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A CASE STUDY

Preservation of ready to eat drumstick products by canning and retort packaging

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Drumstick (*Moringa oleifera*), a perennial crop, is indigenous to India and it is cultivated all over the country. The tree is valued mainly for its tender pods, which are esteemed as vegetable. The tender leaves and flowers are also used as vegetable. They are rich in vitamin C. In general vegetables are parts of plants, which can be consumed either raw or processed in some way. Based on consumer acceptance and usage, vegetables are consumed with the main course of a meal. Vegetables, apart from providing nutrition, contribute to the appealing colour, texture and flavour of the food. Vegetables contain nonvolatile acids, such as citric, malic, oxalic, succinic acids. These contribute to the flavour of the vegetables.

Though drumstick is a perennial crop, limited availability during the off season makes it expensive. Also the consumers now-a-days look for the ready to eat form of food items. Thus it becomes necessary to preserve the drumstick. Various methods of preservations employs, high and low temperatures, preservatives, dehydration, irradiation, etc. Among these various methods, the use of high temperature, thermal processing is one of the proven food preservation techniques in which heat treatment destroy the pathogens as well as the oxidative enzymes and finds very wide applications.

In thermal processing, canning and retort packaging of foods have been the most widely used methods of food preservation. Thermal processing consists of heating food containers in pressurized retorts at specified temperatures for prescribed duration. The process time is calculated on the basis of achieving sufficient bacterial inactivation in each container/ pouch to comply with public health standards and to ensure that the probability of spoilage will be less than some minimum. It generally refers to a process during which the food product is subjected to high temperatures with the objective of inactivating the undesirable microorganisms or enzymes.

Wijayawardana and Bamunuarachchi (2002) reported that drumstick being a low acid vegetable and rich in vitamin C, has potential as a canned product. Freshly harvested drumstick samples were peeled and cut, rinsed and canned in 2.5% brine at 55% solids content. Processing at 121°C for 20 minutes resulted in optimum product safety and quality. Also allowed 69% retention of vitamin C and totally killed pathogens.

Researchers reported that thermal processing of fish products in retort pouches resulted in a product with good sensor attributes and also gave a shelf life of more than one year at ambient temperature (Bindu *et al.*, 2004; Gopal *et al.*, 2001; Ravishankar *et al.*, 2002). A convenient and ready to consume thermally processed black clam product was developed by Bindu *et al.* (2007) and vacuum packaged in indigenously developed retortable pouch. The total process

time was 44 minutes calculated using formula method. Ball formula method is used in the thermal processing industry, the basis and the precursor of a number of most recent technologies. It has received a lot of attention, being reviewed criticized, compared and compared by several investigators (Stoforos, 2010).

In this context this work has been undertaken to preserve the drumstick curries in cans and retort pouches for use during off seasons and in non production areas, besides use during travel.

EXPERIMENTAL METHODS

Raw material :

Fresh drum sticks (*Moringa oleifera*) of uniform in size, 15 to 17 mm diameter and 400 to 600 mm length, free from damage and blemishes were procured from the local market. They were washed in tap water to remove the dirt and other extraneous matter and cut into uniform length (4 cm).

Preparation of drumstick curry :

The following four types of drum stick curries were prepared and used in the experiments.

- Drum stick curry without coconut (T_1)
- Drum stick curry with coconut (T_2)
- Drum stick curry in spicy medium (T_3)
- Drum stick pulp in spicy medium (T_4)

The drumstick curry without coconut (T_1) was made using the ingredients like, boiled tur dhal, drumstick pieces, onion, asofetida, tomato, tamarind, salt and seasoned with mustard, and no coconut was added. Drum stick curry with coconut (T_2) was prepared with boiled tur dhal, coriander seeds, jerra seeds, red chilly, fenugreek seeds, onion, tamarind, asfoetida, tomato and seasoned with mustard and added with coconut to taste. A spicy curry of drum stick (T_3) was prepared using ground tomato and onion, common spices like fenugreek, jeera and chilly powder, without dhal and coconut. Another curry was prepared from the drum stick pulp. Drum stick pieces were boiled and the pulp was removed by scraping. Drum stick pulp curry (T_4) was prepared with common spices, asofetida, onion, tomato, tamarind juice and salt.

Canning of drumstick curries :

Lacquered cans of size 301 × 203, obtained from a leading manufacturer were used in the experiments. About 200 ml of drum stick curry prepared as explained, was filled in the cans. The filled cans were exhausted at 80°C (measured at can centre) for 5 minutes. The exhausted cans were immediately seamed and processed in a vertical retort at 121.1°C for the calculated process time at pressure of 100 kPa.

