Optimizing Process Conditions for Sterilization of Plastic Tray Products in Water Spray Retort

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Keywords: Plastic Tray Product, Sealing Conditions, Thermal Process, Water Spray Retort.

Abstract: Effect of some parameters in packing and retorting on the thermal process of a two-hole plastic tray product, were investigated. The research aimed to obtain a high-quality product with a safe procedure for thermal processed ready to eat rice and fried chicken with garlic and pepper product. Effects of head space, vacuum level, sealing temperature, delay time of product, temperature and pressure of retort on defect occurrence of package were investigated. Heat penetration profile and sterility test of product were examined to obtain target F_o value. The optimum process conditions for the products packed in the two-holes plastic trays were 115°C and 1.5 bar. The total come up time was 25 minutes and process time was 45 minutes to achieve the target F_o value of the products. The cooling period was applied by holding products at 1.5 bar for 2 mins at temperature of 100°C. The head space of the product, rice and fried chicken with garlic and pepper" in the tray should be less than 3/16 inch and 4/16 inch, respectively. Sealing conditions without leakage of the two-hole plastic tray product with film were achieved when spend 0.5 sec to reach the vacuum condition and sealed at 195°C for 1.3 sec. In addition, the changes in chemical and sensory characteristics of the products during storage for 12 months at room temperature were determined. The acceptable quality of the products during storage were obtained.

1 INTRODUCTION

Plastic trays is the alternative from semi rigid packaging to tin cans for the thermal processing of ready to eat. In the commercial heat sterilization of foods in cans or retortable pouches and plastic trays, the container is heated in pressurized steam or hot water retort at certain condition of temperature and time. (Mokwena, K. K. and Tang, J, 2012) The optimum process temperature, which guarantees destruction of all spoilage factors and maximum preservation of quality constituents depends, among other things, on the rate that heat penetrates to the coldest point in the container to good test and appearance of products.

The original products of factory were ready to eat rice and Thai style food packed separately in retort pouch and plastic cup, then new package type was applied to be two holes plastic tray for more convenience.

The aim of the study was to obtain the optimum conditions of package sealing and thermal process for producing the product packed in two holes plastic tray to achieve both safe to consume and good appearance for quality of food and packaging.

2 MATERIALS AND METHODS

2.1 Materials

2.1.1 Rice

The solution for cook rice consisted with citric acid 0.08 % and salt 1.0%. The rice was precooked at 100°C for 5 mins. The rice storage period of 5 months or old rice that used for experimental. The moisture of rice after cooked was 58.6 %. (AOAC,1995)

2.1.2 Chicken

The chicken breast were sliced and mixed with exact ratio of baking powder. The precooked at 100°C for 7 mins. (Drotz, H, .2012) Precooked chicken was mixed with garlic and pepper sauce in the ratio of 70:30.

Plodklaew, K. and Wattanachant, S.
Optimizing Process Conditions for Sterilization of Plastic Tray Products in Water Spray Retort.
DOI: 10.5220/0009993000002964
In *Proceedings of the 16th ASEAN Food Conference (16th AFC 2019) - Outlook and Opportunities of Food Technology and Culinary for Tourism Industry*, pages 91-96
ISBN: 978-989-758-467-1

2.1.3 Trays

The size of two holes plastic tray is 118x179x40 mm. The layer structure is PP/PP + Additive/Tie /EVOH/Tie/PP + Additive/PP and their thickness is 1000 micron as shown in figure 1.

2.2 Methods

Factors have been analyzed since the preparation of raw materials filling, sealing condition and sterilization profile in retort.(Lakshmana, ., Kumar R., Kumaraswamy, T. JH., Jayaprahash, CNadanasabapathi, ,2013) Figure 2 shown that the factors were headspace, delay time of products, temperature sealing vacuum level and profile of retort. The resulted from plastic cup were tested and compared with two holes plastic tray to find suitable condition and reduce defect of product.

