dish method. The test samples were canned beef rendang, while beef rendang before canning was used as control. In addition, the measurement was repeated 3 times for each test sample. The results were in color unit L*a*b* (CIELAB) and presented in number and color coordinates. The average values of L*a*b* between the test samples and control were subtracted and justified, followed by the evaluation of total color difference using the Formula 1 (Gómez-Limia et al., 2022; Wrolstad, 2017).

$$\Delta E = \sqrt{(L_t^* - L_c^*)^2 + (a_t^* - a_c^*)^2 + (b_t^* - b_c^*)^2} \quad (1)$$

Note, ΔE: Total color difference, $L_t^* a_t^* b_t^*$: L*a*b* of sample test, and $L_c^* a_c^* b_c^*$: L*a*b* of sample control.

Fourier-Transform Infrared Spectroscopy (FTIR)

The spectroscopy measurement of canned beef rendang was carried out with FTIR instrument from Brucker Vertex-80. An ATR (Attenuated Total Reflectance) method was used as the sampling technique because it was quick and did not require samples preparation. The samples were scanned for 32 in the spectral range of 400-4000 cm^{-1} with a resolution of 4 cm^{-1}.

The first step was measuring the background (a condition without sample), and the samples were directly placed on the ATR plate and measured. After the samples spectra were obtained, the wavenumber of the rising peaks was shown by menu a peak picking. Subsequently, the result spectra were compared to the literature data for analysis.

Moisture Content Analysis with the Oven Method (AOAC, 2005)

A total of 3 porcelain cups were dried for 2-3 hours in an oven at 105 °C and cooled in a desiccator for 15 minutes. Furthermore, each porcelain cup was weighed as an empty cup (a) and set to zero. The process was continued by placing 1 g of mashed samples in every cup, followed by weighing. The samples were milled without any additives to expand the surface area. The weight of the empty cup and the samples were added up to the weight of the product before being placed in an oven (b).

The following step was drying the cup with the samples for 24 hours in an oven at 105 °C. Drying for 24 hours was carried out to remove the moisture content of the samples in the cup, leading to a constant cups weight (Hafiludin, 2011). The cups filled with the

samples were cooled in a desiccator for 15 minutes, weighed, placed in the oven again for 3 hours at 105 °C, and cooled in a desiccator for 15 minutes. The weight of the cups with the samples was examined and calculated for the water content in every 3 hours until the weight was constant (c). The calculation of water content was carried out using the Formula 2.

$$\text{Moisture content} = \frac{b-c}{b-a} \times 100\% \quad (2)$$

Note, a: Weight of empty cup (g), b: weight of cup and sample before oven (g), and c: weight of the cup and sample after oven (g).

pH Analysis (AOAC, 2005)

The samples treatment was similar to the previous test, where grinding in a blender was conducted to maximize the contact area between the samples and solvent. A total of 5 g mashed samples was diluted with 50 mL of distilled water to obtain an unconcentrated solution to facilitate the analysis. Subsequently, the solution was homogenized and filtered with filter paper. The pH measurement was performed with a pH meter by Eutech PC 700, Thermo Scientific to measure the degree of acidity or alkalinity in the solution.

TBA Analysis (Sudarmadji, 1997)

In this method, the samples were mixed and heated with reagent Thiobarbituric Acid (TBA). The reagent formed a pink and fluorescent compound at maximum absorbance and emission of 532 and 553 nm, respectively, when reacted with malonaldehyde or other lipid peroxidation product, indicating food rancidity.

A total of 10 g mashed samples and 50 mL of distilled water were mixed in a blender for approximately 30 seconds. The mixture was then transferred to a 250 mL distillation tube, followed by the addition of 47.5 mL distilled water and 4M HCl (around 2.25 mL). Distillation was then carried out to obtain 50 mL of distillate.

The following step was to place 2.5 mL of distillate with the addition of 2.5 mL of reagent TBA in the test tubes. The process was replicated 3 times for each distillate, and a blank solution was also made with 2.5 mL of distilled water and 2.5 mL of TBA for calibration purposes. The blank solution was characterized by the absence of an analyte. Subsequently, the test tubes were heated in a water bath for 35 minutes at a temperature of 95 °C and cooled down by soaking the test tubes in a beaker filled with water. The heating process was performed to incubate the solution (Darmayani et al., 2021).

The final step was the measurement of the absorbance with a spectrophotometer (Dynamica Halo RB-10) at 528 nm wavelength. This wavelength was used to determine the intensity of a red color based on the absorbance and the amount of malonaldehyde (Marsh & Bugusu, 2007). The TBA test results were recorded as mg malonaldehyde/kg sample (Azizah et al., 2016), which was calculated using the Formula 3.

$$\text{TBA number} = \frac{3 \times A \times 7.8}{\text{sample weight (g)}} \quad (3)$$

Note, A: Absorbance at 528 nm, 7.8: TBA number mg malonaldehyde/kg sample, and 3: Iod number (degree of unsaturation of oil/fat).

Statistical Analysis

Statistical analysis was applied only to the moisture content data since measurements were carried out in triplicate. The data were analyzed statistically using one-way and two-way analysis of variance (ANOVA) with a confidence level of 95%. A CoStat software was used for the computation, followed by the calculation of mean data and standard deviation. Subsequently, the significance and correlation among the data were obtained.

