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Thermal Process Evaluation of Analogue Shrimp Product (ASP) from Lizard Fish (*Saurida tumbil*) in Retort Pouches

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ABSTRACT

Background: Seafood analogue is a ready to make value added product prepared out of surimi. Thermal processing of restructured products in retort pouches such as fish ball in curry medium, surimi stew in white tripod, boneless rohu balls in curry. Also no work had done on thermal processing of shrimp analogue products in retort pouches. The main objective of this work was to develop the analogue shrimp product from lizardfish and to compare the heat penetration attributes of analogue shrimp curry and masala using retort pouches and different sterilization methods such as steam / air over pressure retort and water immersion retort.

Methods: Analogue shrimp products were prepared and thermally processed in retortable pouches. About 125g of shrimp analogue product and 100g of curry (masala) were filled in retort pouches of size, 150x200mm. Air inside the pouch was exhausted by steam injection followed by heat sealing and processing at 121.1°C in a retort by steam/air over pressure retort and water immersion retort. The difference in the heat penetration characteristics of analogue shrimp products processed in retort by steam/air over pressure retort and water immersion retort were studied.

Result: The results showed that minimum heating lag factor and minimum come up time led to faster heating rate which decreased total process time in imitated shrimp curry by steam/ air retort. At the same time the cook value was low in curry medium processed by steam air retort. So finally conclude that imitated shrimp curry processed by steam air retort was good.

Key words: Come up time, Ellab data recorder, Heat penetration, Shrimp analogue, Steam air, Water immersion.

INTRODUCTION

Seafood analogues / Imitation products are one of the most popular product in fish processing industry, due to its low cost fish source, fish protein or surimi and are designed to high cost of the product (Remya *et al.* 2015). So many researchers studied heat penetration characteristics in retortable pouch products were found to be acceptable at ambient temperature. Thermal processing of restructured products in retort pouches such as fish ball in curry medium, surimi stew in white tripod, boneless rohu balls in curry (George *et al.* 2015; Hema *et al.* 2015; Majumdar *et al.* 2017).

Several works have been carried out on the use of retort technology, but not much had done for comparing the rate of heat penetration using different methods and different mediums in analogue shrimp product in retort technology. Also no work had done on thermal processing of shrimp analogue products in retort pouches. The main objective of this work was to develop the analogue shrimp product from lizardfish and to compare the heat penetration attributes of analogue shrimp curry and masala using retort pouches and different sterilization methods such as steam / air over pressure retort and water immersion retort.

MATERIALS AND METHODS

Preparation of analogue shrimp product

Frozen lizard fish surimi (*Saurida tumbil*), was procured from a commercial factory and stored in a deep freezer (-20°C) until further use. Frozen lizard fish surimi was taken out (at 0°C for 10 h) and was chopped in a silent cutter at low speed and mixed for 1 min. Followed by mixing with sucrose (4%), sorbitol (4%), sodium tripolyphosphate (0.25%), sodium chloride (2.5%) and microbial transglutaminase (0.3%), grounded well in a silent cutter for 15 minutes to obtain a fine paste. To this synthetic shrimp flavour solution (1%) was added. This was then kept in a polylacticacid shrimp mould and placed in a pressure retort at 90°C for 20 mins. The product was packed in see through retort pouches and were sealed by a vacuum sealing machine to remove the air present in the headspace. The pouches were again sealed using continuous band sealer and kept in a water bath at 90°C for 25mins. The packed analogue shrimp products were stored in Hera freezer (-40°C) until further use.

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Preparation of analogue shrimp curry and masala

Ingredients were used for the preparation of analogue shrimp curry (ASC) and analogue shrimp masala (ASM) were given in Table 1. The formulation for analogue shrimp curry (ASC) and analogue shrimp masala (ASM) was standardized with slight modifications Sreenath *et al.* (2008).

Filling and sealing

Analogue shrimp curry and masala medium were filled into the pouches in 225 ± 2g packed per retort pouch. Thermocouple probes were fixed at the geometric centre of retort pouches prior to filling. A total of three thermocouple glands were inserted into the analogue shrimp pieces to record the core temperature and one thermocouple was left in the retort to measure the retort temperature. The pouches were immediately exhausted in steam injection for 10 min at 100°C to remove the residual air Madhwaraj *et al.* (1992). Then the pouches were sealed by foot operated impulse sealing machine to withstand high pressure processing for final airtight sealing of retort pouches. The pouches were thermally processed in the steam - air mixture over pressure retort and water immersion retort at 15 psi pressure. After thermal processing, the pouches were cooled at 40°C and the cooling water was maintained with constant chlorine residual level of 2mg/L. The pouches were air dried, labelled and stored at ambient temperature (32 ± 2°C). The time temperature data were recorded for every single minute of processing using Ellab data recorder. A specially designed packing gland was used to record core temperature, retort temperature, F_0 value and cook value at a specific time interval of 60 sec.