2.2.1 Condition Process

The old products were ready to eat rice in plastic cup size 109x59 mm and stirred fried chicken with garlic and pepper in plastic cup size 109x37mm and retort pouch. To combine the packaging into one, the two holes plastic tray was selected. However, we found that the problem of defect caused by products from rice. Therefore, it represents the development of products for packing in two holes plastic trays.

2.2.2 Over Pressure Water Spray Retort

The pilot-scale overpressure retorting FM, Thailand consisting of retort, boiler, air compressor, centrifugal pump, and the control system (PLC) was used for thermal processing. The FMC retort used in the study is similar to the commercial-scale equipment, which trays a high degree of process reproducibility and accuracy. After processing the trays to a required F_o value, they were cooled rapidly to 50 ± 10°C by spraying water under pressure and further cooled in chilled water immediately after taking out from the retort. (Williams, T.S., 2012).

2.2.3 Thermol Process Evaluation

The temperature Microprocessor " Ellab" Evalflex was connected through the body of the retort by copper with constant thin wire leads and scaled into a pressure tight gland fitted. The 15 leads terminated in male Ecklund plugs inside the retort for direct connection to compatible Ecklund stainless steel sheathed needle copper constant thermocouple, another terminated side is connected to Temperature Modules available in 15 channels module (Measuring Range: -60°C …+170°C, Measuring Accuracy : +/- 0.1°C). Heat penetration characteristics of thermal process of ready to eat rice and fried chicken with garlic and pepper was determine (Stowe, C .H ., Smith, G .L., Thomas, R .L., Whiteside, W .S.,2016). Figure 3 showed the middle of trays were fixed with thermal couple. The intention of the temperature distribution study was to set an appropriate come-up cycle for the retort in order to achieve an efficient come-up which may effect the rate of heat transfer and process lethality during the cooking cycle of the process. (Tang, F.,,Xia, W.,Xt, Y., Jiang, Q., Zhang, Q., Zhang, W.,Zhang, L,2014)

2.2.4 Filling and Sealing

Determine the optimum weight for packing the rice and chicken meat in the two-hole plastic tray packaging to suit the consumption per 1 serving of 150 grams of rice and fried chicken with garlic and pepper was at 75 grams. Then weight of heat penetration was 165 grams of rice and fried chicken with garlic and pepper was at 95 grams. Total net weight was 260 grams. Adequate numbers of retort pouches were fixed with thermocouples and the tip of the thermocouple was inserted into the rice and chicken pieces as shown in figure 3. The trays were sealed with a pneumatic machine (SAMRAK engineering, Thailand). The sealed tray were subjected to thermal processing for optimizing the F_o value at process temperature.(Abhishek, V., Kumar, R., Geroge, J., Nataraju, S., Lakshmana, J. H., Kathiravan, T., Madhukar, N. Nadanasabapathi., 2014).

Figure 1: The size of two holes plastic tray 118x179x40 mm with layer structure is PP/PP + Additive/Tie /EVOH/Tie/PP + Additive/PP.

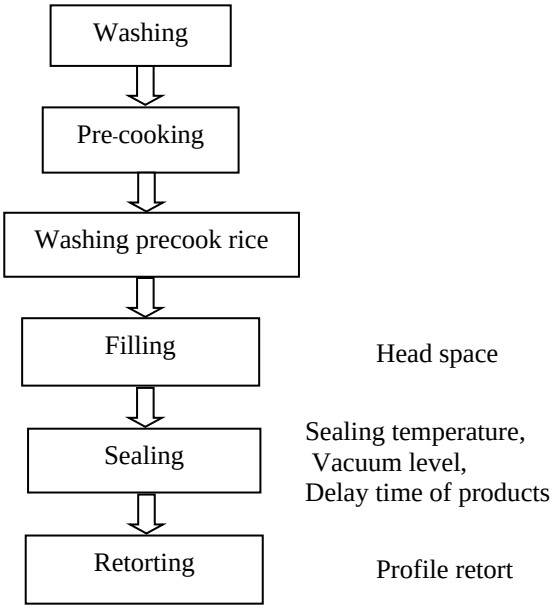

Figure 2: Factor affecting of defect from product of rice in plastic cup.

