Development and evaluation of retort pouch processed *chhenapoda* (cheese based baked sweet)

U. S. Pal¹ · M. Das¹ · R. N. Nayak¹ · N. R. Sahoo¹ · M. K. Panda¹ · S. K. Dash¹

Revised: 10 October 2018 / Accepted: 6 November 2018 / Published online: 29 November 2018
© Association of Food Scientists & Technologists (India) 2018

Abstract A study has been undertaken to optimize ingredient proportions for preparation of *chhenapoda* and the effect of retort processing on its quality and storability. *Chhenapoda* was prepared from cottage cheese with standard practices followed by confectioners using different levels of semolina (0, 50, 100, 150, 200 g) and sugar (0, 100, 200, 300, 400 g) per kg cheese and ingredient proportion was optimized based on sensory scores. Prepared *chhenapoda* sample of 200 g were packed in pre-fabricated 3 side seal multilayer laminated retortable pouches, hermetically sealed and retort processed at different temperatures (100, 110 and 120 °C) and time intervals (15, 30 and 45 min). It was found from Response Surface Methodology (RSM) technique that addition of 18.5% sugar and 7.5% semolina with cottage cheese was optimum for *chhenapoda* preparation. Microbiological analysis showed that total plate count and yeast and mould count (YMC) decreased from 110×10^7 to 4×10^4 and YMC from 3×10^3 to 0 respectively during retort processing (30 min thermal processing in laminated pouch at 120 °C). From the storage study, it can be concluded that retort processing of *chhenapoda* in laminated pouch at 120 °C for 30 min resulted in microbiological safe and sensory acceptable product which could be stored up to 30 days under refrigerated condition.

Keywords Retort processing · *Chhenapoda* · Storage · Total plate count · Yeast and mould count

Introduction

Chhenapoda is a roasted cheese dessert prepared in the state of Odisha, India which is a traditional cottage cheese based baked sweet and is priced for its unique taste, texture and appearance. It has originated in Nayagarh, Odisha in the first half of the twentieth century. *Chhenapoda*, literally means burnt cheese, which is made of well-prepared homemade cottage cheese or *chhena*, sugar, semolina, cashew nuts and raisins, and is baked for several hours until it turns brown. It has many varieties with distinct characteristics attributed to the area specific traditional method of preparation and ingredients used. It is usually available in the sweetmeat shops across the state and is often made at home during traditional festivals. Although it has a great demand, but owing to its perishability (shelf life not more than 2–3 days in ambient condition) hinders from transportation and marketing (Ghosh et al. 2002, 2007; Khandelwal and Kumar 2007; Mukhopadhyay et al. 2013). In both the developed and developing countries there is a continuous growth in the demand for convenient ready-to-eat traditional food products and has led to an increase in its commercial production (Kamatt et al. 2005). Today, the consumer demands for safe and shelf-stable foods and insists on high-quality foods.

Thermal processing of foods is one of the most important preservation techniques in the food industry to extend the shelf-life of foods. Retort (thermal) processing is intended to kill micro organism in food products to extend the shelf stability of the product, by the application of extreme heat condition (121.1 °C). However, exposure of

✉ U. S. Pal
us_palcaet@yahoo.co.in

¹ AICRP on PHET, Department of Agricultural Processing and Food Engineering, College of Agricultural Engineering and Technology, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha 751003, India

food to that condition may result in loss of nutritional and sensory qualities (Chiralt et al. 2001). Thermal process design is adopted to maximize microbial inactivation with minimal collateral degradation to product quality (Gould 1995). The other methods to minimize the quality degradation are combination of hurdles such as temperature (high or low), water activity, redox potential, preservatives and irradiation, which ensure stability, microbial safety and sensory quality of food (Leistner 2000).

