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Ready-To-Eat Rice in Retort Pouch Packaging as an Alternative Emergency Food Product

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ABSTRACT

Recently, the rising incidence of natural catastrophe has increased the disaster preparedness, aiming to mitigate its devastating effect. Developing an emergency food is one of meaningful attempts to rise the preparedness. This research aimed to determine the best formula of ready-to-eat rice in retort pouch packaging accepted by consumers, and to determine the operating time to reach a lethality value (F_0) to meet the commercial shelf-stable food requirements as an emergency food. The thermal process adequacy (F_0) was used to determine the commercial shelf-stable products according to Indonesian regulation. The results showed that the determination of ready-to-eat rice was dependent on the ratio of rice and water. The most accepted product was determined according to quality attributes and organoleptic tests applied to meet the criteria for emergency food, namely color, flavor, and texture and best perceived by consumers. A formula with 140 g of half-cooked rice and 60 g of water was attributed to the best sample, having hardness of 7305.45 gf, elasticity of 36.40%, gumminess of 2185.720 gf, and adhesiveness of -167.975 g.s. In terms of microbiological quality, the TPC for the half-cooked rice sample reached 7.2×10^7 CFU/mL, while cooked rice in retort pouch packaging was <25 CFU/mL. Using heat distribution curve, heating at 110°C produced a come up time (CUT) after 40 min. Furthermore, the F_0 value was 4.12 which was in accordance with the Indonesian regulation.

Keywords: formula, lethality value, retort pouch, rice, water

INTRODUCTION

Indonesia is considered as one of the most disaster-prone countries in the world. In one-year period of January 1st 2020 and January 1st 2021, government recorded 2,592 natural disasters, and nearly half of which occurred on Java island, amounting to 1,554 incidents (BNPB, 2021). In response to these incidents, government and private sectors offered foods for refugees, including instant noodles, rice, and bottled water. Instant noodles and rice must be prepared prior to consumption. In situations where cooking is not possible, emergency food that is ready to eat is required.

Emergency food products (EFP) are specially processed food items which are designed to meet daily energy needs for human (2100 kcal) and consumed at abnormal situations such as floods, landslides, earth-quakes, droughts, fires, wars and other incidents causing humans unable to live normally. The energy requirement for one emergency food package is 233 kcal (Zoumas *et al.,* 2002).

The development of EFP should consider some critical characteristics, including (i) safe, (ii) acceptable attributes such as color, aroma, texture, and appearance, (iii) easy to distribute, (iv) easy to use; and (v) complete nutrition. EFP is designed to contain energy reaching 2100 kcal, which comes from 35-45 % fats, 10-15 % proteins, and 40-50 % carbohydrates (Zoumas *et al.,* 2002). In accordance with BPOM (Indonesian FDA) regulation for commercial sterilization food requirements, the product should have F_0 value of >3.0.

Currently, emergency food is developed in the form of military food through sterilization at 121°C for 20 min using a retort (Stanley *et al.,* 2018). However, the use of retort is unfeasible in disaster-susceptible areas such as Sukabumi, Probolinggo, and Malang. Due to its simplicity, pressure-cooker (*presto*) technology was used in this study. The use of the technology may allow National Disaster Mitigation Agency (BNPB) to prepare foods adequately for refugee.

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Carbohydrates are often the main chemical component in emergency food (Giyatmi dan Anggraini, 2017). Rice is a staple food for the majority of Indonesian people, provoking a very common expression “no rice no eat”. In general, rice is cooked with water, but the exact amount of water required is unknown, which could be associated with storability. In addition, cooked rice is often linked to its short shelf life, i.e. one day, which make it less effective for an emergency food. Therefore, investigating the exact ratio of rice to water in rice cooking in order to create packaged rice remains a great challenge.

This present work investigates the impact of rice formula (rice to water ratio) for making sterilized rice and determine the operating time to achieve a certain level of F_0 value as required for an emergency food. The greater F_0 value resulted in the better heat obtained by the product which prolong its product shelf life.