RESULTS AND DISCUSSION

F_0 Test Result

During the sterilization process, a heat penetration test was carried out on canned beef rendang, and the results were presented in Figure 4.

Based on rules from BPOM Indonesia no. 24 of 2016 and previous studies (Featherstone, 2015; Stojanović et al., 2021), the minimum lethality value for sterile processed food was F_0-3. As shown in Figure 4, the lethality value of canned beef rendang after the sterilization process was 3.819 minutes. In addition, the

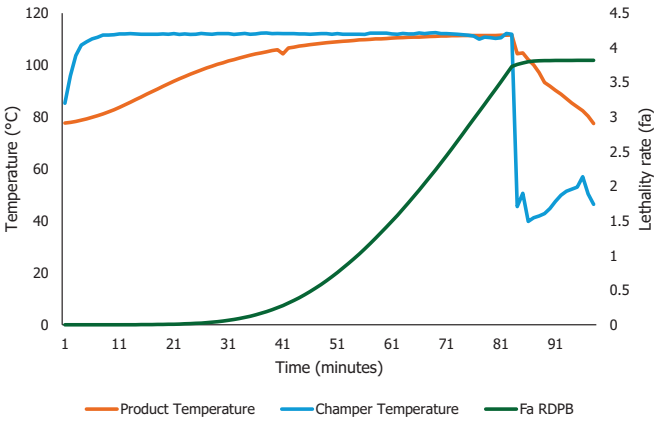


Figure 4. Product heat penetration test

Table 1. Proximate analysis of canned product from SME Pabos

Parameter	Lab Result			SNI 7474 2009
	Value		Unit of detection	
Total energy	240 .88		kcal /100 g	-
Energy from fat	128.88		kcal /100 g	-
Total fat	14.32		%	Max 30%
Saturated fat	11.88		%	-
Protein	20.88		%	Min 25%
Total carbohydrate	7.12		%	
Sugar	4.17		%	
Natrium	398.49		mg / 100 g	-
Hg	Not detected	mg/kg	Limit detection 0.0004	Max 0.03
Cd	Not detected	mg/kg	Limit detection 0.00005	-
As	Not detected	mg/kg	Limit detection 0.0005	Max 1.0
Sn	Not detected	mg/kg	Limit detection 0.0025	Max 40
Pb	0.08	mg/kg	-	Max 2
Ash content	2.48		%	Max 5%

sterilization process for the product met the food safety standards because its lethality value was greater than 3 based on the rules and the heat penetration results.

Proximate Analysis

The results of the proximate analysis by SIG laboratory were given in Table 1.

The results of the proximate analysis were compared to the SNI standard for Beef Rendang (BSN, 2009). The findings showed that the total fat and ash content of the product were 14.32 % and 2.38 %, respectively, as shown in Table 1. In addition, these results did not exceed the standard of 30% and 5%, respectively. The protein percentage of canned beef was lower than the SNI standard, but the proportion of protein was comparable to the minimum allowed in other studies (Hamasalim, 2012) (36). Several reports showed that having a high protein source was not essential in increasing local protein consumption. Despite the presence of a small dose of Pb, the metal contamination in the product was mostly undetectable, indicating that canned beef rendang passed safety standards for consumption by SNI.

Sensory Assessment

Table 2 summarized the panelist preference for canned beef rendang. A sense of rancidity or acidity could characterize the change in smell and taste (Prasafitra et al., 2014). Food spoilage could be identified by the appearance of the food when microbial growth was present. Furthermore, the panelists gave an average scale of 4.52 out of a maximum scale of 5, indicating their pleasure with the outcome of the product.

Based on the evaluation in Table 2, there was no value below 3 (ordinary). The majority of the panelists gave a score of 4 (like) or 5 (very like) for each parameter. The results were considered to be more than ordinary, indicating their satisfaction. As the panelists opened the can, there was no indication of microbial growth in the product during visual observation. The appearance of canned beef rendang was impressive,

Table 2. The sensory test result of canned beef rendang Pa Bos

Parameter	Assessment from panelist (average value)
Appearance	4.5
Color	5.0
Taste	5.0
Aroma	4.5
Texture	4.0
Average score	4.52

looking more colorful and attractive. This was because the high pressure and temperature during the sterilization enhanced its appearance. Thermal and pressure treatment could change the constituents through chemical reactions, and the covalent bonding was rearranged. Subsequently, the food compounds, such as pigments, flavoring agents, and vitamins were either enriched or deteriorated (Butz et al., 2003). For example, heating sugar or carbohydrate sources caused caramelization, leading to the production of a brown or darker color.

In terms of the aroma, the panelists could smell the aromatic herbs and spices of the product when not expected to remain. The taste and flavor were also considered to be the same as before the canning process after several days had passed. Beef rendang had no sour taste, proving that the dish was not spoiled. Based on these findings, the dish could be stored in a canning package with a similar quality as originally served in the restaurant. In general, the panelists had a good impression of canned beef rendang.

Despite the score obtained from the assessment, the texture parameter had the lowest result. This was because the texture of fully cooked beef (100% cooked) became too soft and lost sensation to bite after canning. Processing at high temperatures and pressure during sterilization could change this parameter. Heating collagen, which was the largest protein group in the animal at 60 °C-70 °C, had been reported to have a significant influence on the texture. The heat shortened the fiber size, which could hold water and cause shrinkage, leading to tougher meat. In addition, heating protein caused coagulation or a combination process from the adjacent protein molecules to the side-chain hydrogen bonds, resulting in a more complex texture of the material (Nurhikmat & Hendrix 2016). Above the temperature, tenderization speed increased faster, and the meat was easily separated into the strands. For the future process, the panelists suggested preparing the half-cooked beef (80% cooked) before canning to obtain the desired texture.