Retort pouch technology is a modern accepted packaging technology which is used to increase the shelf life of various food materials. The retort pouch is recognized as an economic alternative to metal cans for producing thermally processed shelf stable foods (Sabapathy et al. 2001). The retortable pouch is a flexible laminated pouch that can withstand thermal processing temperatures and combine the advantages of the metal can and plastic packages for which is treated as a unique alternative packaging method for sterile shelf stable products (Sabapathy and Bawa 2003). The retort pouch has many advantages over canned and frozen food packages for both the customers as well as food manufactures. The advantages are pouch profile, storage and preparation efficiency, savings in transportation and packaging cost, improved flavour and savings of energy (Kumar et al. 2007). Retort pouches of low-acid solid foods have attained commercial acceptance, and as the technology is more widely used and accepted, other heat sterilized foods are expected to appear in pouches, resulting in a new, expanding segment within the packaged foods industry. Several researchers reported retort pouch processed technology for products such as tender jackfruit curry (Lakshmana et al. 2013), traditional Thari kanchi payasam (Mohammedali Shihab et al. 2013), soy-peas curry (Abhishek et al. 2014), chapattis (Khan et al. 2011), coconut kheer (Kumar et al. 2007) and black clam (Bindu et al. 2007) to extend the shelf life.

Literature reviews revealed that, no technology or process is available so far for producing shelf stable '*chhenapoda*', a traditional cottage cheese based baked sweet. Keeping in view the perishability of *chhenapoda*, this study is an attempt to develop retort pouch processed *chhenapoda* technology and to evaluate the changes in its physico-chemical and microbiological qualities during processing and storage in ambient and refrigerated storage.

Materials and methods

Raw materials and standardization of the ingredient proportion for *chhenapoda* preparation

Good quality cottage cheese, semolina (*Suji*) and sugar were purchased from the local market of Bhubaneswar

(20.27°N 85.84°E), Odisha, India. *Chhenapoda* was prepared from the cottage cheese with the standard practice followed by the local confectioners using different levels of semolina (0, 50, 100, 150, 200 g) and sugar (0, 100, 200, 300, 400 g) per kg cheese. Central Composite Rotatable Design (CCRD), 2 factors, 5 levels (mentioned above) was used for optimization of ingredient proportion for producing best quality *chhenapoda* in terms of sensory attributes i.e. taste, colour and texture following response surface methodology. Cottage cheese, sugar and semolina were mixed thoroughly in the designed proportion followed by baking in a household oven at 200 °C for 60 min (both side heating). Sensory evaluation of the samples was conducted for colour, taste and texture attributes and finally surface plot of the scores were analysed to optimize the ingredient proportion.

Retort processing of *chhenapoda*

Chhenapoda was prepared from the optimum ingredient proportion from the RSM design which was used for the retort processing study. Pre-fabricated multilayer laminated retortable microwavable pouches having configuration of 12 µ Polyethylene Terephthalate (PET)/9 µ Aluminium foil/62.5 µ Nylon Cast Polypropylene (CPP) of size 12 cm × 15 cm were used as packaging material. The packaging material has seal strength of 7 kgf and seal temperature of 130–150 °C. Individual *chhenapoda* samples of 200 g size were kept in pouches, hermetically sealed by an impulse heat sealer and loaded into a horizontal sterilizer for thermal processing at different product temperature and time combinations of 100, 110 and 120 °C for 15, 30 and 45 min. The temperatures of the products were measured by thermocouples inserted to the product. The samples were taken out from the sterilizer after processing for specified time period and cooled immediately in running tap water for 10 min.

Analysis of quality parameters of *chhenapoda*

Hardness, bio-chemical parameters, microbial load and sensory evaluation of the retort processed *chhenapoda* obtained from different temperature and time combination were studied to analyse the effect of retort processing on quality parameters.

Hardness

The hardness of *chhenapoda* samples obtained from different temperature and time combinations were found out by bulk compression in a texture analyzer (TA-HT plus, Stable Micro Systems, UK). Samples were removed from the pouches and uniform size samples were cut for testing.

The P75 pressure plate (75 mm dia) and 50 kg load cell were used to compress the under following instrument parameters: pre-test speed-1 mm/s; test speed-5 mm/s; post-test speed-5 mm/s; strain-75% of sample height. The maximum force value obtained during the compression test was considered to be an indication of the overall hardness of the sample (Panda et al. 2015). At least 10 measurements were carried out for each condition and average value was taken.

Biochemical qualities evaluation

Different bio-chemical parameters of the samples such as moisture content, fat content, acidity, Free Fatty acid (FFA) expressed as oleic acid and peroxide value (PV) were estimated using standard methods (Ranganna 1986; AOAC 1984).

