Thermal Processing and Chemical Characteristics of Canned Traditional Foods Based on Beef: Rawon, Kuah gandul and Empal gentong

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ABSTRACT
The traditional food products were produced by home industries need to be packaged to extend the shelf life and to expand the market during the pandemic. The study aims to provide information about thermal processing, chemical characteristics and metal contamination on canned *rawon*, *kuah gandul* and *empal gentong* products. Fresh traditional foods packaged in cans and sterilized at operating temperature 121 °C for 60 minutes in different batch. The results of this study showed that lethality value (F_0-value) of canned traditional foods based on beef in the range of 4.02-10.17 minutes. Metal contamination i.e. lead, cadmium, tin, mercury and arsenic were below the limit in Indonesian National Standard (SNI) and National Agency of Drug and Food Control the Republic of Indonesia regulation. Protein contents on three products were in the range 6.56-8.76% and total energy 76-132 kcal/100 g.

Keywords: *Home industry, Beef, Sterilization, Traditional food, Cans.*

1. INTRODUCTION

Indonesian traditional foods are processed from natural products combined with local and unique recipes that represent Indonesian cultures. They have a distinctive taste because spices are added. Some examples of traditional foods made from plant-based ingredients are *bakpia* and *gudeg* (DI Yogyakarta), *pecel* (Madiun), *lumpia* (Semarang) and *papeda* (Papua) while those made from animal ingredients include *bebek sinjay* (Madura), *rendang* (West Sumatra), *ayam taliwang* (West Nusa Tenggara), *ayam betutu* (Bali), *empal gentong* (Cirebon), *kuah gandul* (Pati) and *rawon* (East Java). The main ingredients of traditional food come from plants and animals. Nutritional content of animal protein is more complete amino acids than plant protein. Meat contains protein, fat, carbohydrates and several other micronutrients such as vitamins and minerals [1,2]. Fresh traditional foods are more vulnerable to spoilage as a result of the growth of bacteria, yeasts and molds at room temperature storage [3]. The packaging technology for traditional food products has enabled extending the product shelf life. So, the product can be distributed to a broader market.

Several previous studies on applying packaging technology to traditional foods have been conducted. The traditional food of West Kalimantan, namely spicy porridge, was studied for its packaging process using cans. The results showed that the most preferred canned spicy porridge based on the hedonic test was derived from half-cooked roasted rice with a lethality value (F_0) of 9.141 minutes and sterilized for 60 minutes at 121 °C. The F_0 value in the >3 minutes sterilization process has been able to guarantee that the product is free from microbial spores, but the F_0 value affects the functional properties of the spices used for making spicy porridge. Spicy porridge products are classified as low-acid foods (pH 6.03 – 6.06) so a high temperature heating process (115-121 °C) is needed [4].

Another alternative packaging material besides cans is flexible retort pouch packaging. Soy curry products from India are packaged using multilayer retort pouch packaging and processed using a hot process at 121 °C in a retort machine. Soy curry products experienced insignificant changes in free fatty acids, peroxide and sensory values during a storage period of 9 months and at storage temperatures under refrigeration (4-5 °C), ambient temperature (27-30 °C) and temperature acceleration 45 °C [5]. The important thing to be studied in canned food products is metal contamination. The contaminants in can packaging are lead (Pb) and tin (Sn) which came from the solder between the body and the lid of the can. Contact of Sn and Pb with food products with low acid content can become a causative factor for sulfide strain or black spots appearance on canned food products. According to SNI number 7387:2009, the limit of lead to be allowed in canned food is 1.0 mg/kg for processed meat products. The results of previous research showed that the level of Pb in canned sausage was 0.64 ppm with oxidizing agents HNO_3, H_2SO_4 and H_2O_2, while the levels of Pb in canned lychees were 0.72 ppm with oxidizing agents HNO_3 and H_2SO_4 [6].

This study focused on thermal processing, chemical characteristics and metal contamination of canned traditional foods made from beef, namely *empal gentong, kuah gandul* and *rawon*. The canning method is applied for these short shelf life traditional foods so the food is packaged in a ready-to-eat state and has a long time of shelf life if stored in the right conditions [4]. The aim of this study was to describe scientific information about the characteristics of canned traditional food made from beef as the main raw material produced by small and medium enterprises (SMEs).