Retort packaging of drumstick :

The retort pouch is a flexible package made from a laminate of four materials. The pouch used for experiment is with the outer layer of polyester for strength and printing (12 mm thickness); the next layer with nylon for strength (15 mm thick); the next layer aluminium foil, which acts as a barrier for gas, moisture and light (9 mm thick) and the inner layer is the polypropylene which acts as the heat seal and food contact material (70 mm thickness). The retort pouches of size 150 mm x 200 mm were obtained from a local manufacturer and used.

About 200 ml of curry was filled in the pouches and sealed. Retorting of filled pouches was done in a non-agitating or still retort. This retort was operated in excess of atmospheric pressure with steam as the heating medium for cooking. The pouches were processed at 121.1°C in the retort to the calculated process time.

Thermal process time calculations :

The Ball's formula method is the simplest and most widely used technique for thermal process calculation (Ramaswamy and Singh, 1997).

New process time can be directly calculated if there are changes in the heating – medium temperature (T_r) or the initial product temperature (T_i).

The process time was calculated based on the following equations :

$$B = f_h \log (J_{ch} I_h / g) \quad \text{... (1)}$$

$$J_{ch} = \frac{T_r - Tp_{ih}}{T_r - T_{ih}} \text{ from graph} \quad \text{... (2)}$$

"g" value is obtained from Ball's Table for respective f_h / U value :

$$f_h / U = f_h / F_0 F_i \quad \text{... (3)}$$

where, $F_i = 10^{(121.1 - Tr) / Z}$

$f_h / U = f_h / F_{0\,X}\, 10^{(121.1 - Tr) / Z}$

where,

B - process time, min

f_h - heating rate index (the time in minutes required for change in temperature by 10 degrees

J_{ch} - lag factor

I_h - initial temperature difference

g - T_r –T

T_r - retort temperature, °C

T - product temperature, °C

Tp_{ih} - pseudo initial temperature of product during heating, °C

T_{ih} - initial temperature of product during heating, °C

z - temperature in°C required for the thermal destruction curve to move through one log cycle.

Quality analysis :

The cans and retort pouches with various types of drumstick curries were stored at room condition (temperature: 28 – 32°C and the relative humidity: 65 to 80%). The quality parameters like, pH, Redox potential, colour and microbial quality

were analysed at one month interval. Sensory evaluation was also done on these products at one month interval.

pH and redox potential of the curries **:**

The pH of the drumstick curries was determined using a digital pH meter. The redox potential of the drumstick curries were also determined using same pH meter in mV.

Colour **:**

The colour of the whole drumstick pieces were determined using a Hunter lab colour flex meter. The drumstick curry along with drumstick piece from the cans and pouches were placed in a transparent sample holder in the colour meter and the colour values were noted interms of *L*, *a* and *B*.

Microbial analysis :

The microbial load of the samples were analysed for the canned and retort packaged curries. About 1 ml of the curry was pipetted out using a micropipette and diluted using distilled water blank to 10^{-2} and 10^{-3} dilution. These dilutions were plated by pour plate method in both plate count agar medium for bacterial growth and potato dextrose agar for fungal growth. Two replications for each (10^{-2} and 10^{-3}) dilution were done for both bacteria and fungi. The bacterial count was taken after 2 days and fungal count after 4 days (Rao, 1997). The number of organisms per gram of sample was calculated as given below:

$$N_{CFU} = (M_{CFU} \times D_f)/M_s \quad \text{... (4)}$$

where,

N_{CFU} - number of colony forming units (CFU) per gram of the sample

M_{CFU} - mean number of colony forming units

D_f - dilution factor

M_s - quantity of sample on weight basis.

Sensory evaluation :

Sensory analysis of the products was done by a panel of twelve judges for colour, flavour, texture, taste and overall acceptability using 9-point hedonic scale (Rangnna, 1977).

The following are the details of the scores adopted:

- Dislike extremely
- Dislike very much
- Dislike moderately
- Dislike slightly
- Neither like or dislike
- Slightly like
- Like moderately
- Like very much
- Like extremely.

All the experiments were replicated three times and the results were statistically analysed using AGRES.

EXPERIMENTAL FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Thermal process time calculations for canning and retort pouch :

Heat penetration curves were plotted for canned and retort packaged drumstick curry. The process time required for canning of drumstick was calculated using Ball's formula

Table 1 : pH and redox potential (mV) of drumstick curries in cans and retort pouches