Microbial analysis

Retort processed *chhenapoda* samples were analysed for their commercial sterility. The pouches were incubated at 37 °C for 5 days. Total Plate Count (TPC) was determined using Nutrient Agar (NA) media and incubating for 48 h at 30 °C. Yeast and Mold Counts (YMC) were estimated with the help of acidified potato dextrose agar (PDA) media with, incubation at 30 °C for 4–5 days. Results were expressed as colony forming units per gram of product (Devi et al. 2016).

The unit for calculation is CFU = (Number of colony $\times$ dilution factor)/volume plated in mL.

Sensory evaluation

Sensory evaluation of retort processed *chennapoda* obtained from different temperature and time treatment combinations was done on a 9-point hedonic scale recommended by the Bureau of Indian Standards (IS: 6273 1971) with consumer test panel comprising of 9 members. The sensory characteristics like color, texture and taste were rated numerically using nine point hedonic scale with scores assigned from '1 = like extremely' to '9 = dislike extremely' (Tirkey et al. 2014).

Storage study of retort processed *chhenapoda*

Chhenapoda samples retort processed at optimum temperature and time condition were stored under ambient (27–30 °C) and refrigerated conditions (5 °C) of storage. The bio-chemical parameters like acidity, free fatty acid (FFA), peroxide value (PV) and microbial load of samples were analysed at regular interval of 5 days up to 30 days of storage for acceptability and safety of the product.

Statistical analyses

The results obtained were subjected to analysis of variance (ANOVA) using SPSS 10.0 software. The means obtained from each set were compared using the Duncan's multiple range test based on a complete randomized design (at 0.05 confidence level).

Results and discussion

Optimisation of ingredient proportion of *chhenapoda*

The mean sensory scores like taste, colour and texture of *chhenapoda* prepared with different levels of ingredient as per the experimental combinations in coded and decoded values are given in Table 1. Table 2 shows the co-efficients, and anova analysis of the responses with respect to different ingredient proportion i.e. semolina (A) and sugar (B). The F-value of 5.07, 5.34 and 11.0 for taste, colour and texture attributes respectively implied that the models developed with the coefficients are significant ($p < 0.05$). Similarly, the R-squared value i.e. 0.7835, 0.7922, 0.8871 for taste, colour and texture respectively and C.V. values less than 10% suggested that the models are significant for each responses. The Lack of Fit is not significant ($p < 0.05$), suggesting the good fit of the models developed for taste, colour and texture. In the case of taste, the interaction term AB and quadratic term of B^2 are significant model terms. In the case of colour, A, B, B^2 are significant model terms. In the case of texture, A, AB, A^2 , B^2 are significant model terms. The interaction of ingredient proportions i.e. suji and sugar is significantly varying the taste and texture attributes of *chhenapoda* but not the colour attribute (which was non-significant) and the effects were synergetic.

The surface plots of taste, colour and texture of *chhenapoda* at different levels of semolina and sugar proportion and the overlaid contour plots are given in Fig. 1. It was observed that, the sensory scores for taste, colour and texture of *chhenapoda* are better at lower proportion of semolina and medium proportion of sugar. With increasing in the semolina content the texture and colour attributes of *chhenapoda* are reduced. From the numerical optimization, the optimized semolina and sugar proportion were found as – 0.50 and – 0.15 respectively in coded form, which corresponds to the actual values of semolina and sugar as 75 g and 185 g per 1 kg of cheese. Therefore, addition of 7.5% semolina and 18.5% sugar per kg of cheese was found out to be the optimized ingredient proportion for preparation of *chhenapoda*.