Figure 3: Placed the largest possible pieces of chicken on the thermocouple.

3 RESULTS AND DISCUSSION

3.1 Head Space

Headspace, the distance between the surface of food and the underside of the lid, allows for expansion of food solids or bubbling up of liquid during processing. Adequate headspace allows a vacuum to form during the processing of the food. The samples rice of cup and two holes plastic trays were pressed for three different headspace to 4/16, 7/16 and 9/16 inches. They placed in retort at 116°C for 40 mins at pressure 1.6 bar and pressure cooling hold at 1.6 bar and reduce temperature from 115°C to 110°C within 2 mins. The results from figure 6 showed the largest amount of defect was at 9/16 inches of the head space in two holes plastic tray. The small amount of defect were found pound in two-hole plastic tray for 4/16 inches.

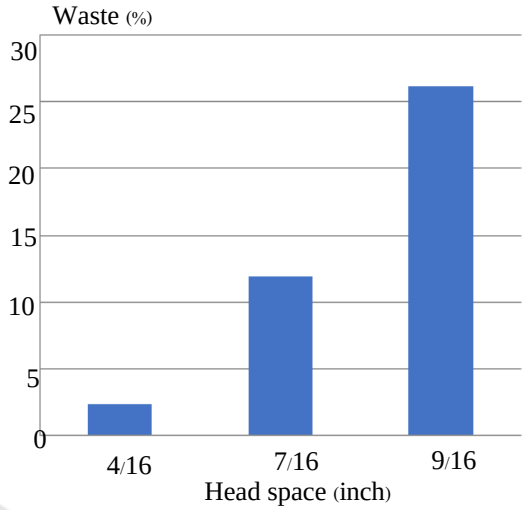

Figure 4: Effect of head space on defect of two-hole plastic trays.

3.2 Sealing Temperature

Sealing Process: Proper sealing conditions include temperature, pressure and sealing time. Figure 5 showed that sealing temperature of two holes plastic tray at 185°C were leak 100% and the other sealing temperature at 195°C were pound 4.5. %The sealing temperature at 205°C was burn. At present, the plant used sealing temperature at 195°C for two holes plastic tray by Samrak machine.

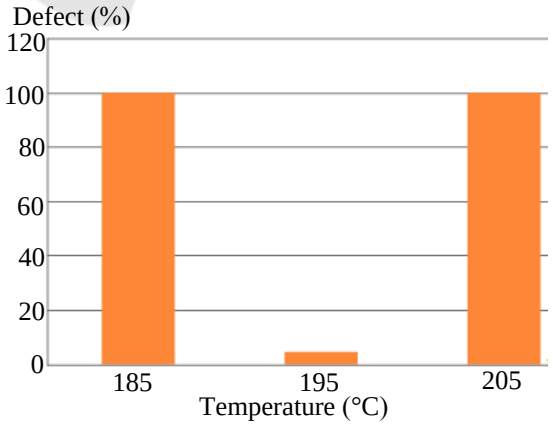

Figure 5: Effect of sealing temperature on defect of two-hole plastic trays.

3.3 Vacuum Level

Table 1: Effect of different vacuum level on defect of plastic cup.

Vacuum Level (sec)	Sample (cup)	Defect (cup)
0.3	90	90 (100%)
0.4	90	18 (20%)
0.5	90	0

The factor vacuum level for products in cup with three different level were 0.3, 0.4 and 0.5 sec that sealed by G.Mondini machine. The result showed on table 1 that the best vacuum level was 0.5 .The vacuum level affected pound and leak for semi rigid packaging that were determined for two holes plastic trays.