Statistical analysis

The obtained data were statistically analysed using version 20.00 of Statistical Product and Service Solution (SPSS 20.00, Chicago, IL, USA). Analysis of variance was used to calculate significant difference between the two processing methods employed. Differences were considered to be significant at $p < 0.05$ using t test at a 95% confidence level.

RESULTS AND DISCUSSION

Come up time (CUT)

Come up time to reach the reference retort temperature (121°C) varied between 3 - 6 minutes and should be kept as possible NCA (1968). Come up time of analogue shrimp curry and masala processed by steam - air and water immersion retort are presented in Table 2. In the present study, come up time (CUT) of 5 min for the analogue shrimp curry and masala thermally processed by steam - air and water immersion retort, respectively. These process times were sufficient to take commercially sterile.

Heating rate index

Heating rate index of analogue shrimp curry and masala processed by steam - air and water immersion retort are given in Table 2. In the present study, the maximum value of heating rate index indicated that 28 min in analogue shrimp masala and the minimum value was observed to be 19 min in curry processed by steam - air retort. The heating rate index was faster in curry medium by steam-air retort than in curry medium processed by water immersion application. Earlier reports were observed heating rate index of 18 min for jewfish paste Thankamma *et al.* (1998) and the same values were observed in mackerel curry Gopal *et al.* (1998), 25 - 32 min for seer fish curry Ravishankar *et al.* (2002), 19 min for shrimp kuruma Mohan *et al.* (2006), 19 - 23.30 min for prawn kuruma Mohan *et al.* (2008), 13 - 18 min for fish peera from anchovy Bindu *et al.* (2010), 18.60 to 24.50 min for rohu curry at different F_0 values Majumdar *et al.* (2015), 17.50 min for tilapia sandwich paste Dhanapal *et al.* (2016), 28.19 min for rohu balls curry Majumdar *et al.* (2017), 10.50 - 11.71 min for eel steaks in brine, Mugale *et al.* (2018a) and 8.88 - 10.15 min for eel curry Mugale *et al.* (2018b). In most of the above studies, heating rate index values were within the range of 8.88 to 32 min. Similar reports were observed in this study, for convective heat transfer in food products, in contrast, the f_h value in conductive heat transfer are higher *i.e.* 30 - 40 min Horner, (1992). Heating rate index (f_h) for convective heating products has been reported to be dependent upon temperature of heating medium and condensing surface, steam - air flow rate and direction, surface size and orientation, viscosity, film thickness and stagnant air layer thickness Tung *et al.* (1990). In this study, the difference of f_h values were ratio of product liquids to solids in the container, this could be due to higher rate of heat penetration in the product because of the different filling media and different types of retorts.

Lag factor for heating (J_h) and cooling (J_c)

The lag factor for heating (j_h) was significantly lower for analogue shrimp curry (1.26 min) processed by water immersion whereas it was highest for masala processed (1.34 min) by steam air retort, respectively ($p< 0.05$). Based on the results, it indicates highest j_h values have a slower heat penetration and the lowest j_h value indicates faster cooling. Heating lag factor (J_h) that is close to or above1.0 and cooling lag factor (J_c) less than 1.0 is an indication of faster heat penetration and this is evident in steam- air in curry medium (J_h) 1.48 min and masala medium 1.34 min compared to 1.26 min of water immersion in curry medium. In this study, the heating lag factor (J_h) in both methods were above 1.0 with minimal lag period (*i.e.*, the come up time is very short); therefore, PID and ID overlap, so that J_h is equal to 1.0. However, in actual practice, there is always some gap in time period before a product could reach the retort temperature, leading to differences in come up time depending on the composition, size *etc.* and hence to variations in j_h value. Products heated under agitation have large j_h values, but it takes some for the viscous forces of the product to be overcome by the inertial forces induced by the rolling of the can Berry and Bradshaw (1980). As

shown in Table 2, Lag factor for cooling curve (J_c) the analogue shrimp curry and masala medium processed by steam air 1.00 min and 1.08 min and to compared the water immersion retort in analogue shrimp curry medium had 0.97 min. These values which were in conformity with the values reported for convective heating liquid products Horner (1992). J_c value increases with increase in processing temperature but in this study, retort temperature was set constant at 121°C so not much variation in these values was observed. Based on the result, the cooling lag factor was not considerably different from each other. In this study, (J_c) values were lower than the J_h values for all the analogue

Table 1: Recipes of the analogue shrimp curry (ASC) and masala (ASM).