MATERIALS AND METHODS

Materials

The rice (variety IR-64) was obtained from local market in Dramaga, Bogor. Retort pouch packaging (20x15 cm) was used, filled with other ingredients namely vegetable oil (Bimoli), NaCl (fine salt), cooked chicken pieces, garlic powder, white pepper, soy sauce, sweet soy sauce and sesame oil.

The ratio of rice to water

The ratio of rice to water in the packaging was determined using the method described in a previous work (Shah *et al.,* 2017). The pouch was manually filled with 200 g (100 g of solid and 100 g of liquid). This process consists of two stages. The first stage was the rice boiling, enabling to water absorption (the quantity of water used is 80% of the rice weight), thus half-cooked rice was obtained. The ratio of half-cooked rice to water was set in each packaging as follows: (1) 140 g:60 g, (2) 150 g:50 g, (3) 160 g:40 g, (4) 170 g:30 g, and (5) 180 g:20 g (Souripet, 2015). The second stage was the measurement of the adequacy of thermal processes. At this stage there was the addition of protein in the form of pieces of cooked chicken meat (15% of the weight of half-cooked rice) to the package. The composition used in the selected product was 131.6 g of half-cooked rice, 11.81 g of meat and 56.4 g of water, amounting a total weight of 200 g (Figure 1).

Thermal process adequacy (F_0)

The selected products from the optimization stage were analyzed for the adequacy of the thermal process using a 25-liter NAGAMI brand pressure-cooker pan with a specially ordered support rack (Figure 2). The half-cooked rice was then packaged in a retort pouch and added with chicken pieces (15% protein). The trapped water in packaging was expelled manually. After filling, the package was sealed using a sealer machine (KS-F350, Indonesia) and sterilized for 45 min at 110°C, started with come up time (CUT). Measurement of F_0 values during the heating process was conducted using F_0 meters Ellab TMP 248129-1 series number 280235 and 280240. After sterilization was complete, the stove was turned off, allowing to cool for 30 min, and the hot air was gradually removed through the bleeder. In a pressure cooker, the bleeder was a part where the airflow occurred.

Figure 1. Ready to eat rice in a retort pouch packaging with 5 different rice and water ratios, namely: (1) 140:60, (2) 150:50, (3) 160:40, (4) 170:30, and (5) 180:20

Hedonic testing

Hedonic test following a study by Ares *et al.* (2014) was carried out with 60 untrained panelists (30 males and 30 females, age range of 19-45 years old). The attributes (color, aroma, taste, texture, and overall) were assessed through 4-scale points: (1) strongly dislike, (2) dislike, (3) like, and (4) like very much. Each panelist tasted 5 samples. The data were analyzed by Analysis of Variance (ANOVA) at level of 5%, and Duncan test was carried out to verify the differences.

Texture analysis

The texture of samples (similar dimension) was measured by TA-XT2i Stable Microsystem Texture Analyzer (Stable Micro Systems, UK), using cylindrical probe (Figure 3) with a speed of 1.5 mm/second (Fibrianto *et al.,* 2019). When sample was ready, texture analyzer was operated, while the computer recorded the force automatically (N). Each type of sample was measured five times. Textural parameters included hardness, elasticity, gumminess and adhesiveness.

A

B

Figure 2. Pressure cooker (A) with aluminum retort pouch basket (B)

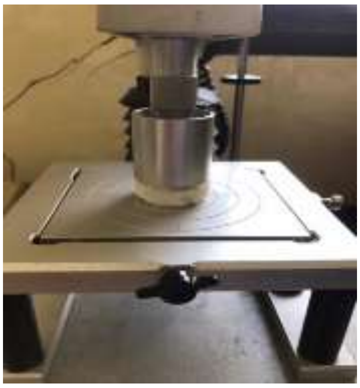


Figure 3. Cylindrical probe type 35 mm

Total plate count analysis

The microbiological testing began with the sample mixing in sterile KH_2PO_4 diluent solution. 1 mL of sample was aseptically transferred to 9 mL of sterile distilled water (dilution 10^{-2}). This step was repeated until a dilution of 10^{-4} was obtained. A total of 1 mL of each dilution was aseptically inoculated into a petri dish in duplicate, then incubated at 37°C for 48 hours and the colonies formed were counted (Kurniadi *et al.,* 2019). The colony range conformed to Bacteriological Analytical Manual (BAM) standard established by Food and Drug Administration (FDA), reaching 25-250 colonies per petridish (Sutton, 2012).