Table 1 Mean sensory scores of *chhenapoda* prepared from different ingredient proportions based on RSM design

Sl nos	Coded		Actual		Mean sensory scores		
	Suji	Sugar	Semolina	Sugar	Taste	Colour	Texture
1	0	0	100	200	6.75	6.80	6.60
2	0	1.41	100	341.42	6.0	6.40	6.10
3	1.41	0	170.5	200	6.80	7.05	6.85
4	− 1	1	50	300	6.30	6.85	6.80
5	0	− 1.41	100	58.6	5.70	6.30	5.80
6	0	0	100	200	6.20	6.60	6.30
7	− 1.4	0	29.5	200	7.25	7.20	7.30
8	1.0	1.0	150	300	7.10	6.55	6.65
9	0	0	100	200	7.10	7.05	6.80
10	− 1	− 1	50	100	7.10	7.0	7.25
11	1	− 1	150	100	6.10	6.10	5.95
12	0	0	100	200	7.10	6.70	6.70
13	0	0	100	200	7.05	6.80	6.50
*Optimum value based on RSM		0.00	0.47	6.78	6.76	6.56	0.712

Table 2 Coefficients, F, *p* values and analysis of variance of different responses of *chenapoda*

Source	df	Taste			Colour			Texture		
		Co-efficient	F-value	<i>p</i> value	Co-efficient	F-value	<i>p</i> value	Co-efficient	F-value	<i>p</i> value
Model	5	6.84	5.07	0.0278**	6.79	5.34	0.0244**	6.58	11.00	0.0033***
A	1	− 0.10	0.85	0.3864 ^{ns}	− 0.18	6.65	0.0366**	− 0.26	13.63	0.0077***
B	1	0.078	0.48	0.5128 ^{ns}	0.055	0.65	0.4467 ^{ns}	0.084	1.42	0.2718 ^{ns}
AB	1	0.45	7.90	0.0261**	0.15	2.40	0.1652 ^{ns}	0.29	8.28	0.0237**
A ²	1	0.15	1.44	0.2693 ^{ns}	0.14	3.6	0.0994*	0.29	14.15	0.0071***
B ²	1	0.44	13.25	0.0083**	− 0.25	11.42	0.0118**	− 0.28	13.41	0.0080***
Lack of fit	3		0.27	0.8454 ^{ns}			0.2882 ^{ns}		1.79	0.4209 ^{ns}
R-Squared		0.7835			0.7922			0.8871		
C.V. %		4.81			2.88			3.03		

Effect of retort processing on quality parameters of *chhenapoda*

Physico-chemical parameters

The physico-chemical parameters of retort pouch processed *chhenapoda* obtained from different process temperature and time combination are given in Table 3. During retort processing, the moisture content of samples decreased significantly ($p < 0.05$) with process time. Decrease in moisture content of *chhenapoda* sample was observed from an initial value of 47.5 to 34.1% (w.b.) at 120 °C of process temperature for 30 min. The hardness decreased from 2624.3 to 2428.9 g as process time decreased from 45 to 15 min for 100 °C report temperature as compared to control sample value of 2698.8 g. For 120 °C report temperature and process time decreased from 45 to 15 min, hardness decreased from 2940.3 to

2771.0 g. It was also observed that hardness decreased at low level of heat treatment and increased with severe heat treatment as compared to control sample. The initial decrease may be due to conversion and dissociation of protein. The increase in hardness for higher temperature and longer process time may be due to coagulation and denaturation of protein. The loss of moisture from sample and accumulation inside the pouch at higher temperature and longer process time may be the indication of coagulation of protein. Hardness changed significantly ($p < 0.05$) with process temperature and time which agrees with the results reported for ready-to-eat tender jackfruit curry (Lakshmana et al. 2013) and Rohu fish in curry (Majumdar et al. 2015) in retort pouches.

There was no significant change in fat content of samples processed at different temperature and time combination range taken during the study. However, fat content decreased from an initial value of 4.89 to 3.64% at process

Fig. 1 Surface and overlay plot of sensory attributes with ingredient levels

temperature of 120 °C for 30 min which might be due to oxidation and hydrolysis of fat. Though peroxide value increased during thermal processing, the difference was not significant with different process temperature. However, the peroxide value increased significantly ($p < 0.05$) with process time. The change in free fatty acid content was not significant with the process temperature and time range taken for the study. However peroxide and free fatty acid content of control sample were 6.02 and 0.97 which increased to 6.98 and 1.16, respectively in sample retort processed at 120 °C for 30 min which justifies the results reported by Mohammedali Shihab et al. (2013) for ready-to-drink traditional Thari Kanchi payasam in flexible retort pouches and Kumar et al. (2007) for processed ready-to-eat coconut kheer in retort pouches.