Storage period (Months)	Treatments							
	Drumstick curries in cans				Drumstick curries in retort pouches			
	With coconut (T_1)	Without coconut (T_2)	In spicy tomato medium (T_3)	Drumstick pulp in spicy medium (T_4)	With coconut (T_5)	Without coconut (T_6)	In spicy tomato medium (T_7)	Drumstick pulp in spicy medium (T_8)
pH of the drumstick curries								
Fresh	5.58	5.5	5.9	5.51	5.60	5.55	5.87	5.65
1.	5.42	5.34	5.23	5.3	5.53	5.43	5.32	5.30
2.	5.2	5.18	5.1	5.22	5.46	5.35	5.27	5.23
3.	5.1	5.10	4.8	5.17	5.39	5.28	5.23	5.16
4.	4.7	5.02	4.3	5.12				
5.	4.53	4.98	4.26	5.08				
Redox potential (mV)								
Fresh	81	88.5	94.4	88.4	82.3	85.0	93.9	89.8
1.	81	88.0	94.1	88.0	81.7	84.8	92.9	88.9
2.	80	87.5	93.8	87.8	80.1	81.6	90.3	86.3
3.	78.5	85	93.0	87.2	79.85	80.36	89.55	85.83
4.	76.32	82.3	90.1	83.3				
5.	75.82	81.93	89.2	82.69				

method as given in eq. (1). The thermal process time calculated for canning and retort packaging of drumstick curry at 121.1°C were, 21 and 15 minutes, respectively. Tripathi and Nirankar Nath (2003) evolved the thermal process schedule for baked soybean canned in 2.5% brine (pH 5.66) and in tomato sauce pH (4.98). The corrected process time to achieve sterilization value (Fo) corresponding to 6 minutes for A 2½ can size at 121.1ºC in still and agitating retorts calculated by improved general and lethal rate paper methods were found to be 35.6 minutes, respectively and the thermal process schedule for baked soybean canned in 2.5% brine (pH 5.66) and in tomato sauce pH (4.98) was 40.8 and 40.4 minutes, respectively.

pH of canned and retort packed drumstick curry on storage :

The keeping quality of the foods is related to their restrictive pH. Every microorganism has a minimal, maximal and optimal pH for growth. Microbial cells are significantly affected by the pH of food because they apparently have no mechanism for adjusting their internal pH.

The pH of the canned and retort packaged drumstick curries on storage is given in Table 1. Not only the rate of growth of the microorganisms is affected by pH, also their rate of survival during heating, storage and other forms of processing. The pH of the products decreased subsequently as the storage period increased. The initial pH of the products in cans, with coconut (T_1), without coconut (T_2), in spicy medium (T_3) and drumstick pulp in spicy medium (T_4) were 5.58, 5.5, 5.9 and 5.51, respectively and after 5 months of storage, the pH decreases to 4.53, 4.98, 4.26 and 5.08, respectively (Table 1). For the products with coconut (T_5), without coconut (T_6), in spicy medium (T_7) and drumstick pulp in spicy medium (T_8) packed in retort pouch also, decrease in pH was noted with respect to storage period. The initial pH of the products in retort pouch were 5.60, 5.55, 5.87 and 5.65, respectively. After 3 months of storage, the pH decreased to 5.39, 5.28, 5.23 and 5.16, respectively.

The pH of the canned and retort packaged drumstick curries reduced over the period of storage. As the pH of the product decreases, the acidity increases, resulting destruction

Table 2 : Colour changes in canned drumstick curry

Storage period (Months)	Parameters	Colour value							
		Drumstick products in cans				Drumstick products in retort packages			
		With coconut (T_1)	Without coconut (T_2)	In spicy tomato medium (T_3)	Drumstick pulp in spicy medium (T_4)	With coconut (T_5)	Without coconut (T_6)	In spicy tomato medium (T_7)	Drumstick pulp in spicy medium (T_8)
Fresh	L	39.94	41.62	56.5	49.04	43.2	42.8	55.6	48.3
1		39.89	41.43	55.3	44.2	42.1	41.8	54.6	47.54
2		38.66	41.23	54.22	43.33	41.9	41.3	54.32	47.46
3		37.63	40.22	52.3	41.23	40.93	40.92	53.92	47.31
4		37.54	40.12	52.19	41.20				
5		37.43	39.53	51.63	40.89				
Fresh	a	4.56	5.40	6.23	7.52	5.4	5.56	6.75	5.66
1		4.53	5.31	6.01	6.81	5.2	5.5	6.52	5.43
2		4.21	5.20	5.97	6.77	5.1	5.46	6.50	5.39
3		4.16	5.03	5.88	6.49	5.02	5.32	6.43	5.31
4		4.13	5.01	5.76	6.35				
5		4.11	4.99	5.52	6.26				
Fresh	b	28.51	39.59	1.46	47.73	29.3	28.3	27.3	28.5
1		27.02	39.43	1.44	46.1	28.9	27.5	26.54	27.33
2		26.83	38.69	1.40	35.56	28.5	27.3	26.43	27.29
3		26.67	38.50	1.35	35.00	28.2	27.06	26.26	27.04
4		26.53	38.46	1.33	34.93				
5		26.44	38.25	1.31	34.53				
Fresh	DE	0.01	0.03	0.02	0.03	0.03	0.03	0.03	0.01
1		0.02	0.02	0.03	0.01	0.02	0.02	0.01	0.03
2		0.03	0.01	0.02	0.01	0.02	0.01	0.01	0.01
3		0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
4		0.01	0.01	0.02	0.01				
5		0.01	0.02	0.01	0.01				

