

Design and development of small-scale pasteurizing equipment for thermal processing of acidified bamboo shoot packed in rectangular package

¹Pitukuteepong P., ²Yoovidhya T., ³Chaiwanichsiri S.

¹ Division of Agricultural and Food Engineering, Pibulsongkram Rajabhat University, Pitsanulok

²Department of Food Engineering, King Mongkut's University of Technology Thonburi, Bangkok

³Department of Food Technology, Chulalongkorn University, Bangkok

Abstract

The aim of this research was to design and construct a small-scale pasteurizer for thermal processing of acidified bamboo shoot packed in a rectangular can. The design was based on food hygiene, economic consideration, and production capacity. Boiling water was used as a heating medium and a temperature distribution test was conducted to investigate the slowest heating zone in the equipment. It was found from the experiment that the slowest heating zone in the boiling equipment was migratory. The position of the fire wood and wind direction regulated the location of the slowest heating area; however, the left side of the equipment had a tendency to be the slowest heating zone. Furthermore the result demonstrated that the maximum difference in the heating medium's temperature in the same batch at various positions was 5°C. The maximum difference in heating time between the fastest and slowest positions, to reach the desired heating temperature was 10 minutes.

Keywords: Rectangular can / Slowest heating zone / Temperature distribution / Thermal processing

Corresponding author: E-mail:

การประชุมวิชาการนานาชาติวิทยาศาสตร์และเทคโนโลยีทางการเกษตร ครั้งที่ 1 21-22 กรกฎาคม 2554 **CAST2011-P-18**

The 1st International Conference on Agricultural Science and Technology, 21-22 July 2011

Introduction

Bamboo shoot contain a low fat but rich in dietary fiber and mineral. In Thailand bamboo shoot are seasonally harvested between July and September. Due to seasonal availability of bamboo shoot, processing for enhancement of shelf life of the value added product assume great significance for business potential (Satya, 2009). The food borne botulism outbreak caused by small-scale canned bamboo shoots was reported by Thailand Ministry of Public Health (TMPH) (Centers for Disease Control and Prevention, 1999). One of the possible cause for the outbreak is an under sterilizing process. This research aims to design and construct a small-scale pasteurizer for thermal processing of acidified bamboo shoot packed in rectangular can. The work was divided in to two parts. The first part concerned with design and construct the pasteurizer. In the second part, a temperature distribution test was carried out to investigate the slowest heating zone in the pasteurizing equipment.

The basic engineering requirements of process equipment are the containment of material, the strength of the components, the efficiency of the operation, and the transfer of energy during processing. In addition, the food processing equipment must comply with strict standards and regulations, which are necessary for securing the quality and safety of the food products presented to the consumers. Stainless steel is generally used for food equipment (Saravacos et al., 2002). High-grade stainless steel is the most important type of steel used for direct contact with food in construction food-processing equipment. There are more than 100

different type of stainless steels. These materials are high chromium or high nickel-chromium alloys of iron containing small amounts of other essential constituents. They have excellent corrosion-resistance (Cardarelli, 2000). Stainless steels are characterized, in general, by chromium content higher than 12% and by their passivity, i.e., the ability to form an impervious surface coating, which inhibits corrosion (Perry and Green, 1997). In most food equipment, two types of stainless steel are used: AISI 304 and AISI 316.

Uniform temperature and heat transfer condition throughout the equipment are key element in the successful application of preservation method to create safe and high quality product. Heat distribution studies are therefore of crucial importance to ensure effective heat treatment of the food. Heat distribution is frequently translated in term of temperature distribution (Smout, 2000). Once the pasteurizing equipment was constructed, a temperature distribution test was performed in order to determine the slowest heating zone in the equipment. In addition any differences in water temperature at various positions in the equipment during boiling could be observed.

Materials and method

Pasteurization equipment was designed to complement the production of bulk packaged bamboo shoot and to achieve the hygiene standard. The criteria of the design included the production area, production capacity, economic considerations and food hygiene. Boiling water was used as a heating medium in the equipment. The lower number of product package provided the better circulation of water in the equipment.