In most cases, beef was sliced unequally, and a small piece of the herbs, such as lime leaves was placed in the can, thereby reducing the appearance of the product. In addition, beef must be sliced more uniformly, and other herbs must be carefully removed for the following preparation. Additives, such as flavor enhancers, preservatives, and coloring agents were not allowed. The usage of these additives could be sensed during the sensory test. This was to gain the trust of the customer given that the cuisine initially had a good taste and was healthy without the enhancer. Furthermore, it also proved that the food could have long-term durability because of the role of technology instead of chemicals.

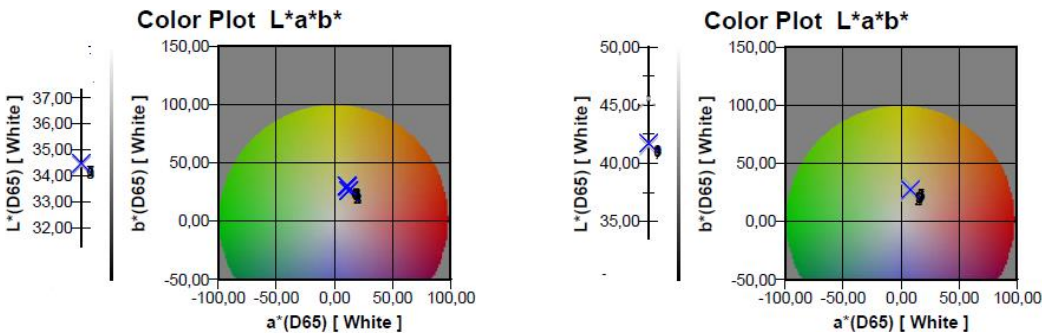
Color Analysis

The measurement results of the test samples (canned beef rendang) and control of beef rendang were presented in Table 3.

L* represented the luminosity and ranged between 0 (black) and 100 (white). a* showed the variation

Table 3. Color measurement results in L*a*b*

Sample name	The average value in Colour unit		
	L*(D65)	a*(D65)	b*(D65)
Sample test (canned beef rendang)	34.43	11.29	29.49
Sample control (beef rendang)	41.66	8.04	27.52
Different (test-control)	-7.23	3.25	1.97
Justification	Darker	reddish	yellowish
ΔE		8.16	



(a) (b)

Figure 5. Color coordinate of (a) sample test (canned beef rendang) and (b) sample control (beef rendang)

between red (>0) and green (<0), while b* expressed the variation between yellow (>0) and blue (<0). In Table 3, negative ΔL* numbers gave a darker color to test samples, while positive ΔL* numbers produced lighter luminosity. Positive Δa* indicated that the test samples had a more reddish tone (or less "green") compared to the control, with negative Δa* numbers indicating a greenish tone. In addition, positive Δb* numbers showed a yellowish tone (less "blue'), and negative Δb* numbers were the opposite (Stojanović et al., 2021; Wrolstad, 2017). The quantitative results of color measurement confirmed the qualitative result from sensory assessment, where the color of canned beef rendang was enhanced and looked darker. The calculation of the total difference was approximately 8.16, which showed the magnitude difference and not the direction. The illustration of the color result is presented in Figure 5, where the color of canned beef rendang was slightly shifted toward the up and right side, indicating more yellowish and reddish coloration.

FTIR Analysis

FTIR measurement was carried out to analyze the functional group of canned beef rendang. In addition, FTIR spectra of beef rendang before and after canning were presented in Figure 6. Based on previous studies (Candoğan et al., 2021), the band assignment of each peak was described in Table 4.

As shown in Figure 6, beef rendang before and after canning showed the same FTIR spectra. This indicated that the functional group of canned beef was mostly unchanged from its initial condition. In addition, the samples predominantly contained protein, lipid, and carbohydrate, as presented in Table 4. Some peaks of canned beef rendang occurred at wavenumber 2961, 2926, and 1158 cm^{-1}, corresponding to lipid molecules. The heating process during sterilization caused the addition of lipid product. However, due to SNI standards as stated in Table 1, the total fat of canned beef rendang did not exceed the permissible value.

The results in Table 4 showed that both samples gave the same spectra with slightly different wavenumbers, namely 1627 cm^{-1} and 1624 cm^{-1}. Canned beef rendang spectra mostly had a lower wavenumber compared to beef rendang, showing the presence of more degradation. The sterilization process could reduce the food quality, but FTIR measurement could not predict the quantification of the degradation. The possible evaluation to quantify the degradation could be combined with chemometric analysis for future assessments.

Moisture Content

Moisture content referred to the presence of water vapor or volatile compounds in the samples, serving as a substantial parameter for food preservation because the increased water in canned product increased microbes that spoiled the food. The statistical analysis of moisture content, which was stored at accelerated temperature for 21 days, is presented in Tables 5, 6, 7, and 8.