of microorganisms. In drumstick pieces, after thermal processing, the chlorophyll is destroyed by the conversion of chlorophyll to pheophytin and this to pyropheophytin, this results in the change of colour of the drumstick from green to dull olive brown colour at 121.1° C, with decrease in pH (Schwartz and Von Elbe, 1983). Adsule *et al*. (1983) reported that the tomato juice pulp could be a new canning medium for mushrooms at the concentration of 4% solid content and pH of 4.4 in combination with 1% sugar and 0.5% salt.

Effect of redox potential on canned and retort packed drumstick curries on storage :

The oxygen tension or partial pressure of oxygen about a food and the oxidation-reduction potential of the food itself influence the type of organisms which will grow and hence the changes produced in the food. Microorganisms affect the Redox potential of their environment during growth, similar to pH. Processing of the food remove the oxidizing or reducing substances and growth of an organism alter the Redox potential of a food enough to restrain other organisms.

Initially the redox potential values of the canned products with coconut (T_1), without coconut (T_2), in spicy medium (T_3) and drumstick pulp in spicy medium (T_4) were 81, 88.5, 94.4 and 88.4, respectively as shown in Table 1. As the storage period increased to five months, the redox potential decreased to 75.82, 81.93, 89.2 and 82.69, respectively (Table 1). The redox potential of the products in the retort pouches also decreased as storage period increased. Initially the redox potential of the products with coconut (T_5), without coconut (T_6), in spicy tomato medium (T_7) and drumstick pulp in spicy medium (T_8) were 82.3, 85, 93.9 and 89.8, respectively. As the storage period increased to three months, the redox potential decreased in retort pouches as 79.85, 80.36, 89.55 and 85.83, respectively (Table 1). The redox potential is dependent on the pH of the product as the pH of the product decrease, the redox potential also decreased. Most of the plant foods have a low redox potential because of the reducing substances like ascorbic acid within them. The oxygen content and the access of the atmosphere to the food influences the redox potential. Food that is packed in a material impermeable to oxygen should have lower redox potential. Here, the redox potential of the drumstick curries decreased on storage along with the pH of the product.

Traditional Kerala style fish curry was processed in retortable pouch having configuration of 12 µ polyester / 15 µ

Table 3 : Colour changes in canned drumstick

Storage period (Months)	Value	Drumstick products			
		With coconut T_1	Without coconut T_2	In spicy tomato medium T_3	Drumstick pulp in spicy medium T_4
Fresh	L	39.44	37.05	42.38	42.2
1.		39.36	36.9	42.29	41.1
2.		38.42	35.7	42.29	41.1
3.		37.62	35.7	42.29	41.1
4.		37.55	34.9	42.13	40.8
5.		37.23	33.85	41.79	39.73
Fresh	a	4.56	4.61	5.88	5.03
1.		4.43	4.56	5.76	4.67
2.		4.37	4.43	5.63	4.67
3.		4.23	4.39	5.58	4.56
4.		4.20	4.37	5.52	4.53
5.		4.18	4.32	5.09	4.51
Fresh	b	28.51	26.87	29.31	28.3
1.		28.33	25.33	28.6	26.3
2.		27.28	24.83	27.6	25.63
3.		27.11	24.2	26.1	24.69
4.		26.73	23.8	25.6	24.5
5.		26.52	23.2	25.23	23.86
Fresh	DE	0.01	0.02	0.01	0.02
1.		0.02	0.01	0.02	0.01
2.		0.01	0.01	0.01	0.02
3.		0.02	0.02	0.01	0.01
4.		0.01	0.02	0.02	0.01
5.		0.01	0.01	0.02	0.01

aluminium foil / 75 µ cast propylene by Gopal *et al.* (2001). The fish curry was processed to a F_0 value of 8.43, the curry remained sterile throughout the storage period of one year, stored at ambient temperature (25-30°C).

Ravi *et al.* (2002) reported that seer fish curry medium in retortable pouch (12.5 µ polyester / 12.5 µ aluminium foil / 80 µ polypropylene) and heat processed to F_0 value of 11.5 and the samples had a shelf life of about 24 months at room temperature.

Colour of the drumstick curries preserved in canned and retort packaged products :

Colour of the canned and retort packaged drumstick and drumstick curry was determined in terms of 'L', 'a' and 'b' values and the "DE" indicates the illuminant deviation or total change in colour. Illuminant deviation or the total change in colour had a drastic impact with respect to the treatments. The colour of canned and retort packaged drumstick and drumstick curry has changed slightly on storage.