Analogue Shrimp Curry (ASC)		Analogue shrimp masala (ASM)	
Ingredients	Qty (gms)	Ingredients	Qty (gms)
Analogue shrimp	1kg	Analogue shrimp	1000g
Onion	1kg	Onion	1000g
Tomato	500g	Tomato	500g
Green chillies	50g	Green chillies	50g
Ginger	50g	Ginger	50g
Garlic	3.5g	Garlic	3.5g
Chilly powder	33.33g	Chilly powder	33.33g
Pepper powder	10g	Pepper powder	10g
Coriander powder	17g	Coriander powder	17g
Turmeric powder	2g	Garam masala	3.5g
Oil	100ml	Turmeric powder	2g
Curry leaves	As required	Oil	100ml
Salt	As required	Curry leaves	As required
Water	As required	Salt	As required
		Water	As required

Preparation

For curry preparation, chopped onion, ginger and green chillies were ground in a mixer and it was heated in refined sunflower oil until it turns light brown in color. Turmeric powder, chilly powder, pepper powder and curry leaves were added to the onion-ginger - green chilly mixture and fried gently. Chopped tomatoes were made into paste and added to the mixture and heated continuously. Potable water was added to adjust the consistency of the curry and heated gently under low flame until the gravy gets boiled. Finally add cooked analogue shrimp product and boil for 5mins.

Preparation

For curry preparation, chopped onion, ginger and green chillies were ground in a mixer and it was heated in refined sunflower oil until it turns light brown in color. Turmeric powder, chilly powder, garam masala, pepper powder and curry leaves were added to the onion-ginger - green chilly mixture and fried gently. Chopped tomatoes were made into paste and added to the mixture and heated continuously. Potable water was added to adjust the consistency of the curry and heated gently under low flame until the gravy gets boiled. Finally add cooked analogue shrimp product and boil for 5 mins.

Table 2: Heat penetration attributes of analogue shrimp product from lizard fish thermal processed by steam air application and water immersion.

Parameters	Steam Air	Water Immersion	
	Curry medium	Masala medium	Curry medium
CUT (58%)	1	2.9	1
Heating rate index f_h (min)	19	28	26
Heating lag factor (J_h)	1.48	1.34	1.26
Cooling lag factor (J_c)	1.008	1.086	0.97
Sterilization value (g)	1.80	2.24	2.48
F_0 value (min)	10.53	12.51	10.48
Cook value (Cg) (min)	89.99	122.16	108.81
Initial Temperature Deficit (I)	74.02	88.94	87.12
Final Temperature Deficit (g)	1.65	2.34	2.47
Process time (B)	34.99	48.03	42.81
Total Process time (TPT) (min)	35.99	50.93	43.81
Cook value/F_0 ratio	8.54	9.76	10.38

shrimp curry and masala medium in water immersion and steam air application processed products.

F_0 value

In present study, the F_0 value for analogue shrimp product from lizard fish in curry medium was observed to be 10.53 min in steam - air and 10.48 min in water immersion, while the F_0 value for the analogue shrimp product from lizard fish packed in masala was 12.51 min in steam - air (Table 2). Depending upon the product and climatic conditions of storage, the F_0 value recommended for thermal processed fish products varies in the range of 5-20 minutes Pflug and Chirstensen (1980), Frott and Lewis (1994). There are no literatures available regarding analogue shrimp products in retortable pouches. In the present study, I conclude that the F_0 values were observed for analogue shrimp product from lizard fish in curry medium is slightly more or less similar to be 10.53 min and 10.48 min in steam - air and water immersion application. This process employed for analogue surimi curry was thus within the prescribed F_0 values for fish products. This process was also considered more suitable, as in home canning, conventional cooker operate at 15 psi, which is equivalent to around 121°C. In this study, higher F_0 value was observed for analogue shrimp product from lizard fish in masala medium was12.51min in steam - air application.