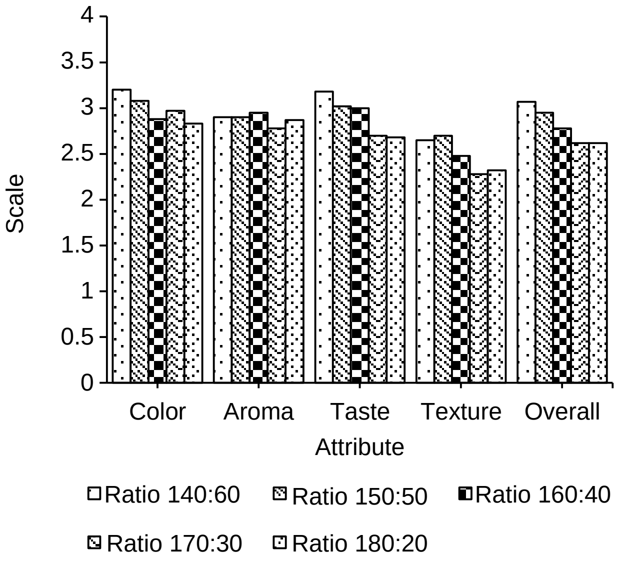
Data analysis

The samples were prepared in triplicate and analysed in *triplo*. The statistical analysis was performed in SPSS 25 software using non-parametric test, namely Friedman test for organoleptic testing.

RESULTS AND DISCUSSION

Sensory characteristics

Organoleptic test was carried out to determine product acceptance. This is imperative since EFP should concern sensory attributes such as color, aroma, texture, and appearance (Zoumas *et al.,* 2002). The samples were considered “acceptable” when they had average acceptance score of 3 (likes) to 4 (very likes) for each attribute (color, smell, taste, texture, and overall). As depicted in Figure 4, sample with a rice-to-water ratio of 140:60 showed acceptance score of 3 from panelists.



Note: Parameter values 1 (strongly dislike), 2 (dislike), 3 (like) dan 4 (like very much)

Figure 4. Organoleptic test results for ready-to eat rice in retort pouch packaging

The quality of cooked rice, primarily its texture, can be represented by its amylose content. Rice with high content of amylose is not sticky (locally known as *pera*), in contrast, rice with low amylose content resulted in sticky texture (locally known as *pulen*). Amylose level is closely related to water absorption (Luna *et al.,* 2015). The rice and water ratio at 140:60 resulted in the highest rating value, in terms of overall attribute (Figure 5). This is because the sample contains a higher proportion of water compared to other samples, leading to sticky rice texture, which was more preferred by consumers, especially those from Java. Intriguingly, the *pulen* or sticky rice was not always preferred by Indonesian people. The people of West Sumatra often prefer *pera* or non sticky rice (Syamsir *et al.,* 2014). In addition to *pulen* rice texture, color and taste attributes of the sample was much preferred by consumers.