Canned drumstick **:**

The initial values of *L, a, b* and *DE* of product, drumstick with coconut (T_1) were 39.44, 4.56, 28.51 and 0.01, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 37.23, 4.18, 26.52 and 0.01, respectively (Table 3). The initial values of *L, a, b* and *DE* of product, drumstick without coconut (T_2) were 37.05, 4.61, 26.87 and 0.02, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 33.85, 4.32, 23.2 and 0.01, respectively. The initial values of *L, a, b* and *DE* of product, drumstick in spicy tomato medium (T_3) were 42.38, 5.88, 29.31 and 0.01, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 41.79, 5.09, 25.23 and 0.02, respectively. The initial values of *L, a, b* and *DE* of product, drumstick pulp in spicy medium (T_4) were 42.2, 5.03, 28.3 and 0.02, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 39.73, 4.51, 23.86 and 0.01, respectively.

Canned drumstick curry **:**

The initial values of *L, a, b* and *DE* of product, drumstick curry with coconut (T_1) were 39.94, 4.56, 28.51 and 0.01, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 37.43, 4.11, 26.44 and 0.01, respectively (Table 2). The initial values of *L, a, b* and *DE* of product, drumstick without coconut (T_2) were 41.62, 5.40, 39.59 and 0.03, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 39.53, 4.99, 38.25 and 0.02, respectively. The initial values of *L, a, b* and *DE* of product, drumstick in spicy tomato medium (T_3) were 56.5, 6.23, 1.46 and 0.02, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 51.63, 5.52, 1.31 and 0.01, respectively. The initial values of *L, a, b* and *DE* of product, drumstick pulp in spicy medium (T_4) were 49.04, 7.52, 47.73 and 0.03, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 40.89, 6.26, 34.53 and 0.01, respectively.

Table 4 : Colour changes in retort packed drumstick curry

Storage period (Months)	Value	Drumstick Products			
		With coconut T_5	Without coconut T_6	In spicy tomato medium T_7	Drumstick pulp in spicy medium T_8
Fresh	L	38.94	48.56	57.8	48.36
1.		38.89	41.86	56.2	47.33
2.		38.82	41.5	55.8	47.12
3.		38.63	41.21	55.29	47.09
Fresh	a	4.45	5.5	6.43	4.69
1.		4.33	5.46	6.39	4.53
2.		4.21	5.32	6.29	4.43
3.		4.19	5.29	6.27	4.36
Fresh	b	28.64	39.06	1.39	48.23
1.		27.02	39.01	1.34	47.55
2.		26.92	38.95	1.31	47.23
3.		26.73	38.56	1.26	47.12
Fresh	DE	0.02	0.02	0.01	0.02
1.		0.02	0.02	0.01	0.03
2.		0.01	0.01	0.02	0.02
3.		0.02	0.01	0.02	0.01

Retort packaged drumstick **:**

The initial values of *L, a, b* and *DE* of product, drumstick with coconut (T_5) were 43.2, 5.4, 29.3 and 0.03, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 40.93, 5.02, 28.2 and 0.01, respectively (Table 2). The initial values of *L, a, b* and *DE* of product, drumstick without coconut (T_6) were 42.8, 5.56, 28.3 and 0.03, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 40.92, 5.32, 27.06 and 0.01, respectively. The initial values of *L, a, b* and *DE* of product, drumstick in spicy tomato medium (T_7) were 55.6, 6.75, 27.3 and 0.03, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 53.92, 6.43, 26.26 and 0.01, respectively. The initial values of *L, a, b* and *DE* of product, drumstick pulp in spicy medium (T_8) were 48.3, 5.66, 28.5 and 0.01, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 47.31, 5.31, 27.04 and 0.01, respectively.

Retort packed drumstick curry **:**

The initial values of *L, a, b* and *DE* of product, drumstick curry with coconut (T_5) were 38.94, 4.45, 28.64 and 0.02, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 38.63, 4.19, 26.73 and 0.02, respectively (Table 4). The initial values of *L, a, b* and *DE* of product, drumstick without coconut (T_6) were 48.56, 5.5, 39.06 and 0.02, respectively. As the storage period increased, there were slight changes in the *L, a, b* and *DE* values to 41.21, 5.29, 38.56 and 0.01, respectively. The initial values of *L, a, b* and *DE* of product, drumstick in spicy tomato medium (T_7) were 57.8, 6.43, 1.39 and 0.01, respectively. As the storage period increased, there were slight changes in the L, a, b, DE values to 55.29, 6.27, 1.26 and 0.02, respectively. The initial values of *L, a, b* and *DE* of product, drumstick pulp in spicy medium (T_8) were 48.36, 4.69, 48.23 and 0.02, respectively and were 47.09, 4.36, 47.12 and 0.01, after a storage period of 3 months.