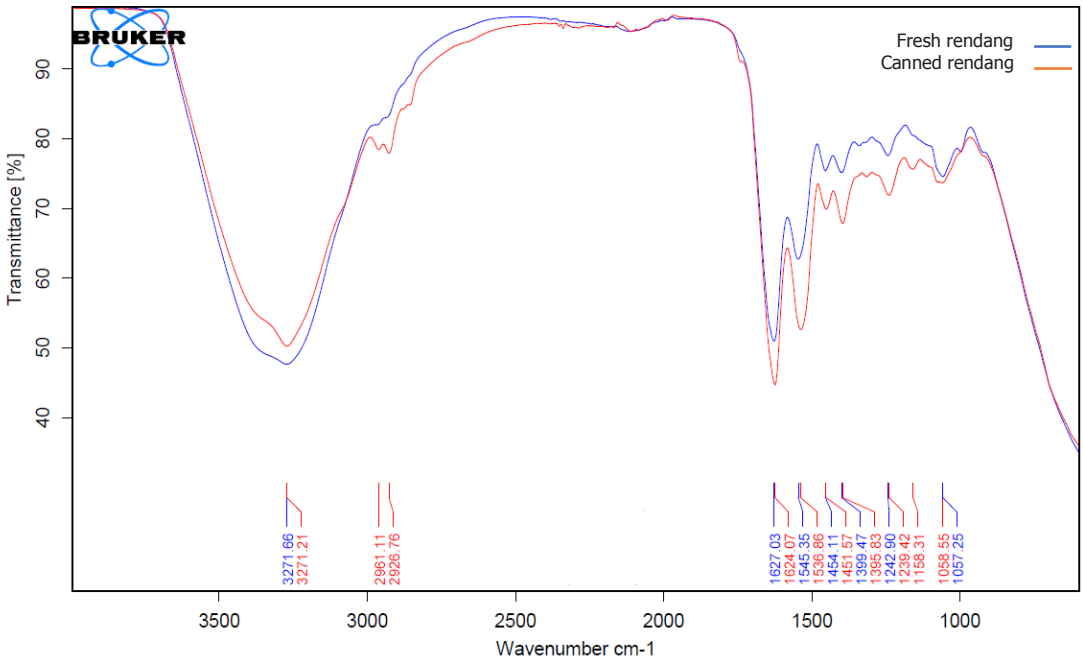


Figure 6. FTIR spectra of beef rendang before and after canning

Table 4. Band assignment of the measurement spectra

Wavenumber detected. (cm^{-1})		Band assignment	Related Molecules
Fresh rendang	Canned rendang		
3271.6	3271.2	Amide A, mainly due to N-H stretching of protein with contribution of O-H stretching of polysaccharides	Protein, carbohydrate
	2961.1	CH_3 asymmetric stretching	Lipids (mainly), protein
	2926.7	CH_2 asymmetric stretching	Lipids
1627.03	1624.07	Amide I (C=O stretching, N-H bending, C-N stretching)	Protein
1545.3	1536	Amide II (N-H bending, C-N stretching)	Protein
1454.1	1451.5	C-O-H bending of methyl group	Protein, Lipid
1399.4	1395.8	C-N stretching of amide, NH deformation	Protein
1242	1239	PO_2 asymmetric stretching (non H-bonded)	Nucleic acids, phospholipids, phosphorylated proteins
	1158	C–O stretching	Esters of lipids
1058	1057	C–O stretching	Nucleic acids, polysaccharides (glycogen)

Table 5. Normal distribution and the homogeneous variant of moisture content data

Parameter	P(K^2)	P
Moisture content	0.4288	0.6280

Notes: P(k^2) ≤0.05 indicated the data was probably not normally distributed P≤0.05 indicated the variant could not be homogeneous.

Table 6. One-way ANOVA of the moisture content data

Storage Factor	Mean
Day 7.35 ^{0}C	50.30±1.41^{e}
Day 7.45 ^{0}C	48.44±1.67^{f}
Day 7.55 ^{0}C	51.92±0.76^{cde}
Day 14.35 ^{0}C	53.22±0.58^{c}
Day 14.45 ^{0}C	58.82±0.69^{a}
Day 14.55 ^{0}C	51.14±0.46^{de}
Day 21.35 ^{0}C	55.27±1.06^{b}
Day 21.45 ^{0}C	58.78±0.44^{a}
Day 21.55 ^{0}C	52.38±0.66^{cd}

Note: Similar letters do not differ significantly Significance level 0.05

The values of P(K^2) and P were higher than 0.05 based on the results in Table 5. Therefore, moisture content data were normally distributed and homogenous. This indicated that the analysis could be continued with one-way and two-way ANOVA, as shown in Tables 6, 7, and 8.

Table 7. Two-way ANOVA

Storage Factor	F	P	Sig
Time	76.974	0.000	***
Temperature	32.568	0.000	***
Interaction Time*Temp	32.144	0.000	***

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

According to Table 6, the moisture data was similar on the same day but the difference in the temperature storage gave a significant difference in the statistical analysis. For example, days 14 and 21 had different subscription letters for every temperature storage. However, on day 7, the moisture data at temperatures 35^{o}C and 55^{o}C gave a similarity (same subscribe ^{e}). This could be in the first week or shorter time, where the moisture content experienced lesser changes. Storing canned beef at the temperature of 55^{0}C caused insignificant changes although it had passed several days (same subscribe ^{d}). The temperature 45^{o}C also gave the same pattern on days 14 and 21, but the moisture content at 35^{o}C changed significantly during storing time. The changes during the storage period due to temperature could be caused by the chemical reaction in the food components. The analysis proceeded

Table 8. Post-hoc test for each storage factor

Storage Time	Mean	Storage Temperature	Mean
Day 7	50.30±1.9[c]	35°C	52.93±2.35[b]
Day 14	54.39±3.4[b]	45°C	55.34±5.26[a]
Day 21	55.47±2.8[a]	55°C	51.81±0.77[c]

Note: The same column with a similar letter does not differ significantly Significance level 0.05

to assess the significant effect of the two factors on moisture content through two-way ANOVA.