However, based on the local production capacity, twenty to twenty five products per batch is preferred. The package-rack was required for this work and these was designed to facilitate product distribution. (Figure 1)

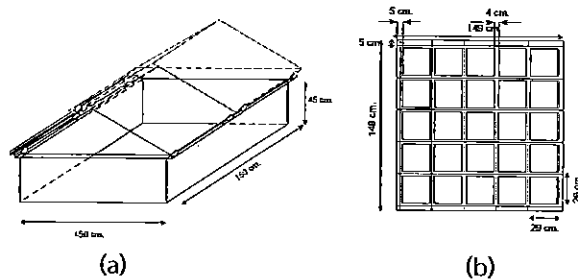


Figure 1 Pasteurization Equipment Design

(a) Outside Dimension

(b) Inside Dimension

Thermal distribution was tested after the new equipment was constructed. Twenty five packages were arranged in the package-rack in the equipment. Twelve thermocouples were placed within the twenty five packages-racks. Water was then added to the equipment until its level reached the height of the rack. The thermocouples were placed in such a way to ensure that their junctions were immersed in water. The thermocouples were then connected to the Data Taker to record and display time and temperature data. Fire wood was placed in the pit and ignited. This marked the beginning of the data collection phase. Time and temperature data were collected until the water temperature reached a constant at approximate boiling point. The temperature distribution test was replicated five times to ensure the results.

Results and discussion

According to the production needs, the pasteurizing equipment was design to suit the existing fire pit size and to maintain current production capacity. In addition hygienic standard and economical aspects were also taken into consideration. The new equipment was constructed from four sheets of stainless steel with the size of 150x150x45 centimeters. (Figure 2) During heating, the products package was left open therefore steam condensate could enter into the packages and alter the product pH. The sliding roof with a triangle shape was designed in order to prevent condensate form entering into product package.

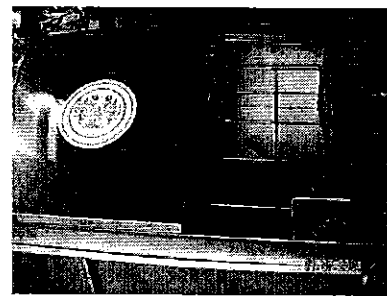


Figure 2 Pasteurization Equipment

The uniformity of heating medium during processing is investigated. Since fire wood is loaded into the fire chamber form the front of the pit. (Figure 3) It was anticipated that the middle area along the equipment represented the area directly heated by the fire. In addition the right and left hand side of the equipment would show up as the slowest heating zone. Thus in the middle area of the equipment had to be investigated to determine the difference in maximum and minimum temperature during heating.



Figure 3 The position of the fire pit and the pasteurizing equipment.

Twenty five of dummy packages were placed into the equipment after the water in the equipment had boiled. Cautions must be taken to ensure that the thermocouple junctions were immersed in the boiling water and did not contact the packages. After the dummies were placed into the equipment, the water temperature slightly decreased but later on it increased and maintained at the boiling temperature. This time period has been called Come Up Time. Temperature distribution test was carried out for five times and results are shown in Figure 5.1-5.5.

In Figure 5.1-5.5 (b), the horizontal blue line represents the minimum water temperature during heating. While the blue narrows shows the maximum difference in the heating time between the fastest and the slowest heating position of the heating water to reach the heating temperature. The results were summarized in Table1.