3.4 Target Temperature

For thermal process evaluation, filled and sealed cups and trays were heat processed to the required F_o values. Ellab Eval Flex sixteen Channel Thermal Validation and Sterilization Monitoring System, Thermometer and F_o value integrator was used to record core temperature, retort temperature, F_o value, and cook value (CV) at a specific time interval of 60 s. The F_o constants were programmed at T = 121.1°C, Z= 10°C. Thermocouple outputs (time- temperature data) were analysed using a computer. The heat penetration data were plotted on a semi- log paper with temperature deficit (retort temperature-cold spot temperature) on log scale against time. Lag factor for heating (J_h), slope of the heating curve (F_h), time in minutes for sterilization at retort temperature (U), and lag factor for cooling (Jc) were determined. The process time was calculated by a mathematical method. Total process time was determined by general method and the 58% of the come- up time. CV, a measure of heat treatment with respect to texture changes that occur during processing. The samples process at suitable for F_o value were incubated at 37° for 15 days and at 55°C for a minimum of 5 days). The sample was done according to AOAC (AOAC,1995).

Table 2 shown the results that the target temperature at 115°C were 100% of pound but the 5% at vacuum level 0.5 sec at pressure in retort 1.5 bar.

3.5 Profile Cooling

The suitable come up time profile retort was 115°C at 1.5 bar and the cooling profile was dropped the

Table 2: The effect of vacuum and pressure level during heating in retort on defect of two-hole plastic tray.

Temp (°C)	Vacuum level	Pressure	Defect
115	**0.5**	1.4	leak100%
		1.5	**Pound5%+normal 95%**
		1.6	Pound 100%
	1.0	1.4	Pound 100%
		1.5	Pound 100%
		1.6	Pound 100%
	1.5	1.4	Pound 100%
		1.5	Pound 100%
		1.6	Pound 100%

Table 3: Effect of profile cooling on defect of two- hole plastic tray.

Temperature step 1 (°C)	Pressure in retort (bar)	defect
110	1.5	Pound32 %
	1.3	Pound+leak+ damage seal 22%
100	**1.5**	**Normal**
	1.3	Leak42%
90	1.5	Leak100 %
	1.3	Pound+leak+ damage seal 16%

temperature from 115°C to 100°C and hold the pressure at 1.5 bar for 2 mins as shown in Table3.

3.6 Processing Time

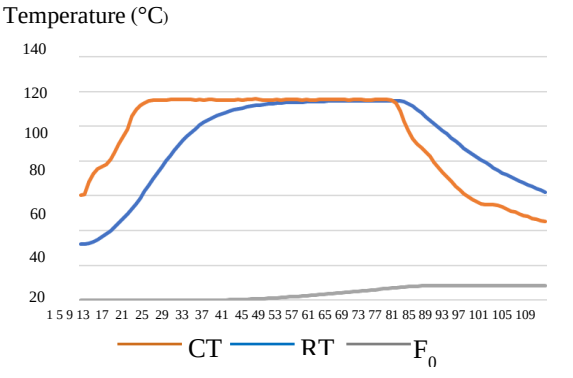

Figure 8: Total process time taken to reach the F_0 value of rice. The ready to eat rice was thermally processed at 4.21 mins. F_0 value for 45 min at 115°C, 1.5 bar in retort.

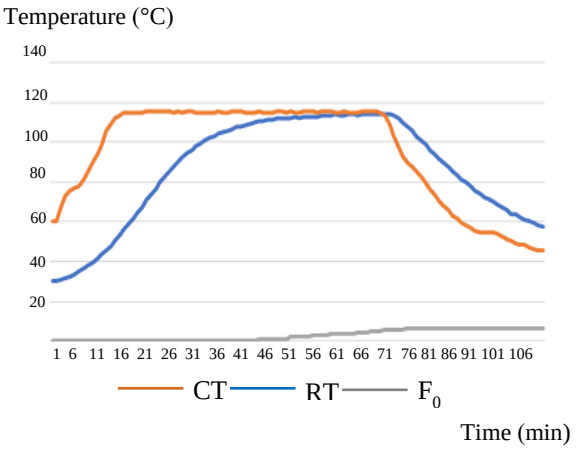

Figure 9: Total process time taken to reach the F_0 value of chicken with garlic and pepper. The ready to eat chicken with garlic and pepper was thermally processed at 6.26 mins. F_0 value for 45 min at 115°C, 1.5 bar in retort.