In drumstick pieces, after thermal processing, the chlorophyll is destroyed by the conversion of chlorophyll to pheophytin and this to pyropheophytin, this results in the change of colour of the drumstick from green to dull olive brown colour at 121.1° C, with decrease in pH (Schwartz and Von Elbe, 1983).

The product, the spicy tomato medium (T_3 and T_7) in can and retort pouch gave higher values of "a +" *i.e.,* 42.38 and 55.6, respectively because of the redness of the tomato medium. The colour of the stored canned and retort packed curry predominates with "b+" values because of the turmeric (yellow colour) used in the product preparation.

It is observed that the decrease in L value in all the treatments indicated the change of lightness to slightly dark. Similarly the decrease in a+ and b+ value indicated the increase in red colour and yellow colour in the product as the storage period increased.

Microbial qualities of canned and retort packaged drumstick products :

Standard procedure was followed to analyse the total bacterial and fungal count in canned and retort packaged drumstick products. The bacteria count (in CFU/g) increased from 8×10^{-3} to 14×10^{-3}, 4×10^{-3} to 6×10^{-3}, 3×10^{-3} to 5×10^{-3}, 4×10^{-3} to 6×10^{-3} for the products T_1, T_2, T_3 and T_4, respectively. The bacterial count increased from 4×10^{-3} to 6×10^{-3} in T_5 and 4×10^{-3} to 6×10^{-3} in T_7 and the bacterial count maintained as 5×10^{-3} in T_6 and T_8 throughout the storage period. The bacterial count increased as the storage period increased from

Table 5 : Microbial load in canned drumstick products

Storage period (Months)	Canned drumstick Products							
	With coconut (T_1)		Without coconut (T_2)		In spicy tomato medium (T_3)		Drumstick pulp in spicy medium (T_4)	
	Bacteria x 10^{-3}	Fungi x 10^{-3}	Bacteria x 10^{-3}	Fungi x 10^{-3}	Bacteria x 10^{-3}	Fungi x 10^{-3}	Bacteria x 10^{-3}	Fungi x 10^{-3}
Fresh	8	1	4	0	3	1	4	1
1.	9	1	5	0	4	0	4	1
2.	12	0	5	0	4	1	5	1
3.	12	1	5	1	4	0	5	1
4.	13	1	5	0	4	1	6	1
5.	14	1	6	1	5	1	6	1

Table 6 : Microbial load in retort packed drumstick products

Storage period (Months)	Retort packed drumstick products							
	With coconut (T_5)		Without coconut (T_6)		In spicy tomato medium (T_7)		Drumstick pulp in spicy medium (T_8)	
	Bacteria x 10^{-3}	Fungi x 10^{-3}	Bacteria x 10^{-3}	Fungi x 10^{-3}	Bacteria x 10^{-3}	Fungi x 10^{-3}	Bacteria x 10^{-3}	Fungi x 10^{-3}
Fresh	4	1	5	1	4	0	5	1
1.	5	0	5	1	4	0	5	1
2.	6	1	5	0	5	0	5	1
3.	6	1	5	1	6	1	5	1

fresh to 5 months and 3 months in cans and retort pouches, respectively. The fungal load maintained as 1 in all the products throughout the storage period. The counts of the organisms are given in Tables 5 and 6, respectively.

The counts of the microorganisms were within the permissible limits (30×10^{-3}) (Sharma *et al.*, 1978) for canned and retort packaged foods. So, the products were found to be microbiologically safe on storage.

Sensory evaluation :

The sensory evaluation of the products was conducted as explained in earlier section. The colour of the food, in addition to giving pleasure is used as an index to the quality of the foods. The sensory score and colour for the product, drumstick with coconut (T_1, T_5) decreased on storage in canned and retort packed foods whereas the colour scores of the other products, drumstick without coconut (T_2, T_6), drumstick in spicy tomato medium (T_3, T_7), drumstick pulp in spicy medium (T_4, T_8) remained closer. The sensory score for colour decreased from initial value of 9 to 6 in cans and 9 to 7 in retort pouches on storage.