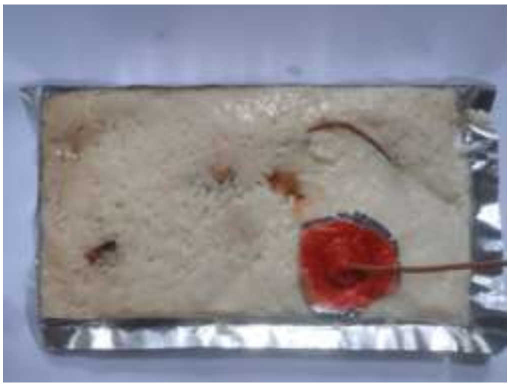


Figure 5. The appearance of sample prepared with rice to water ratio of 140:60

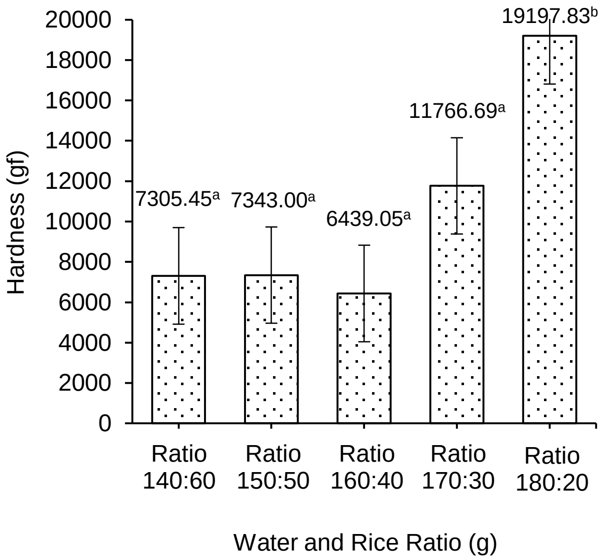
Hardness

Hardness is one of the important factors in the assessment of food quality, especially cooked rice products. Simply, it represents the magnitude of the pressure required to make the product break or break apart (Sugiyono *et al.,* 2013).

Figure 6 demonstrated that sample with rice to water ratio of 180:20 had the highest hardness, reaching 19197.83 gf. This related to the limitation of water absorbed by starch during gelatinization, leading to non sticky texture (Juwita, 2020). In addition, such hard texture resulted from storage at room temperature prior to testing, which provoked retrogadation, namely reassociation of hydrogen bonds from amylose and amylopectin (Rahmadi, 2020). The limited amount of water and space in the packaging also enhanced the integrity between rice grains, leading to more dense structure.

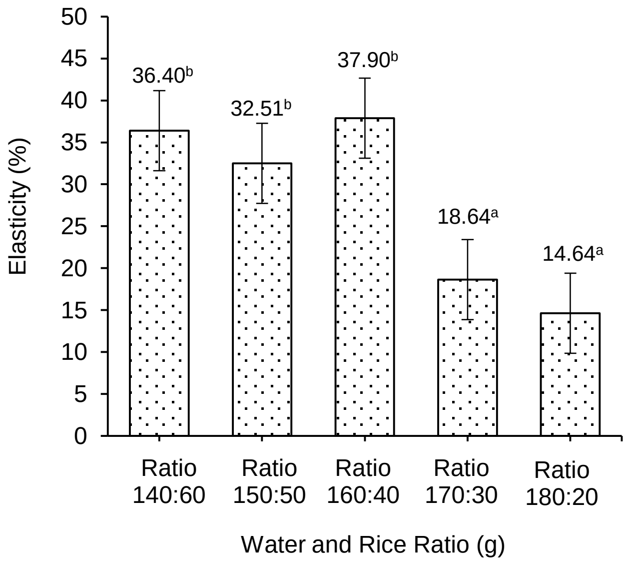
Elasticity

Elasticity represents the ability of food products to return to their original form after breaking due to tensile force (Thomas *et al.,* 2014). In this work, sample elasticity can be seen in Figure 7, reporting the highest value (37.90%) achieved by sample with rice:water ratio of 160:40. The elasticity properties can be affected by the content of amylose. IR-64 rice contained a moderate level of amylose (Aziez *et al.,* 2016). Low or moderate amylose rice tends to have higher elasticity properties (Biduski *et al.,* 2018). Meanwhile, sample with ratio of rice to water (140:60) was found as the best composition regarding its elasticity. The proportion of rice and water markedly affects the elasticity of sample, where the more water leads to sticky rice texture. Conversely, the less water results in non sticky rice texture.



Note: Different numbers show significantly different values (p<0.05). The same number shows that the values are not significantly different (p>0.05)