Microbial load

The microbial analysis showed that total plate count and yeast and mould count decreased with retort processing. The process temperature was observed to be the

predominant factor in reducing the microbial load. It was observed that TPC reduced from 11×10^7 to 4×10^4 and YM from 3×10^3 to 0 during 30 min thermal processing in laminated pouch at 120 °C (Table 3). This processing condition confirmed the adequacy of processing which became commercially sterile after retort processing. The limit of total plate count is 10^5 CFU/g and yeast and mould count is 10 CFU/g. These results were in agreement with Lakshmana et al. (2013) for processed ready-to-eat tender jackfruit curry in retort pouches.

Sensory quality parameters

From the sensory score, it was observed that the scores did not change significantly with processing conditions taken during the study. Thermal processing of *chhenapoda* develops desirable colour, texture and taste of the product to some extent but beyond the optimum level (at higher temperature and long process time) affects the sensorial qualities particularly colour and texture of the product.

Table 3 Physico-chemical, microbial and sensory parameters of retort pouch processed chhenapoda obtained from different temperature–time combination

Retort temperature (°C)	Total process time (min)	Physico-chemical parameters				Microbial load				Mean sensory scores		
		Moisture content, % (w.b.)	Hardness (g)	Fat content (%)	Peroxide value (meq/kg)	FFA content (% oleic acid)	TPC	YM	Colour	Texture	Taste	
100	15	36.8 ± 1.3	2428.9 ± 5.2	4.54 ± 0.91	6.28 ± 0.74	1.08 ± 0.21	(60 ± 2.3) × 10 ⁶	(3 ± 1.8) × 10 ²	7.36 ± 0.04	6.72 ± 0.05	6.93 ± 0.07	
	30	34.5 ± 1.2	2443.9 ± 8.2	4.00 ± 0.63	6.69 ± 0.81	1.16 ± 0.37	(51 ± 2.8) × 10 ⁶	(3 ± 1.5) × 10 ²	7.45 ± 0.06	6.95 ± 0.05	6.84 ± 0.07	
	45	30.2 ± 1.8	2624.3 ± 3.9	4.54 ± 0.21	6.84 ± 0.37	1.21 ± 0.67	(46 ± 3.1) × 10 ⁶	(2 ± 1.3) × 10 ²	7.16 ± 0.05	6.87 ± 0.03	7.02 ± 0.05	
110	15	35.3 ± 0.9	2471.5 ± 7.1	4.01 ± 0.32	6.36 ± 0.90	1.22 ± 0.63	(30 ± 3.4) × 10 ⁵	(2 ± 1.5) × 10 ²	7.20 ± 0.03	7.27 ± 0.04	7.73 ± 0.04	
	30	32.6 ± 1.7	2592.1 ± 8.1	3.84 ± 0.26	6.66 ± 0.63	1.20 ± 0.81	(29 ± 3.2) × 10 ⁵	(2 ± 1.1) × 10 ²	7.09 ± 0.04	7.00 ± 0.06	7.14 ± 0.06	
	45	30.4 ± 1.2	2659.7 ± 5.9	3.56 ± 0.51	7.01 ± 0.57	1.38 ± 0.43	(27 ± 3.5) × 10 ⁵	(1 ± 0.8) × 10 ²	6.90 ± 0.07	6.64 ± 0.05	6.86 ± 0.03	
120	15	34.8 ± 1.5	2771.0 ± 6.1	4.28 ± 0.42	6.46 ± 0.43	1.18 ± 0.85	(11 ± 3.1) × 10 ⁴	(2 ± 1.2) × 10 ²	7.10 ± 0.05	7.10 ± 0.05	7.45 ± 0.06	
	30	34.1 ± 1.0	2784.9 ± 4.9	3.64 ± 0.39	6.98 ± 0.72	1.16 ± 0.39	(4 ± 1.7) × 10 ⁴	-	7.06 ± 0.04	7.03 ± 0.03	7.24 ± 0.05	
	45	28.7 ± 0.8	2940.3 ± 8.4	3.28 ± 0.21	7.04 ± 0.49	1.55 ± 0.54	(2 ± 1.3) × 10 ⁴	-	6.36 ± 0.03	6.54 ± 0.03	6.72 ± 0.08	
Control	-	47.5 ± 1.4	2698.8 ± 4.7	4.89 ± 0.37	6.02 ± 0.54	0.97 ± 0.23	(11 ± 2.5) × 10 ⁷	(3 ± 1.8) × 10 ³	7.20 ± 0.06	6.92 ± 0.04	7.05 ± 0.07	

Minimum sensory scores were observed for samples thermally processed at 120 °C for 45 min (Table 3).