Laced the test pouches in the established slowest heating point in FM retort (DrotZ H, 2012). The retort was full of dummy trays that 7%solution starch was contained. The retort temperature up by following the come up time procedure as per heat distribution study was 25 mins. The ready to eat rice and fried chicken with garlic was thermally processed at 4.21 and 6.26 $F_{o\ value}$ for 45 mins at 115°C, 1.5 bar (Ali A.A, 2006, Abhishek V, 2014) in retort that showed from figure 8 and 9 .

3.7 Shelf-Life of Products

The changes in the color parameters during thermal processing of ready to eat rice and fried chicken with garlic and pepper by hunter lab (L*a*b*) that showed that all products increase in lightness (L*value) and yellow color (b*value) (Hunter lab colorimeter) method Chen,Lu and Lii (1999). Inspection period are 1,2,3,6,9 and 12 months.(Tang, F.,,Xia, W.,Xt, Y., Jiang, Q., Zhang, Q., Zhang, W.,Zhang,2014)

The maximum force required to cut the sample was determined by shear force. The piece of sample was placed on its side in Texture analyzer (Texture Analyzer model CT3, Brookfield, UK) (R. K. Majumdar., D. Roy., A. Saha. 2017.) The resut shown on table 4 and 5.

Table 4: Sensory score of ready to eat rice of two holes tray.

Rice				
time (month)	color	Body	texture	Overall acceptance
0	5.25±0.45	4.51±0.51	4.16±0.57	4.66±0.49
1	5.08±0.51	4.83±0.57	4.66±0.49	4.66±0.49
2	4.75±0.62	4.66±0.49	4.33±0.49	4.75±0.45
3	5.00±0.42	5.41±0.51	4.75±0.45	4.83±0.38
6	4.58±0.51	5.25±0.45	4.75±0.45	5.16±0.57
9	4.28±0.11	5.55±0.53	4.80±0.45	5.06±0.17
12	4.21±0.52	5.36±0.38	4.65±0.15	5.10±0.5

Table 5: Sensory score of ready to eat chicken with garlic and pepper of two holes tray.

time (month)	color	Texture	Overall acceptance
0	4.83±0.38	4.58±0.51	5.00±0.42
1	4.58±0.51	4.58±0.51	4.75±0.45
2	4.50±0.52	4.33±0.49	4.58±0.51
3	4.33±0.49	4.00±0.73	4.33±0.49
6	4.13±0.38	4.03±0.38	4.03±0.38
9	3.93±0.11	4.15±0.27	4.22±0.33
12	3.78±0.18	4.00±0.18	4.10±0.28

4 CONCLUSIONS

The optimum process conditions for the products packed in the two-holes plastic trays were 115°C and 1.5 bar. The total come up time was 25 minutes and process time was 45 minutes to achieve the target F_0 value of the products. The cooling period was applied by holding products at 1.5 bar for 2 mins at temperature of 100°C. The head space of the product, rice and fried chicken with garlic and pepper in the tray should be less than 3/16 inch and 4/16 inch, respectively. Sealing conditions without leakage of the two-hole plastic tray product with film were achieved when spend 0.5 sec to reach the vacuum condition and sealed at 195°C for 1.3 sec. In addition, the changes in chemical and sensory characteristics of the products during storage for 12 months at room temperature were determined. The acceptable quality of the products during storage were obtained.

ACKNOWLEDGEMENTS

We would like to thanks Prince of Songkla University for funding support.

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