Based on the statistical analysis, the storage factor of time, temperature, and their interaction presented significant differences in the moisture content (given by notation ***), as shown in Table 7. The results indicated that the changes in the moisture content were affected by the factors. These findings were in line with previous studies that the storage time and condition affected the parameter in food preservation (Jayadi et al., 2016; Solihin et al., 2015). In addition, the result in Table 8 showed an increased tendency of moisture content at longer storage time and it was significantly different according to the statistical result (different letter in the same column). The increasing trend occurred because the beef absorbed liquid from rendang pasta, which then accumulated every day and caused higher moisture content. Meanwhile, the storage temperature gave a fluctuating trend of moisture content, which increased at storage 45°C and decreased at a temperature of 55°C. The difference was also significant according to the statistical result (different notation). The higher temperature could increase the absorption rate of liquid paste to beef but could also evaporate the liquid from food component.

Canned beef rendang had a slightly higher value compared to the retort pouch, and this could be due to the difference in cooking time and pre-treatment before the sterilization process. Beef rendang in the pouch was vacuum sealed to gain more shelf lifetime before undergoing sterilization, which could reduce the moisture content (Praharasti et al., 2019). Therefore, the moisture content of beef rendang in the pouch led to a lower value. The average value of the moisture content in Table 6 did not exceed the permissible criteria (60%) of canned meat from previous studies (Hamasalim, 2012).

pH Test Result

pH measured the degree of acidity, indicating the hydrogen ion concentration in food. Furthermore, it was an essential parameter for preserving food because microorganisms were unable to live in environments with either very high or low pH. Table 9 showed the pH result of canned beef rendang at an accelerated time during 21 days of storage.

According to Table 9, pH measurement had dynamic change during 21 days of storage, and the value for all temperatures decreased on the 7th day, and increased slightly on the 14th day. Except for the 30 °C temperature, the pH decreased again on the 21st day. The decreasing pH in canned beef rendang indicated acid accumulation. Glucose in food ingredients changed into pyruvic acid, leading to the production of acetic acid and alcohol in anaerobic conditions (Sharma et al., 2020). The increasing pH could be explained by micro and macromolecule degradation into alkali compounds. During the storage period, proteolytic enzymes changed protein into alkali compounds, namely ammonia, carboxylic acid, sulfuric acid, and other types of acid (Wahyuni et al., 2021).

The pH result had a minimum value of 5.315 and a maximum of 5.745, as shown by the results in Table 9. *Clostridium botulinum* found it difficult to grow in an environment with a pH of 4.6 or less (Featherstone, 2015). However, canned beef rendang had been sterilized and the pH was typically in the range of 5.3-5.7 (Saleh et al., 2015). This indicated that canned beef rendang was safe for consumption, and the result showed a similar range to a previous study on beef rendang in pouch packages. These findings were also

Table 9. pH result of canned beef rendang

Temperature	pH on storage days period			
	Day-0	Day-7	Day-14	Day-21
30 °C	5.745 ± 0.007	5.550 ± 0.014	5.600 ± 0.000	5.645 ± 0.007
45 °C	5.745 ± 0.007	5.515 ± 0.007	5.525 ± 0.007	5.510 ± 0.014
55 °C	5.745 ± 0.007	5.315 ± 0.007	5.595 ± 0.007	5.335 ± 0.014

(p<0.05)

Table 10. TBA values of canned beef rendang

Temperature	TBA (mg/kg) on storage days period			
	Day-0	Day-7	Day-14	Day-21
30 °C	0.185861	0.190475	0.236247	0.230353
45 °C	0.185861	0.189808	0.319459	0.237769
55 °C	0.185861	0.233821	0.237769	0.243651

A greater TBA number indicated the more rancidity.

in line with other types of cuisine, including Wagyu Beef and Bali Beef, which had a pH range between 5.41 and 5.85 (Merthayasa et al., 2015).

TBA Results

The measurement result of degree rancidity was presented as TBA value and shown in Table 10.

Based on Table 10, the TBA value for all temperature variations in 21 days was in the range of 0.1859 – 0.3195 mg/kg. This data showed that the TBA value was below the critical limit of 0.5 mg/kg or met the criteria (Herawati et al., 2017). Another study stated that the TBA value of 1.8 mg/kg indicated a spoiled beef (Pearson, 1968). Therefore, canned beef rendang could be accepted for consumption. The TBA result of beef rendang in pouch had a slightly lower result of 0.145 – 0.24 mg/kg compared to this study. However, both had a similar fluctuating trend during storage time and temperature variation. The variation occurred due to an unstable and easily decomposed TBA reagents (Ketaren, 1986).