Figure 6. Hardness of ready-to-eat rice in retort pouch packaging

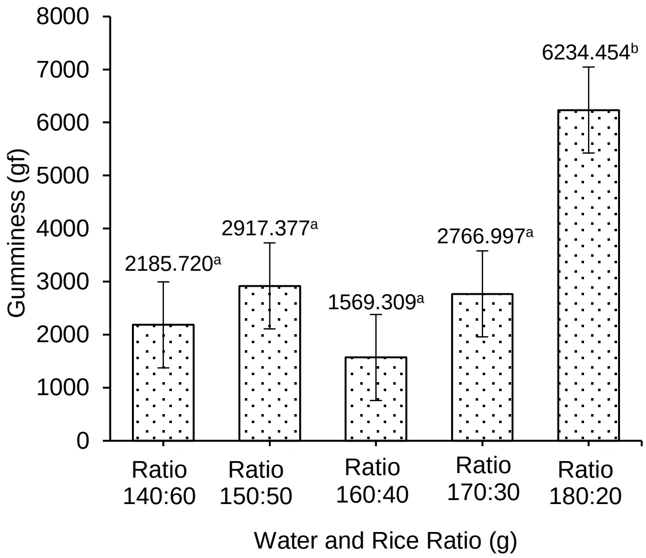


Note: Different numbers show significantly different values (p<0.05). The same number shows that the values are not significantly different (p>0.05)

Figure 7. Elasticity of ready-to-eat rice in retort pouch packaging

Gumminess

Gumminess is the durability properties of materials to escape or break by the presence of compressive power. As presented in Figure 8, sample with ratio of rice : water (180:20) had the highest value of 6234.454 gf. Gumminess positively correlated with hardness. The higher amylose leads to the rise of gumminess.



Note: Different numbers show significantly different values ($p<0.05$). The same number shows that the values are not significantly different ($p>0.05$)

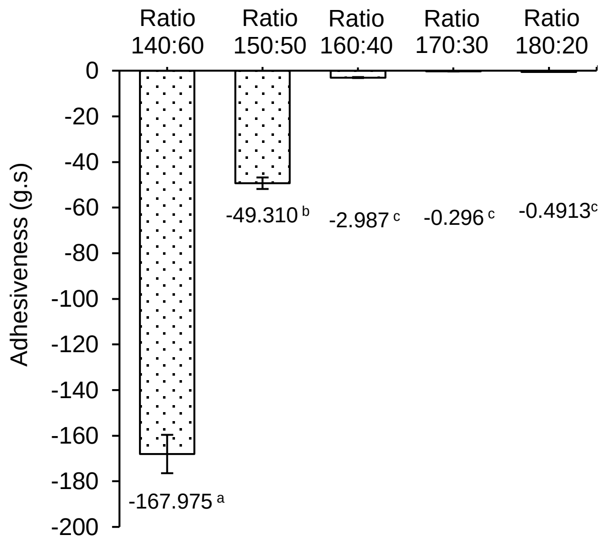
Figure 8. Gummines of ready-to-eat rice in retort pouch packaging

Adhesiveness

Adhesiveness is a physical attribute that describes the stickiness of food in the teeth when chewed in the mouth. It indicated the amount of energy needed to overcome the tensile forces between the food surfaces (Qiu *et al.,* 2021). Figure 9 shows that samples with a ratio of rice to water (140:60) had the highest adhesiveness (67.975 g.s). The sample contained more water content when compared to other samples. The more water decreased the hardness, but increased adhesiveness (Li and Gilbert, 2018). Water absorbed by starch can act as a plasticizer in amorphous areas and produce a chewy, sticky texture (Qiu *et al.,* 2021).

Total plate count (TPC)

Water was perfectly absorbed in a half-cooked rice through a heating process equal to pasteurization. In general, pasteurization is the process of heating at relatively low temperatures (<100°C) and aims to destroy vegetative cells from microbes but not kill their spore cells (Hariyadi, 2019). For this reason, microorganisms are stil present in the sample. Meanwhile, in the pouch packaging rice sample, no microorganims was detected, since it was processed differently, using the sterilization process. In this process, the heating was performed at high temperatures (>100°C) with the aim of killing all pathogenic microorganisms both vegetative cells and spore cells (Hariyadi, 2019). As seen in Table 1, a half-cooked rice sample has a microbial count of 7.2×10^7 CFU/mL. Meanwhile, in sterilized samples, the microbial count was <25 CFU/mL.