The flavour of the food contributes immeasurably to the pleasure of eating. The sensory score in respect of flavour of product, drumstick with coconut (T_1, T_5) decreased from 9 to

Table 7 : Sensory evaluation scores of canned drumstick products

Storage period (Months)	Parameters	Drumstick products			
		With coconut (T_1)	Without coconut (T_2)	In spicy tomato medium (T_3)	Drumstick pulp in spicy medium (T_4)
Fresh	Colour	9	8	9	8
	Flavour	9	8	7	9
	Taste	9	8	7	9
	Appearance	9	9	8	8
	Texture (mouth feel)	9	9	8	9
	Overall acceptability	9	8	7	8
1.	Colour	8	8	6	8
	Flavour	8	7	6	8
	Taste	8	8	6	7
	Appearance	8	9	8	7
	Texture (mouth feel)	8	7	8	8
	Overall acceptability	8	7	7	8
2.	Colour	8	8	6	5
	Flavour	6	7	5	5
	Taste	6	8	3	5
	Appearance	7	9	8	7
	Texture (mouth feel)	7	7	4	6
	Overall acceptability	7	7	5	6
3.	Colour	7	9	8	7
	Flavour	5	8	9	6
	Taste	5	8	7	6
	Appearance	7	8	7	7
	Texture (mouth feel)	7	9	8	7
	Overall acceptability	5	8	7	7
4.	Colour	7	9	8	7
	Flavour	4	8	8	6
	Taste	4	8	7	6
	Appearance	7	8	7	7
	Texture (mouth feel)	7	8	8	7
	Overall acceptability	4	8	7	7
5.	Colour	6	8	7	6
	Flavour	3	7	7	5
	Taste	3	7	6	5
	Appearance	6	8	6	6
	Texture (mouth feel)	6	7	7	6
	Overall acceptability	3	7	6	6

Table 8 : Sensory evaluation scores of retort packed drumstick products

Storage period (Months)	Parameters	Drumstick products			
		With coconut (T_5)	Without coconut (T_6)	In spicy tomato medium (T_7)	Drumstick pulp in spicy medium (T_8)
Fresh	Colour	9	9	9	9
	Flavour	9	8	8	9
	Taste	9	8	8	9
	Appearance	9	9	8	8
	Texture (mouth feel)	9	9	8	9
	Overall Acceptability	9	8	8	8
1.	Colour	8	8	7	8
	Flavour	8	7	7	7
	Taste	8	8	7	7
	Appearance	8	9	7	7
	Texture (mouth feel)	8	7	7	7
	Overall Acceptability	8	7	7	7
2.	Colour	7	8	7	7
	Flavour	7	7	7	7
	Taste	7	8	6	6
	Appearance	7	8	6	6
	Texture (mouth feel)	8	7	6	7
	Overall Acceptability	7	8	7	7
3.	Colour	7	8	7	7
	Flavour	7	7	6	7
	Taste	7	7	5	5
	Appearance	7	8	6	6
	Texture (mouth feel)	7	7	6	7
	Overall Acceptability	6	7	6	6

3 in cans and 8 to 7 in retort pouches on storage due to the rancidity of the coconut in the product, all the other products had good flavour during the entire storage period.

Consumers value food for its taste. Except the product, drumstick with coconut (T_1), whose sensory score decreased from 9 to 3 in cans and all the products a score was in the range of 9 to 5 over the storage period.

The overall acceptability of the products, drumstick without coconut (T_2 and T_6), drumstick in spicy tomato medium (T_3 and T_7) and drumstick pulp in spicy medium (T_4 and T_8) varied marginally over the storage period of 5 and 3 months for the cans and retorted pouches, respectively.

The sensory score decreased in product, drumstick with coconut (T_1, T_5) in cans and retort pouches because of the rancidity caused by the coconut in the medium. The sensory evaluation scores of canned and retort packaged drumstick products are given in Tables 7 and 8, respectively.

LITERATURE CITED

Adsule, P.G., Onkaraya, H., Tewari, R.P. and Girija, V. (1983). Tomato juice a new canning medium for European mushrooms *Agaricus bisporous* (large) imbach. *Mushroom J.,* **124** : 143-145.

Azad, K.C., Srivastava, M.P., Singh, R. and Sharma, P.C. (1986). Commercial preservation of mushrooms-I a technical profile of canning and its economics. *Indian J. Mushrooms*, **12** : 21-29.

Bhatia, B.S., Mathur, V.K., Ramanathan, L.A., Prasad, M.S. and Vijayaraghavan, P.K. (1964). Canning of pulav. Indian food packer: 19-23.

Bindu, J., Ravishankar, C.N. and Srinivas Gopal, T.K. (2007). Shelf life evaluation of a ready to eat black clam (*Villorita cyprinoides*) product in indigenous retort pouches. *J. Food Engg.,* **78** (3) : 995-1000.

Bindu, J., Srinivasa, T.K., Gopal, T.S. and Nair, Unnikrishnan (2004). Ready-to-eat mussel meat processed in retort pouches for the retail and export market. *Packaging Technol. & Sci.,* **17** (3): 13-117.

Chaddha, K.L. (2001). Drumstick. Hand book of horticulture. 396-398.

Chauhan (2003). Gherkin processing in India. *Indian Food Industry*, **22**(1): 21-25.