Heat penetration characteristics

The heat penetration and lethality plots are given in Figs. 2 and 3. Retort come up time to reach 121 °C was found to be 10 min which is sufficiently shorter. The total process time (TP) was 30 min and a final F_0 (total process time at reference temperature (121 °C) to reduce the microbial load to a safe limit) value of 4.08 min was achieved. *C. Botulinum* was considered as the target microorganism for the processed *chhenapoda*. The *chhenapoda* samples were processed to F_0 value of 4 min which gave a product with good textural and nutritional properties. After heat processing the pouches were cooled rapidly by circulating water. This sudden cooling prevents over cooking as well

Fig. 2 Heat penetration curve during retort pouch processing of chhenapoda

Fig. 3 Lethality plot of retort pouch processed chhenapoda (at 121 °C)

as survival of thermophiles. The cook value was found to be 40 min for F_0 value of 4 min, which indicated optimal degree of tenderness in the finished product. Bindu et al. (2007) reported similar study for shelf life evaluation of a ready-to-eat black clam product in indigenous retort pouches.

Storage study of retort processed *chhenapoda*

The change in bio-chemical parameters like acidity, peroxide and FFA content of retort processed *chhenapoda* during storage are shown in Table 4. It was observed that acidity increased with storage period which might be due to break down of reducing sugar to acid along with the degradation of proteins and liberation of free amino acids (Rajkumar et al. 2010; Rajan et al. 2014). However, the rate of increase of acidity in refrigerated storage condition was observed to be less than ambient storage. Acidity of retort processed *chhenapoda* increased from an initial value of 0.3–0.76% after 15 days of storage under ambient condition, whereas in refrigerated storage condition it increased to 0.55% after 30 days of storage. Peroxide value also showed similar increasing trend during storage with lower rate under refrigerated storage condition. It increased from 6.98 to 8.85 meq/mg after 15 days under ambient storage and to 8.98 meq/kg after 30 days of storage under refrigerated condition. It clearly shows that the rancidity development is temperature dependent. Other authors also (Kumar et al. 2007; Agathian et al. 2009; Mohammedali Shihab et al. 2013) found a slight increase in the peroxide value of retort processed samples when stored under different storage temperatures. There is a gradual increase in FFA content during refrigerated storage condition. The increase in FFA content was more under ambient condition which is due to the due to the breakage of long fatty acid chains into individual fatty acid moieties and increased lipid hydrolysis at elevated temperature (Khan et al. 2011; Bindu et al. 2007). The ambient stored samples were not acceptable after 15 days of storage and leaching of liquid were observed in the samples. The results have been supported by Mohammedali Shihab et al. (2013) for ready-to-drink traditional Thari Kanchi payasam in flexible retort pouches and Abhishek et al. (2014) for ready-to-eat soy-peas curry in multilayer flexible retort pouches.

Microbiological analysis

The microbial analysis showed that total plate count and yeast and mould count increased during storage period (Table 4). It was observed that TPC increased from 4×10^4 to 19×10^8 and YMC from 0 to 5×10^2 after 15 days of storage under ambient condition. TPC increased to 8×10^6 and YMC increased to 6×10^2 under

Table 4 Bio-chemical and microbial changes of retort processed *chhenapoda* during ambient and refrigerated storage condition