Rancidity referred to quality deterioration in fatty foods or flavor damage. (Maharani et al., 2012). Beef and coconut milk were the main ingredients of Rendang that contained lipids. The reaction between unsaturated fatty acid and Thiobarbituric Acid caused the release of malonaldehyde. In the oxidation process, the degradation of peroxide compounds produced unstable hydroperoxide compounds, followed by aldehyde and ketone production that caused rancidity. In addition, the increase in water content was related to TBA values (Fauzi et al., 2016). This was probably due to the increase in hydrolysis enzymes, specifically lipase enzymes. Hydrolysis enzyme converted lipids into free fatty acid and glycerol, and the lipase activity released free fatty acid from triglyceride (Tatipata, 2010).

CONCLUSION

In conclusion, the quality of canned beef rendang met the requirement for consumption. The sensory tests yielded a desirable value of 4.5 on a 5-point scale. Moreover, the quantitative result of the color analysis was in line with the sensory assessment, where the color of the canned product was enhanced in yellow and red. The sterilization value (F_0) of 3.819 minutes met the BPOM food safety standards, which required a value greater than 3 minutes. The proximate analysis results confirmed the SNI standard for beef rendang, and metal contamination was majorly undetected. The results showed a minor indication of Pb, but the value was under the limit of detection. In addition, the moisture content increased during the 21-day storage period and did not exceed the permissible limit of 60%. The pH range was 5.315-5.745, which was within the normal range of 5.3-5.7. The findings showed that the TBA range (0.1859-0.3195 mg/kg) was significantly lower than the TBA value of spoiled beef (1.8 mg/kg).

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of the article.

REFERENCES

Apriyani, T. W., Supriyadi, S., & Gunadi, R. (2022). Improvement of Antioxidant Activity and Sensory Quality of Pagilaran ' s Tea Clones Treated by Tannase. *Agritech*, *42*(3), 218–230.

Ares, G., & Varela, P. (2017). Trained vs. consumer panels for analytical testing: Fueling a long lasting debate in the

field. *Food Quality and Preference*, *61*, 79–86. https://doi.org/10.1016/j.foodqual.2016.10.006

Azizah, Z., Rasyid, R., & Kartina, D. (2016). Pengaruh pengulangan dan lama penyimpanan terhadap ketengikan minyak kelapa dengan metode asam thiobarbiturat (TBA). *Jurnal Farmasi Higea*, *8*(2), 189–200.

Brennand, C. (1995). Complete Guide to Home Canning. In *National Intitute of Food and Agriculture* (pp. 1–40).

BSN. (2009). Rendang Daging Sapi. In *SNI 7474:2009*.

Butz, P., Fernández García, A., Lindauer, R., Dieterich, S., Bognár, A., & Tauscher, B. (2003). Influence of ultra high pressure processing on fruit and vegetable products. *Journal of Food Engineering*, *56*(2–3), 233–236. https://doi.org/10.1016/S0260-8774(02)00258-3

Candoğan, K., Altuntas, E. G., & İğci, N. (2021). Authentication and Quality Assessment of Meat Products by Fourier-Transform Infrared (FTIR) Spectroscopy. *Food Engineering Reviews*, *13*(1), 66–91. https://doi.org/10.1007/s12393-020-09251-y

Chatham-Stephens, K., Fleck-Derderian, S., Johnson, S. D., Sobel, J., Rao, A. K., & Meaney-Delman, D. (2017). Clinical Features of Foodborne and Wound Botulism: A Systematic Review of the Literature, 1932-2015. *Clinical Infectious Diseases*, *66*(Suppl 1), S11–S16. https://doi.org/10.1093/cid/cix811

Darmayani, S., Hidana, R., Sa'diya, A., Isrianto, P. L., Hidayati, Jumiarni, D., Hafsari, A. R., Latumahina, F. S., Setyowati, E., E, S. A., A, S. K., Syam, S., Sufiyanto, M. I., Yusal, M. S., Watuguly, T. W., & Gultom, V. D. N. (2021). Bioteknologi Teori dan Aplikasi. In *Widina Bhakti Persada Bandung*.

Elsahoryi, N., Al-Sayyed, H., Odeh, M., McGrattan, A., & Hammad, F. (2020). Effect of Covid-19 on food security: A cross-sectional survey. *Clinical Nutrition ESPEN*, *40*(January), 171–178. https://doi.org/10.1016/j.clnesp.2020.09.026

Fajri, P. Y., Astawan, M., & Wresdiyati, T. (2013). Evaluasi Nilai Biologis Protein Rendang dan Kalio Khas Sumatera Barat. *Penelitian Gizi Dan Makanan*, *36*(2), 113–120.

Fauzi, A., Surti, T., & Rianingsih, L. (2016). Efektivitas daun teh (Camellia sinensis) Sebagai antioksidan pada fillet ikan bandeng (Chanos chanos Forsk.) selama penyimpanan dingin. *Jurnal Pengolahan Dan Bioteknologi Hasil Perikanan*, *5*(4), 14–16.