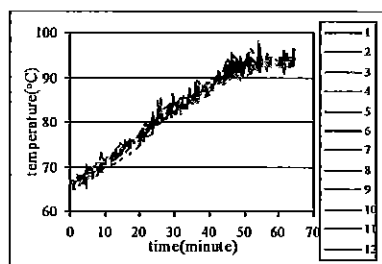
TABLE 1 Temperature distribution test in the pasteurization equipment

Rep.	Come Up Time (minutes)	Maximum Difference in Boiling Water Temperature (°C)	Minimum Boiling Water Temperature (°C)	Maximum Difference in Heating Time (minutes)	Slowest Position *
1	44	5	92	10	Inner left side (11)
2	50	3	97	10	Inner left side (11)
3	32	3	94	7	Left front side (4)
4	37	2	97	10	Front corner left side (3)
5	28	2	96.5	8	Inner left side (2)

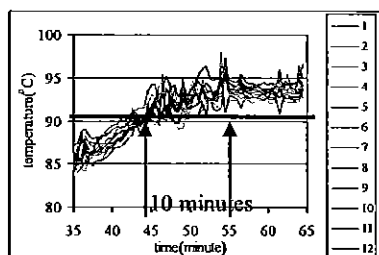
* The positions are shown in Figure 6.

From five runs of the temperature distribution test, it was found that the slowest heating zone was not always located at the same position. However, the left side of the equipment appeared to be the slowest heating zone. Due to position of fire wood that was put on the middle of the pit therefore both two side of the equipment was difficult to heat. Not only this reason, the wind direction flew from left side of the equipment to the right side also affected the slowest heating zone. Furthermore within the same run, the maximum difference in water temperature during boiling was 5°C and the maximum difference in the heating time between the fastest and the slowest heating position was approximately 10 minutes.

During this experiment, come-up time was difficult to control since it depended on the time needed for loading the dummy packages in the equipment. The longer loading time resulted in a large drop in water temperature and hence a longer come-up time as shown in runs 1 and 2. However, in runs 3, 4 and 5, come-up time was reduced to about 30 to 40 minutes after skilled workers were hired.



(a)

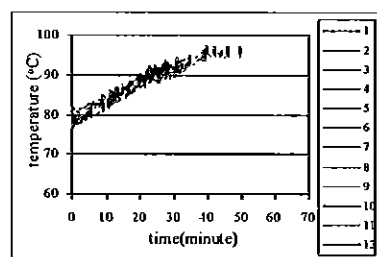


(b)

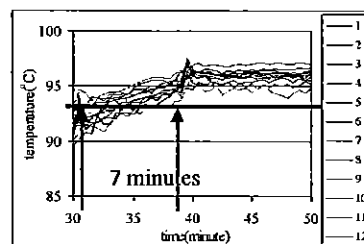
Figure 5.1 The temperature distribution replication 1

(a) Include the come-up period

(b) Exclude the come-up period



(a)

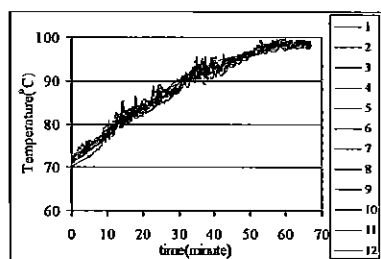


(b)

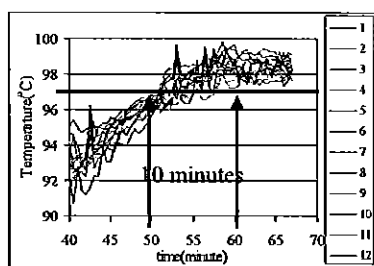
Figure 5.3 The temperature distribution replication 3

(a) Include the come-up period

(b) Exclude the come-up period



(a)

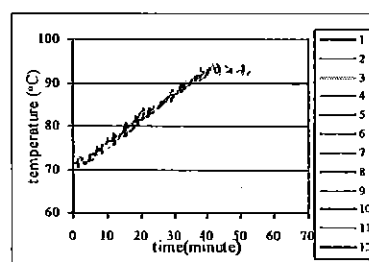


(b)

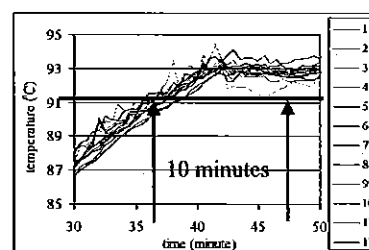
Figure 5.2 The temperature distribution replication 2

(a) Include the come-up period

(b) Exclude the come-up period



(a)