Storage period (days)	Ambient (27–30 °C)						Refrigerated (5 °C)					
	Acidity (%)	Peroxide (meq/kg)	FFA (%)	TPC	YMC		Acidity (%)	Peroxide (meq/kg)	FFA (%)	TPC	YMC	
0	0.30 ± 0.14	6.98 ± 0.28	1.16 ± 0.38	$(4 \pm 2.1) \times 10^4$	0		0.30 ± 0.14	6.98 ± 0.65	1.16 ± 0.37	$(4 \pm 1.6) \times 10^4$	0	
5	0.39 ± 0.10	7.36 ± 0.41	1.73 ± 0.19	$(6 \pm 2.3) \times 10^4$	$(1 \pm 0.9) \times 10^2$		0.25 ± 0.09	7.04 ± 0.91	1.18 ± 0.54	$(4 \pm 2.1) \times 10^4$	0	
10	0.64 ± 0.13	8.24 ± 0.67	2.54 ± 0.42	$(11 \pm 3.2) \times 10^7$	$(3 \pm 1.4) \times 10^2$		0.34 ± 0.25	7.98 ± 0.51	1.17 ± 0.48	$(6 \pm 2.5) \times 10^4$	0	
15	0.76 ± 0.09	8.84 ± 0.52	3.26 ± 0.63	$(19 \pm 3.7) \times 10^8$	$(5 \pm 2.5) \times 10^2$		0.46 ± 0.17	8.46 ± 0.27	1.22 ± 0.73	$(7 \pm 2.8) \times 10^5$	$(1 \pm 0.8) \times 10^2$	
20	–	–	–	–	–		0.49 ± 0.23	8.67 ± 0.61	1.20 ± 0.92	$(10 \pm 3.5) \times 10^5$	$(1 \pm 0.7) \times 10^2$	
25	–	–	–	–	–		0.52 ± 0.19	8.81 ± 0.78	1.28 ± 0.67	$(4 \pm 2.1) \times 10^6$	$(2 \pm 1.3) \times 10^2$	
30	–	–	–	–	–		0.55 ± 0.21	8.98 ± 0.29	1.36 ± 0.32	$(8 \pm 3.2) \times 10^6$	$(6 \pm 2.7) \times 10^2$	

refrigerated condition after 30 days of storage. The product became commercially sterile after retort processing and acceptable during the entire period of the storage under refrigerated condition up to 30 days of storage. The result confirmed the adequacy of the processing as well as its fitness for consumption. Similar study has been done by Mohammedali Shihab et al. (2013) for ready-to-drink traditional Thari Kanchi payasam in flexible retort pouches.

Conclusion

Good quality sensory acceptable *chhenapoda* could be prepared by mixing 18.5% sugar and 7.5% semolina with cottage cheese followed by baking at 200 °C for 60 min. Processing *chhenapoda* in retort pouch at 120 °C for 30 min resulted in significant reduction in microbial population within permissible limit, less physico-chemical change and acceptable sensory score. From the above study, it was concluded that retort processing of *chhenapoda* in laminated pouch (12 µ PET/9 µ Aluminum foil/62.5 µ Nylon CPP) at 120 °C for 30 min resulted in safe, shelf-stable and sensory acceptable product which could be stored up to 30 days under refrigerated condition. However, in-depth study of these processes is required before commercialization of *chhenapoda* based food processing industry. Furthermore, effect of bio-preservatives like nisin and natamycin may be tried in combination with retort processing for increasing the shelf life of *chhenapoda*.