2. MATERIALS AND METHOD

2.1. Materials

Traditional food has been freshly prepared by *Empal gentong* Haji Apud restaurant Cirebon, *Kuah gandul* Bumdes "Abadi" Pati Regency and *Rawon* "Mammams" CV Indonesia Kaya Rasa. Each traditional food was processed in a different batch. Instruments used were cans with dimensions of height 300 mm and diameter 205 mm, Varin double seamer machine, ZonGon horizontal retort machine with a hot steam source from the boiler, data logger ELLAB CTF9004, 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).

2.2. Methods

2.2.1. Canning Process

This study used descriptive data analysis, no replication data. Freshly prepared food was weighed and put into cans with a net weight of 200 g at room temperature immediately. The composition of the ingredients in each traditional food in the can is shown in Table 1. Then the exhausting process is applied at a range temperature of 80-85 °C for 20 minutes to remove steam in the headspace of the can. So, the can is in a vacuum state when sterilized [3]. The next step was sealing the cans using a double seamer machine. According to the previous studies, the sterilization utilized an operating temperature of 121°C for 60 minutes in a retort machine. The last stage was cooling the canned product using water in the cooler box [7,8].

Table 1. Ingredient's composition of traditional food based on beef

Ingredients (Serving size 200 gr)	Percentage (w/w)		
	Empal Gentong	***Rawon***	***Kuah gandul***
Beef	50%	29%	20%
Coconut milk	26.75%	-	50%
Water	-	59%	-
Kluwek	-	4%	-
Shallot	7.15 %	2%	3%
Onion	< 1%	1%	4%
Leek	3.55%	1%	-
Turmeric	2.85 %	< 1%	-
Salt	2.15 %	1%	2%
Chives leaves	2.15 %	-	-
Red chili	-	< 1%	4%
Ginger	< 1%	< 1%	-
Candlenut	< 1%	< 1%	1%

2.2.2. F_0-value Calculation

During sterilization, product temperatures (T) and the retort temperatures were recorded using a data logger with an interval of 1 minute. Thermocouples were installed on the coldest point of the can, geometric axis. F_0-value Equation (1):

$$F_0 = \int_0^t \quad 10^{T-T_{ref}/z} dt \qquad (1)$$

Where F_0 is the heat-adequacy for the canned product which is expressed as the equivalent heating time (minute) at a constant temperature of 121.1 °C to inactive *Clostridium botulinum* spores. T is the product temperature (°C); Tref is a reference processing temperature (121.1 °C) and z value is 10 °C [9].

2.2.3. Chemical and Metal Analysis of Canned Products

Chemical characteristics of canned products were conducted based on six parameters, water, ash, protein, fat, carbohydrate content and energy. Chemical analysis of the samples was carried out based on the SNI 01-2891-1992 method. Parameters of metal contamination in canned products, namely lead, cadmium, cuprum, tin, mercury, zinc and arsenic were tested using the AOAC method (2005) and SNI 1998. Samples were sent to an accredited laboratory in Analytical and Calibration Laboratories Centre for Agro-Based Industry.

3. RESULTS AND DISCUSSION

3.1. Thermal Processing

The optimum sterilization method with an operating temperature of 121 °C can extend the shelf-life of canned traditional food to about one year [7]. Table 2 shows the thermal processing profile during sterilization of canned *empal gentong*, *kuah gandul* and *rawon*.

Table 2. Thermal processing profile during sterilization

Parameters (minutes)	*Empal gentong*	*Rawon*	*Kuah gandul*
Come up time (CUT)	24	17	14
Operator processing time	14	54	46
Cooling time	12	13	11
Lethality value (F_0)	4.02	10.09	10.17

In the operating procedure of the retort machine, the venting process aims to remove air in the retort so that the use of steam as the heating medium has uniform conditions. In addition, the air around cans can act as an insulator which can delay the heat penetration. If the venting process is completed within a certain time, the vent is closed, and the steam valve begins to open. Come up time (CUT) is the time required when the steam valve is opened until it reaches an operating temperature of 121 °C [10]. Heat distribution test periodically on the retort machine is needed in order to determine the venting time. CUT on each product is different because at the beginning of operation, the temperature inside the retort machine is still low as well as the product temperature. In addition, the large composition of the beef in the can also affects the heat transfer. Hariyadi (2014) stated that CUT periods contributed not significantly to attain lethality values during the sterilization process. About 40% of the CUT period is contributed to attain the required lethality values. Operator processing time is calculated when the retort reaches operating temperature until the initial cooling time. The processing time is very dependent on the desired lethality value. After the processing time is reached, the cooling process is carried out by closing the steam valve and opening the cooling water valve. The cooling process is carried out until the product temperature drops below 60 °C [10].