Note: Different numbers show significantly different values ($p<0.05$). The same number shows that the values are not significantly different ($p>0.05$)

Figure 9. Adhesiveness of ready-to-eat rice in retort pouch packaging

Lethality value (F_0)

Heat distribution measurements were carried out at 110°C. Based on the heat distribution curve (Figure 10), it can be seen that all thermo-couples have reached temperature 110°C after warming up for 40 min, suggesting that CUT value was set for 40 min. The heat distribution curve also showed that the entire measurement point takes almost the same time to reach the desired retort temperature. This indicated that the heat is equally distributed inside the retort.

Based on the heat penetration curve (Figure 11), the lethality value F_0 can be calculated. The heat penetration curve also showed the heating and cooling profiles. The data obtained was used to calculate F_0 and estimate the processing time. According to Hariyadi (2019), F_0 value for the sterilization process was 12×0.25= 3 min at temperature of 121.1°C. The value was derived from D value (0.25) and Z value (10°C) at standard temperature of 121.1°C for *Clostridium botulinum*. In this study, it was expected that there was a decrease in the number of *Clostridium botulinum* by 12 logarithmic cycles (12 D process).

Table 1. Total plate count (TPC) on ready-to-eat rice in retort pouch packaging

Sample	Replication	Dilution Factor 10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	CFU/mL
Half-cooked rice	1	TBUD	TBUD	TBUD	TBUD	TBUD	88	7.2×10^{7}
	2	TBUD	TBUD	TBUD	TBUD	TBUD	56	
Retort pouch packaged rice	1	0	0	0	0	0	0	<25
	2	0	0	0	0	0	0	