Featherstone, S. (2015). Heat penetration determinations and thermal process calculations. In *A Complete Course in Canning and Related Processes* (pp. 43–58). https://doi.org/10.1016/b978-0-85709-678-4.00003-8

Garcia, T., Cardoso, C., Afonso, C., Gomes, A., Mesquita, C., Tanni, S., & Bandarra, N. M. (2019). A Study of Lipid Bioaccessibility in Canned Sardine (Sardina pilchardus) and Chub Mackerel (Scomber japonicus). *Journal of Aquatic Food Product Technology*, *28*(4), 402–412. https://doi.org/10.1080/10498850.2019.1594481

Gómez-Limia, L., Carballo, J., Rodríguez-González, M., & Martínez, S. (2022). Impact of the Filling Medium on the Colour and Sensory Characteristics of Canned European Eels (Anguilla anguilla L.). *Foods*, *11*(8). https://doi.org/10.3390/foods11081115

Hafiludin, H. (2011). Karakteristik Proksimat dan Kandungan Senyawa Kimia Daging Putih dan Daging Merah Ikan Tongkol (Euthynus affinis). *Jurnal Kelautan*, *4*(1), 1–10. https://journal.trunojoyo.ac.id/jurnalkelautan/article/view/885

Hamasalim, H. J. (2012). Quality Assessment of the Imported Canned Beef Sold in Sulaimani Markets. *KSU J.Nat.Sci*, *15*(4), 1–6.

Herawati, E. R. N., Nurhayati, R., & Angwar, M. (2017). Pendugaan Umur Simpan Keripik Pisang Salut Cokelat "Purbarasa" Kemasan Polipropilen Berdasarkan Angka Tba Dengan Metode Aslt Model Arrhenius. *Reaktor*, *17*(3), 118. https://doi.org/10.14710/reaktor.17.3.118-125

Homayouni, A., Azizi, A., Keshtiban, A. K., Amini, A., & Eslami, A. (2015). Date canning: a new approach for the long time preservation of date. *Journal of Food Science and Technology*, *52*(4), 1872–1880. https://doi.org/10.1007/s13197-014-1291-0

Igual, M., & Martínez-Monzó, J. (2022). Physicochemical Properties and Structure Changes of Food Products during Processing. *Foods*, *11*(15), 2365. https://doi.org/10.3390/foods11152365

Jayadi, A., Anwar, B., Sukainah, AndiAbon, M., & Terbang, I. (2016). Pengaruh Suhu Penyimpanan Dan Jenis Kemasan Terhadap Mutu Abon Ikan Terbang. *Jurnal Pendidi*, *2*, 62–69.

Kusumaningrum, A., Kurniadi, M., Nurhikmat, A., Susanto, A., Prayogi, S., & Amri, A. F. (2021). Aplikasi Metode Pengalengan pada Produk Siap Santap Berbasis Nasi. *Jurnal Litbang Industri*, *11*(June), 9–15.

Maharani, D. M., Bintoro, N., & Rahardjo, B. (2012). Kinetika Perubahan Ketengikan (Rancidity) Kacang Goreng Selama Proses Penyimpanan (Kinetics of rancidity of fried peanuts during storage process). *Agritech: Jurnal Fakultas Teknologi Pertanian UGM*, *32*(1), 15–22. https://doi.org/10.22146/agritech.9651

Marsh, K., & Bugusu, B. (2007). Food packaging - Roles, materials, and environmental issues: Scientific status summary. *Journal of Food Science*, *72*(3). https://doi.org/10.1111/j.1750-3841.2007.00301.x

Martínez, S., & Carballo, J. (2021). Physicochemical, sensory and nutritional properties of foods affected by processing

and storage. *Foods*, *10*(12). https://doi.org/10.3390/foods10122970

Merthayasa, J. D., Suada, I. K., & Agustina, K. K. (2015). Water holding capacity, pH, color, odor and texture of bali beef and wagyu beef. *Indonesia Medicus Veterinus*, *4*(1), 16–24.

Nurhayati, R., Nh, E. R., Susanto, A., & Khasanah, Y. (2017). Shelf Life Prediction for Canned Gudeg using Accelerated Shelf Life Testing (ASLT) Based on Arrhenius Method. *IOP Conference Series: Materials Science and Engineering*, *193*(1). https://doi.org/10.1088/1757-899X/193/1/012025

Nurhikmat, A, Susanto, A., Kusumaningrum, A., Amri, A. F., Suratno, Amdani, R. Z., & Prayogi, S. (2021). General assessment on the sensory properties of traditional cuisine from java island after canning process. *IOP Conference Series: Earth and Environmental Science*, *759*(1), 012003. https://doi.org/10.1088/1755-1315/759/1/012003

Nurhikmat, Asep, & Hendrix, T. (2016). Traditional Food for Small and Medium Enterprises (SMEs). *Advance in Economics, Business and Management Research*, *15*, 233–237. https://doi.org/10.2991/gcbme-16.2016.43

Olaimat, A. N., Alshami, I. K., Hourani, H. Al, Sarhan, W., Al-holy, M., Abughoush, M., Al-awwad, N. J., Hoteit, M., & Al-jawaldeh, A. (2022). Food Insecurity , Dietary Diversity , and Coping Strategies A Cross-Sectional Study. *Nutrients*, *14*(March), 2252.