The lethality value or F0 value is an absolute requirement for commercial sterile products. According to the Regulation of National Agency of Drug and Food Control the Republic of Indonesia (BPOM RI) number 24 of 2016 concerning commercial sterile food, it is set a minimum lethality values (F0 value) of 3.0 minutes to provide a technical 12 log cycle reduction of the most heat-resistant microbe. The F0 value of canned empal gentong, rawon and kuah gandul were respectively 4.02, 10.09, 10.17 and met the recommended F0 value. Achieving the recommended F0 value >3.0 minutes at 121 °C would take the operating time of 60 minutes for these three kinds of traditional foods. F0-values of canned nasi goreng and nasi serundeng were respectively of 16.32 and 31.77 minutes, sterilized at 121 °C for 20 minutes for solid material in cans [7]. While canned product solid-liquid mixtures based on fish meat has an F0 value of 9.58 minute [11]. The previous research stated that the F0 value for processed meat products ranged from 8 - 15 minutes [5,10]. The difference in thermal processing of these three products is related with heat transfer of solid-liquid mixtures in cans, food material composition and properties [3, 11]. The lethality values above 3 minutes during the sterilization process are used to anticipate the possibility of imperfections such as resistant bacterial spores, poor sanitation, hygiene and to get the desired taste and texture of meat [12].

3.2. Metal Contamination

Heavy metal contamination in canned food products came from the environment along the food chain. During the sterilization, the metal can migrate from cans to food products due to the high temperatures. The maximum limit of heavy metals contamination in canned traditional beef-based food products set by the Indonesian National Standard (SNI) and The Indonesian Food and Drug Authority (BPOM RI) are listed in Table 3. All products studied showed heavy metal contamination below the limit.

Table 3. Metal contamination of cans products based on beef

Parameters (mg/kg)	*Empal gentong*	*Rawon*	*Kuah gandul*	SNI*	BPOM**
Lead (Pb)	< 0.031	<0.031	<0.034	1.0	0.50
Cadmium (Cd)	<0.004	<0.01	<0.007	0.3	0.05
Cuprum (Cu)	0.37	0.9	0.12	-	-
Zinc (Zn)	23.6	9.76	11.0	-	-
Tin (Sn)	<0.8	<0.8	<0.8	200	250
Mercury (Hg)	< 0.005	<0.005	<0.005	0.03	0.03
Arsenic (As)	<0.013	<0.003	<0.013	0.5	0.25

*) Indonesian National Standard (SNI) 7387:2009
**) The Indonesian Food and Drug Authority number 5 year of 2018

Lead contamination in food with exceeding concentrations will have a negative effect on human health [13]. The lead (Pb) and tin (Sn) contained in the can packaging comes from the solder between the body and the lid of the can. The presence of headspace in the can minimizes the contact between the lead from the can and the food material. Interaction between Sn and Pb with food products with low acid content causes sulfide strain or black stains on canned products, so canned food products must have a neutral pH.

Cadmium metal contamination is very important to observe in meat-based foods because cadmium is easily absorbed by organic substances in the soil. Soil containing cadmium will be eaten by plants then the plants are eaten by animals whose lives depend on plants. Essential heavy metals such as cuprum (Cu), selenium (Se), iron (Fe) and zinc (Zn) are important in the metabolism of the human body in an excessive amount. Meanwhile, heavy metals that have no function at all in the body are lead, mercury, arsenic and cadmium [14].

3.3. Chemical Characteristic

The results of chemical analysis in Table 4 showed the information about nutritional facts of the beef products. The higher the water content of three food products, the higher the initial water content caused by the type of soup. The ash content showed the mineral content in the main raw material. The main ingredients of beef minerals were K, Cu, Fe, P, Zn, Mg, Na and Ca. The average value of ash content in beef, is about 0.9 – 0.99% that varies from higher to lower value according to the type of beef sources and function of muscle in the beef [15,16]. In food products for humans, meat protein is an important nutritional source. Nutritional quality of meat proteins is largely dependent on their digestibility. Food processing (salting, drying, heating and sugar addition) can affect the meat protein structure and their digestibility [17].