Cook value

In the present study, the minimum cook value (C_g) was observed in steam - air retort 89.99 min and the maximum cook value (C_g) was 122.16 min in the analogue shrimp curry and masala, as against 108.81 min for analogue shrimp curry medium pack in water immersion retort. Some of the researchers reported the cook value of 89.79 min in seer fish moilee in retort pouch Manju *et al.* (2004), 57.19 to 92.12 min in sardine Ali *et al.* (2006), 86.14 min in shrimp kuruma Mohan *et al.* (2006), 69.73 to 125.65 min for mackerel Mallick *et al.* (2006), 83.19 to 86.14 min for prawn kuruma Mohan *et al*. (2008). Bindu *et al.* (2010) observed the cook value of fish peera from anchovy at 66.02 min. The cook values of the restructured surimi gel products from white tripod fish ranged from 100 to 139 min at 121°C Hema *et al.* (2015). Dhanapal *et al.* (2016) optimized the tilapia sandwich paste processed at 121.1°C and the F_0 value of 8 min and cook value of 75.02 min. The cook values of the product were found similar to the earlier reports. In most of the above studies, cook values achieved by the researchers were between 25 to 139 min. Based on the result of this study the cook value was also low in steam air than water immersion application and this study noticed the higher cook values during processing in masala medium processed by steam air application. In this study, F_0 value increased results in higher cook values meaning thereby more destruction of nutrients measured in terms of thiamine loss. Higher cook values also might result in loss of textural properties. Finally it is concluded that, the cook value was low in analogue shrimp curry processed by steam air application at 121.1°C and the textural properties were also good compared to other mediums.

Process time

The total process time for analogue shrimp curry was observed to be 35.99 min to achieve F_0 value of 10.53 min in steam - air retort and 43.81 min for F_0 value of 10.48 min in water immersion for curry medium, while the total process time for the analogue shrimp product from lizardfish packed in masala medium was 48.30 min at F_0 value of 12.51 min in steam air application which included 58% of come up time. Earlier, Ravishankar *et al.* (2002) reported the process time was 39.50 min and the total process time was included 42% of come up time, was 40.76 min for the storage of seer fish curry in retortable pouches up to 24 months. Later, Manju *et al.* (2004) found a process time of 48.30 min which included 58% of the come up time as sufficient process value for the storage of seer fish moilee, a traditional fish based product of kerala in retort pouch at ambient temperature (27 ± 10°C). Bindu *et al.* (2008) observed that the total process time taken to process the products at F_0 values of 5, 7 and 9 min were 29.22, 34.38 and 40. 57 min, respectively. It has been observed from the result that the total process time increases as F_0value of the product increases in fish peera in retort pouches. Majumdar *et al.* (2015) observed that the total process time taken to reach F_0 values of 7, 8 and 9 min for Rohu - kalia were 37.50 min, 41.70 and 44.50 min respectively. Sreelakshmi *et al.* (2015) optimized that the crab sandwich spread in retort pouch processed at 116.1°C, a process time (B) of 3.99 min, operator's process time of 22.9 min and total process time of 48.5min were obtained. The least process time observed in steam application in curry medium can be attributed to the fast come up time in the method which resulted into faster heating rate. Similar reports were observed with the finding of Adepoju *et al.* (2016), who explained that the total process time for milk fish in drypack and oil medium were observed the least process time observed in steam air application than in water immersion application. It can be attributed to the fast come up time in the method which resulted in to faster heating rate. This actually conforms with the similar finding of Mohan *et al.* (2014), observed that the least process time observed for tuna with broccoli pack could be attributed to soft nature of broccoli, which resulted in the faster heating rate. These findings indicate that the relationship between the retort CUT and the total process time is directly proportional. From the data generated, it was observed that the rate of heat penetration was faster in steam application than in water immersion. The Tukey's test performed on the heat penetration values obtained for the two heat treatment methods slightly showed significant differences ($p < 0.05$). However, the heating rate indices of the samples processed in curry medium by steam application and in the curry medium by water immersion are not significantly different ($p > 0.05$).

Cook value / F_0 ratio

The cook value and F_0 ratio of analogue shrimp curry and masala medium processed by steam - air and water immersion retort is given in Table 3. The results showed that the lowest for analogue shrimp curry processed by steam air retort followed by masala medium and curry medium processed by water immersion retort, respectively. Cook value/ F_0 ratio in the range of 6.88 - 15.30 was reported for mackerel in brine processed at different temperatures Sreenath *et al.* (2008). Mansfield (1962) reported that sterilization rates are slower than cooking rates at low processing temperatures and higher than cooking rates at higher temperatures of processing. The Tukey's test performed on the heat penetration values obtained for the two sterilization methods slightly showed significant differences ($p<0.05$). However, the heating rate indices of imitated shrimp products processed in curry medium by steam air retort and the curry medium by water immersion retort are not significantly different those samples ($p>0.05$).

CONCLUSION

Minimum heating lag factor and minimum come up time led to faster heating rate which decreased total process time in imitated shrimp curry by steam/ air retort. At the same time the cook value was low in curry medium processed by steam air retort. So finally conclude that imitated shrimp curry processed by steam air retort was good.

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