Otunola, G. A., & Afolayan, A. J. (2018). Evaluation of the physicochemical, proximate, and sensory properties of moinmoin from blends of cowpea and water yam flour. *Food Science and Nutrition*, *6*(4), 991–997. https://doi.org/10.1002/fsn3.592

Ozyurt, V. H., & Ötles, S. (2016). Effect of food processing on the physicochemical properties of dietary fibre. *Acta Scientiarum Polonorum, Technologia Alimentaria*, *15*(3), 233–245. https://doi.org/10.17306/J.AFS.2016.3.23

Pascual, P. A. L., & Ludevese-Pascual, G. (2018). Process Optimization , Consumer testing and Shelf-life Determination of Canned " Halang-halang ": A Filipino Traditional Food. *International Journal of Environmental & Agriculture Research (IJOEAR)*, *4*(2), 40–46.

Pearson, D. (1968). Application of chemical methods for the assessment of beef quality. III.—Methods related to fat spoilage. *Journal of the Science of Food and Agriculture*, *19*(10), 553–556. https://doi.org/10.1002/jsfa.2740191001

Praharasti, A. S., Kusumaningrum, A., Khasanah, Y., Nurhayati, R., Nurhikmat, A., Susanto, A., & Suprapedi. (2019). Physicochemical Properties and its Relations of Beef Rendang inside Retort Pouch Packaging in Various Temperature Storage Conditions. *IOP Conference Series: Earth and Environmental Science*, *251*(1), 0–9. https://doi.org/10.1088/1755-1315/251/1/012043

Prasafitra, A., Suada, I., & Swacita, I. (2014). Ketahanan Daging Rendang Tanpa Pemasakan Ulang Selama Penyimpanan Suhu Ruang Berdasarkan Uji Reduktase dan Organoleptik. *Indonesia Medicus Veterinus*, *3*(1), 20–25.

Rini, Azima, F., Sayuti, K., & Novelina. (2016). The Evaluation of Nutritional Value of Rendang Minangkabau. *Agriculture and Agricultural Science Procedia*, *9*, 335–341. https://doi.org/10.1016/j.aaspro.2016.02.146

Saguy, I. S., & Dana, D. (2003). Integrated approach to deep fat frying: Engineering, nutrition, health and consumer aspects. *Journal of Food Engineering*, *56*(2–3), 143–152. https://doi.org/10.1016/S0260-8774(02)00243-1

Saleh, A., Hafez, E. E., Bakeer, N. M., El-Ghannam, Y. G., & Gorbal, S. H. (2015). Quality Assurance of Imported Canned Meat. *Global Veterinaria*, *14*(4), 511–516. https://doi.org/10.5829/idosi.gv.2015.14.04.93248

Sharma, R., Garg, P., Kumar, P., Bhatia, S. K., & Kulshrestha, S. (2020). Microbial fermentation and its role in quality improvement of fermented foods. *Fermentation*, *6*(4), 1–20. https://doi.org/10.3390/fermentation6040106

Singh, R. K., & Singh, N. (2005). Quality of packaged foods. In *Innovations in Food Packaging*. Elsevier Ltd. https://doi.org/10.1016/B978-012311632-1/50035-8

Solihin, Muhtarudin, & Sutrisna, R. (2015). Pengaruh lama penyimpanan terhadap kadar air kualitas fisik dan sebaran jamur wafer limbah sayuran dan umbi-umbian. *Jurnal Ilmiah Peternakan Terpadu*, *3*(2), 48–54.

Stojanović, B., Vasilev, D., Stojanović, Z., Parunović, N., Janković, S., Stanojević, S., Balaban, M., & Antić, V. (2021). Determination of sensory properties and levels of trace elements during storage of canned meat products. *Journal of Food Processing and Preservation*, *45*(3), 1–13. https://doi.org/10.1111/jfpp.15278

Szakály, Z., Szente, V., Kövér, G., Polereczki, Z., & Szigeti, O. (2012). The influence of lifestyle on health behavior and preference for functional foods. *Appetite*, *58*(1), 406–413. https://doi.org/10.1016/j.appet.2011.11.003

Tatipata, A. (2010). Perubahan Asam Lemak Selama Penyimpanan Benih Kedelai (Glycine Max L. Merr) Dan Hubungannya Dengan Viabilitas Benih. *Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy)*, *38*(1), 30–35. https://doi.org/10.24831/jai.v38i1.18229

Wahyuni, N. ., Rianingsih, L., & Romadhon. (2021). Pengaruh Pengemasan Vakum Dan Non Vakum Terhadap Kualitas Bekasam Instan Ikan Mas (Cyprinus Carpio) Selama Penyimpanan Suhu Ruang. *Jurnal Ilmu Dan Teknologi Perikanan*, *3*(1), 26–33.

Weremfo, A., Eduafo, M. K., Gyimah, H. A., & Abassah-Oppong, S. (2020). Monitoring the Levels of Biogenic Amines in Canned Fish Products Marketed in Ghana. *Journal of Food Quality*, *2020*. https://doi.org/10.1155/2020/2684235

Witoonpanich, R., Vichayanrat, E., Tantisiriwit, K., Wongtanate, M., Sucharitchan, N., Oranrigsupak, P., Chuesuwan, A., Nakarawat, W., Tima, A., Suwatcharangkoon, S., Ingsathit, A., Rattanasiri, S., & Wananukul, W. (2010). Survival analysis for respiratory failure in patients with food-borne botulism. *Clinical Toxicology*, *48*(3), 177–183. https://doi.org/10.3109/15563651003596113

Wrolstad, R. E. (2017). Color Analysis. In *Food Analysis* (pp. 545–555). https://doi.org/10.1007/978-3-319-45776-5