Table 4. Chemical characteristic of cans products based on beef

Chemical properties	*Empal gentong*	*Rawon*	*Kuah gandul*
Water (%)	83.8	85.4	68.6
Ash (%)	1.87	1.43	0.91
Protein (%)	8.76	7.34	6.56
Fat (%)	3.73	5.52	1.94
Carbohydrate (%)	1.84	0.31	22
Energy (kcal/100g)	76	80	132

The meat protein quality is mainly concerned with the availability of amino acids present in it. The beef meat appears to have higher contents of three essential amino acids (valine, lysine and leucine). Their composition of amino acids in meat protein could also be affected by the application of processing techniques including heat and ionization radiations but only when the prolonged of these conditions. In a study found out that the effect of processing and the storage have imparted its effect on amino acids, in case of canned meat [15-17].

Fat content is defined as triglycerides that are esters of three fatty acid chains and the alcohol glycerol. Scientific evidence reported that cooking, grilling and pan-frying have a significant effect on fatty acid composition and meat fat content as well as considerable losses of fat [15-17].

Carbohydrate content in *kuah gandul* products is higher than others due to the addition of coconut milk during the cooking process. The main composition in coconut milk is fat, protein and carbohydrate. The chemical composition of coconut flesh varies according to the level of maturity and variety. The low maturity level of coconut flesh is rich in fat and carbohydrate while the higher maturity level the higher fat content [18]. Total energy from 1 g of food that contains carbohydrates, protein and fat are contributed as much as 4 kcal, 4 kcal and 9 kcal respectively.

3.4. Estimation of Added Value of Canned Traditional Food Products

Based on Table 1, the beef composition that is used for each canned traditional food ranges from 20% - 50% of the total serving size per package. Estimation of value added can be done by comparing the raw material price for class 1 beef which is used as the main raw material for the three traditional foods. The estimation of added value is limited only to the value of the main raw materials and the final selling value of the product. The principle is carried out as a form of ABC Analysis application to observe raw material inventory needs as a process cost optimization strategy [19,20].

Table 5 showed the prices list of raw materials for class 1 beef in traditional food production areas along with the highest retail prices on the market. The comparison is made between the prices of raw materials at each price level (producers, wholesalers, traditional markets, modern markets). Table 6 showed that the results about the added value in the range of 10.94 - 45.56%. This indicates that all these SME products can obtain the highest level of added value if they can obtain raw materials at the producer price level. It was not recommended for *kuah gandul* and *rawon* products to procure raw materials at modern market prices because its price can reduce added value which means it will become a source of loss. The canned *empal gentong* is a strategic product whose raw ingredients procurement can be flexible according to all level prices. It can be shown that the entire estimated value added is positive with a range of 23.18 - 45.56% starting from the modern market price level to the producer price level.

Table 5. Information about raw materials price and canned product price

Product	***Empal gentong***	***Rawon***	***Kuah gandul***
Origin	**Cirebon**	**East Java**	**Central Java**
Product Retail Price (Rp/can)	45000*	32500*	35000*
Producer Price (Rp/kg)	122500**	99010**	112990**
Middleman Price (Rp/kg)	130833**	105000**	119058**
Traditional Market Price (Rp/kg)	145000**	123750**	124757**
Modern Market Price (Rp/kg)	172850**	165150**	173967**

*Canned product with net weight approx. 200 gr per serving package
** Average weekly price in May and June 2021
**Source: https://hargapangan.id/ (2021)

Table 6. Estimation of added value based on composition and product price

Added value estimation	***Empal gentong***	***Rawon***	***Kuah gandul***
	Cirebon	**East Java**	**Central Java**
Producer price vs Beef cost (%)	45.56	23.84	10.94
Middleman price vs Beef cost (%)	41.85	19.23	6.16
Traditional market price vs Beef cost (%)	35.56	4.81	1.67
Modern market price vs Beef cost (%)	23.18	-27.04	-37.12

4. CONCLUSION

The sterilization process of traditional food based on beef is an alternative to extend the shelf life of the product. Controlling the sterilization process which includes come up time (CUT), operator processing and cooling time must be carried out carefully to obtain a recommended lethality value of >3 minutes. *Empal gentong*, *rawon* and *kuah gandul* have lethality values of 4.02, 10.09 and 10.17 minutes respectively, so that they are in accordance with The Indonesian Food and Drug Authority (BPOM) regulation on commercial sterile food. Food packaging using cans and processing at high temperatures is at risk of heavy metal contamination. Heavy metal contamination of arsenic (As), lead (Pb), cadmium (Cd), mercury (Hg) and tin (Sn) must be below the maximum limit on the SNI and BPOM regulation. The composition and properties of ingredients, beef raw material characteristics and cooking process affect the chemical characteristics of the canned product. Therefore, it is important to observe the change of nutritional content before and after the canning process on the next research.

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