Note: TBUD = >300 CFU/g

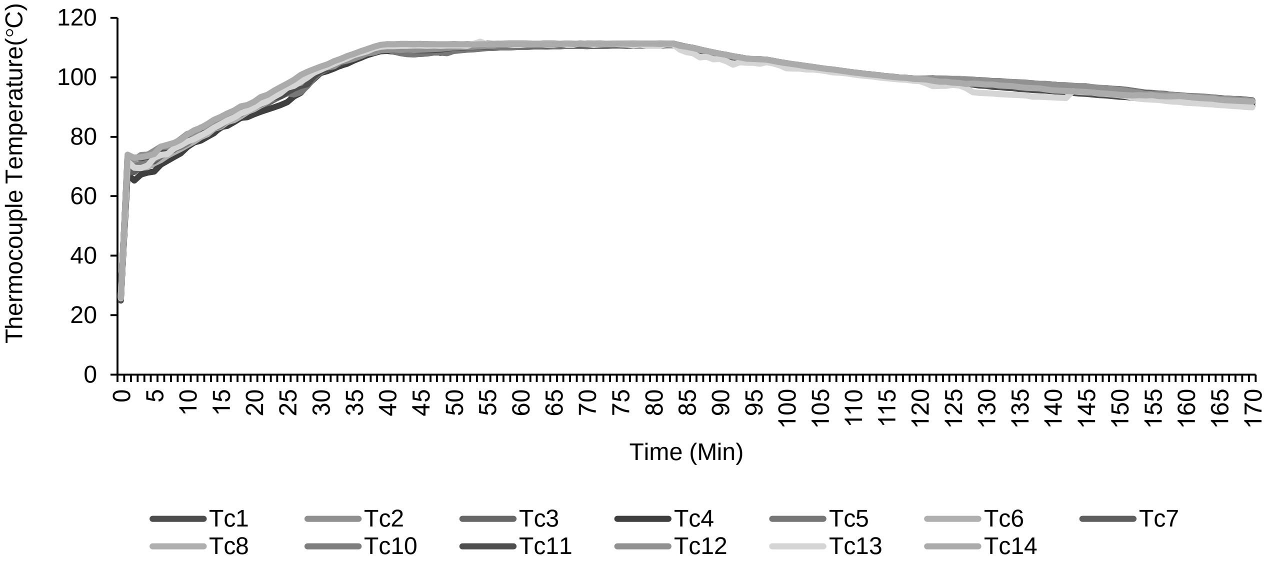


Figure 10. Heat distribution curve

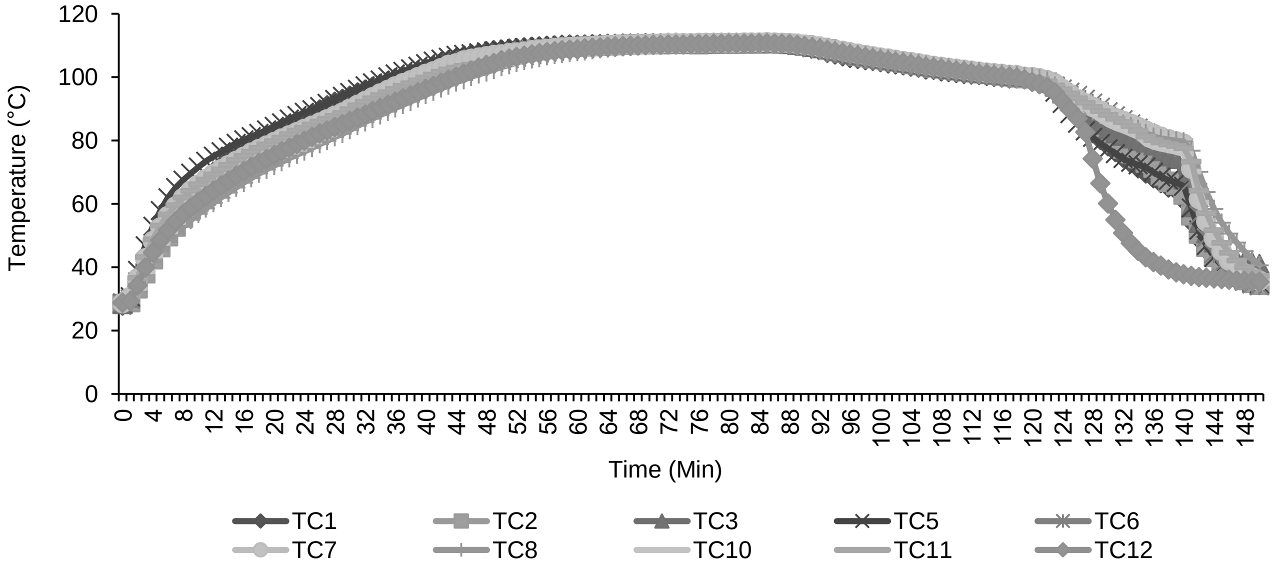


Figure 11. Heat penetration curve

Heat penetration was calculated using the general method. In this case, F_0 was calculated by plotting letality value (LR) against time, in which partial F_0 was obtained from the trapezoidal area by summing two consecutive LR values and then divided by two and then multiplied by the time change value from one LR to the other. The partial F_0 value was then summed to get the accumulative F_0 value and then this total F_0 value was confirmed as the product's F_0 value.

In the study, F_0 value was 4.12 at the temperature 110°C for 45 min starting from cut time for 40 min. As a comparison, canned rice using IR64 rice had a sterility value (F_0) for 15 min, having a greater sterility value when compared to ready-to-eat rice packaged in a retort pouch. The difference between the two products was a type of sterilizer. Canned rice used a retort, which required higher costs. Meanwhile, the pouch rice used a pressure cooker which was more easily applied (Syamsir *et al.,* 2014). This product can be safely stored at room temperature. Compared with a competitor, the ready-to-eat rice product with various variants of side dishes must be stored in refrigerator. The quality was maintained by using proper serving preparation such as boiling or microwave.

CONCLUSIONS

The most proper product was selected based on quality and organoleptic attributes, aiming to fit the criteria for emergency food, including color, flavor, texture, that were most accepted by consumers. As a result, the best sample received the average acceptance value of 3 (likes), prepared with the ratio of 140 g rice and 60 g water, resulting in hardness 7305.45 gf, elasticity 36.40%, gumminess 2185.720 gf, and adhesiveness -167.975 g.s. TPC for half-cooked rice sample was 7.2×10^7 CFU/mL, while the sterilized rice in packaging retort pouch reached TPC <25 CFU/mL. Based on heat distribution curve, at the temperature 110°C, it generated a CUT time after 40 min. In the study, F_0 value of 4.12 complied with BPOM regulation for commercial sterilization food, namely F_0 of 3.0.

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