References

- Abhishek V, Kumar R, George J, Nataraju S, Lakshmana JH, Kathiravan T, Madhukar N, Nadasabapathi S (2014) Development of retort process for ready-to-eat (RTE) soy-peas curry as a meat alternative in multilayer flexible retort pouches. *Int Food Res J* 21:1553–1558
- Agathian G, Nataraj S, Singh S, Sabapathy SN, Bawa AS (2009) Development of shelf stable retort pouch processed ready-to-eat dal makhani. *Ind Food Pack* 7:55–62
- AOAC (1984) Official methods of analysis. Association of Official Analytical Chemists (AOAC), Washington
- Bindu J, Ravishankar CN, Srinivasa Gopal TK (2007) Shelf life evaluation of a ready-to-eat black clam (*Villorita cyprinoides*) product in indigenous retort pouches. *J Food Eng* 78:995–1000
- Chiralt A, Martinez-Navarrete N, Martinez-Monzo J, Talens P, Moranga G, Ayala A, Fito P (2001) Changes in mechanical properties throughout osmotic processes: cryoprotectant effect. *J Food Eng* 49:129–135
- Devi TB, Dash SK, Bal LM, Sahoo NR (2016) Physicochemical and microbiological characteristics of ginger paste (cv. *Suprabha*) during storage in different packaging and temperature conditions. *Cogn Food Agric* 2:1–10
- Ghosh BC, Rao JK, Balasubramanyam BV, Kulkarni S (2002) Market survey of chhanapoda sold in Orissa, its characterisation and utilisation. *Ind Dairym* 54:37–41
- Ghosh BC, Rao JK, Balasubramanyam BV, Kulkarni S (2007) Process standardization and shelf life evaluation of chhana podo. *Ind J Dairy Sci* 60:11–19
- Gould GW (1995) New methods of food preservation. Blackie Academic and Professional, London
- IS: 6273 [II] (1971) Indian Standard, Guide for sensory evaluation of foods (part-II, methods and evaluation cards). Indian Standards Institution, New Delhi, p 36
- Kamatt SR, Chander R, Sharma A (2005) Effect of radiation processing on the quality of chilled meat products. *Meat Sci* 69:269–275
- Khan MA, Semwal AD, Shrama GK, Mahesh C, Natraj S, Srihari KA, Bawa AS (2011) Development and evaluation of long shelf-life ambient stable chappaties without the use of chemical preservatives. *J Food Proc Technol* 2:107
- Khandelwal SK, Kumar S (2007). An improved process of production of channa podo. Indian Patent Application No.: 607/MUM/2003 A
- Kumar R, Nataraju S, Jayaprahash C, Sabhapathy SN, Bawa AS (2007) Development and evaluation of retort pouch processed ready-to-eat coconut kheer. *Ind Coconut J* 37:2–6
- Lakshmana JH, Jayaprahash C, Kumar R, Kumarswamy MR, Kathiravan T, Nadasabapathi S (2013) Development and evaluation of shelf stable retort pouch processed ready-to-eat tender jackfruit (*Artocarpus heterophyllus*) curry. *J Food Proc Technol* 4:274
- Leistner L (2000) Basic aspects of food preservation by hurdle technology—review. *Int J Food Microb* 55:181–186
- Majumdar RK, Dhar B, Roy D, Saha A (2015) Optimization of process conditions for Rohu fish in curry medium in retortable pouches using instrumental and sensory characteristics. *J Food Sci Technol* 52(9):5671–5680
- Mohammedali Shihab CP, Hafeeda P, Kumar R, Kathiravan T, Nadasabapathi S (2013) Development and evaluation of shelf stable retort processed ready-to-drink (RTD) traditional Thari kanchi payasam in flexible retort pouches. *Int Food Res J* 20:2247–2252
- Mukhopadhyay S, Majumdar GC, Goswami TK, Mishra HN (2013) Fuzzy logic (similarity analysis) approach for sensory evaluation of chhana podo. *LWT Food Sci Technol* 53:204–210
- Panda MK, Pal US, Bal LM, Mohapatra T (2015) Changes in tissue structure and textural characteristics of maize grain during cooking process. *J Food Meas Charac* 9:130–134
- Rajan S, Kulkarni VV, Chandirasekaran V (2014) Preparation and storage stability of retort processed Chettinad chicken. *J Food Sci Technol* 51(1):173–177
- Rajkumar V, Dushyanthan K, Das AK (2010) Retort pouch processing of Chettinad style goat meat curry—a heritage meat product. *J Food Sci Technol* 47(4):372–379
- Ranganna S (1986) Hand book of analysis and quality control of fruit and vegetable products, 2nd edn. Tata McGraw-Hill Publishing Company Limited, New Delhi
- Sabapathy SN, Bawa AS (2003) Retort processing of RTE foods. *Food Nutr World* 1:28–29
- Sabapathy SN, Ramakrishna A, Srinivasa AN (2001) Current status and potential for retort processed foods in India. *Ind Food Indus* 20:78–79
- Tirkey B, Pal US, Bal LM, Sahoo NR, Bakhara CK, Panda MK (2014) Evaluation of physico-chemical changes of fresh-cut unripe papaya during storage. *FoodPack Shelf Life* 1:190–197