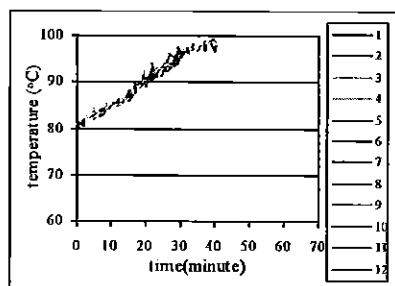


(b)

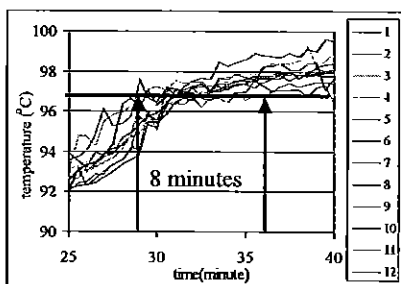
Figure 5.4 The temperature distribution replication 4

(a) Include the come-up period

(b) Exclude the come-up period



(a)



(b)

Figure 5.5 The temperature distribution replication 5

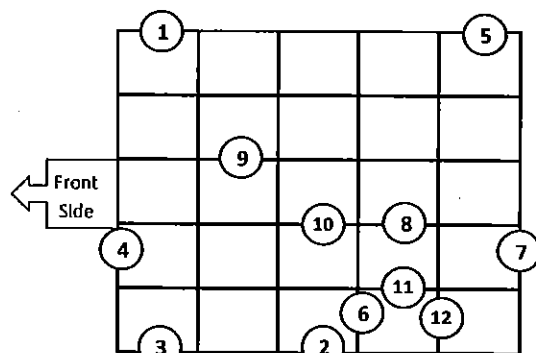
(a) Include the come-up period

(b) Exclude the come-up period

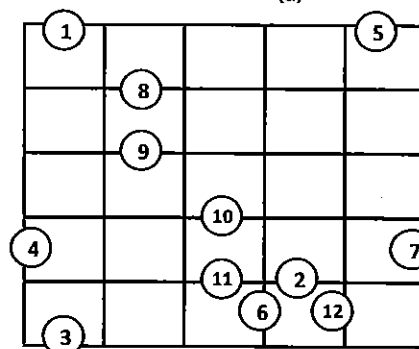
CONCLUSIONS

The small-scale pasteurizing equipment was designed based on food hygiene, economic consideration and production capacity. The pasteurizing equipment was constructed and temperature distribution test was investigated. From these experiments, it was found that the slowest heating zone within the equipment was not always located at the same position. The

tendency was found to be at the left hand side of the equipment.



(a)



(b)

Figure 6 Thermocouples position in equipment rack

(a) For temperature distribution test replication 1, 2 and 3

(b) For temperature distribution test replication 4 and 5

REFERENCES

- Cardarelli, F., 2000, Material Handbook: a Concise Desktop Reference, Springer, London, pp. 12-64.
- Perry, R.H., Green, D.W. and Maloney J.O., 1997, Perry's Chemical Engineers' Handbook, 6th ed., McGraw-Hill, New York, pp. 53-75.
- Saravacos, G.D. and Kostaropoulos, A.E., 2002, Handbook of Food Processing Equipment, Kluwer Academic/Plenum Publishers, New York, pp. 47-74.

- Satya, S., Bal, L.M., Singhal, P. and Naik S, S.N., 2009, "Bamboo-shoot processing : food quality and safety aspect (a review)", *Journal of Trends in Food Science & Technology*, Vol.21, pp.181-189.
- Smout, C., Loey, L.V. and Hendrickx, M., 2000. "Role of Temperature Distribution Studies in the Evaluation and Identification of Processing Conditions for Static and Rotary Water Cascading Retort", *Journal of Food Engineering*, Vol.48, pp.61-68.
- U.S. Department of Health & Human Services, 1999, "Foodborne Botulism Associated with Home Canned Bamboo Shoots-Thailand", Centers for Disease Control and Prevention, 4 June 1999, New York, pp. 437-439