Chen, C.R. and Ramaswamy, H.S. (2002). Modeling and optimization of variable retort temperature (VRT) thermal processing using coupled neural networks and genetic algorithms. *J. Food Engg.*, **53** (3) : 209–220.

De, K.C. (1967). Leaker spoilage in canned foods and its prevention. *Indian Food Packer,* 24-27.

Ghosh, K.G., Krishnappa, K.G., Srivatasa, A.N. Eapen, K.C. and Vijayaraghavan, P.K. (1979). In pack processing of ready–to–eat foods in indigenous flexible packaging materials, Part III. Studies on newer packaging materials capable of withstanding the processing temperature. *J. Food Sci. & Technol.,* **16**(5): 198-201.

Gopal, T.K.S. Vijayan, P.K., Balachnadran, K.K., Madhavan, P. and Iyer, T.G.S. (2001). Traditional Kerlala style fish ucrry in indeginous retort puches. *Food Control*, **12** : 523-527.

Kalpalathika, P.V.M., Swamy, A.M.N. and Patwardhan, M.V. (1988). Studies on canned strained baby foods based on vegetables. II. Green peas. *J. Food Sci. & Technol.*, **25**(4): 236-240.

Magda, R. (1994). Moringa: a health-giving, water-purifying vegetable. *Food Marketing & Technol.,* **8**(6): 10-11.

Mahadeviah, M., Gowramma, R.V. and Naresh, R. (1983). Welded Open Top Sanitory cans as an alternative to soldered cans. *J. Food Sci. & Technol.,* **20** : 241-242.

Nadanasabapathy, S., Krishna, Rama and Srivastava, A.N. (2001). Current status and potential for retort processed foods in India. *Indian Food Packer*, **2**: 21-25.

Nath, N. and Ranganna, S. (1983). Determination of a thermal process schedule for guava. *Fd. Technol.,* **18**(3) : 301-316.

Ramaswamy, H.S. (1995). Thermal processing of fruits: principles and process calculations. Lead paper-L4: 107-117.

Ramaswamy, H.S. and Singh, R.P. (1997). Sterilization process engineering. Handbook of food Engineering practice. CRC press LLC: 37-69.

Ranganna, S. (1974). Determination of thermal process schedule for guava pulp.*Indian Food packer*, **28**(5) : 5-7.

Ranganna, S. (1977). Manual of analysis of fruit and vegetable products. Tata McGraw – Hill publishing Company Limited, NEW DELHI (INDIA).

Rangarao, G.C.P. (1992). Retortable plastic packaging for thermo-processed foods. *Indian Food Industry*, **11**(6) : 25.

Rangarao, G.C.P. (2002). Ready- to-eat Indian foods in retort pouches: The second wave.*Indian Food Industry*, **21**(1) : 12-20.

Rao, K.V.S.S., Thompkinson, D.K. and Mathur, B.N. (1997). Role of sensory evaluation in product development. *Indian Food Industry*, **16**(2) :

Ravi Shankar, C.N., Gopal, T.K. Srinivasa and Vijayan, P.K. (2002). Studies on heat processing and storage of seer fish curry in retort pouches. *Packaging Technol. & Sci. An Internat. J.*, **15**(1): 3-7.

Ravishankar, C.N., Srinivasa Gopal, T.K. and Vijayan, P.K. (2002). Studies on heat processing and storage of seer fish curry in retort pouches. *Pacakging Technol. & Sci.*, **15** (1) : 3-7.

Revanker, G.D. and Baliga, B.L. (1982). Ready-to-heat and serve frozen fish curry. *Indian Food Packer,* **37** (1) : 54-61.

Rosamari feliu-Baez, Hugh E. Lockhart and Gary Burgess (2001). Correlation of peel & burst tests for pouches. *Packaging Technol. & Sci.*, **14** (2) : 63-69.

Schwartz, S.J. and Von Elbe, J.H. (1983). Kinetics of cholorophyll dehradation to pyropheophytin in vegetables. *J. Food Sci.,* **48** (4) : 1303-1306.

Setty, G.R. and Patwardhan, M.V. (1983). Energy conservation in the processing of canned mango pulp. *Indian Food Packer*, **37**(1): 91-93.

Teixeira, A.A. (1994). Thermal Processing: canning and pasteurization. Encyclopedia of Agricultural Science 4: Academic Press, Inc.: 303-311.

Tripathi, R.N. and Nath, Nirankar (2003). Determination of thermal process requirements for baked soybeans canned in brine and tomato sauce: A comparative study of the methods of process calculation. *J. Food Sci. & Technol.,* **40** (1) : 11-16

Verma, S.C., Banerji, R., Misra, G. and Nigam, S.K. (1976). Nutritional value of Moringa. *Curr. Sci.,***45**(21) : 769-770.