J Food Sci Technol (July–August 2010) 47(4):372–379
DOI: 10.1007/s13197-010-0062-9

ORIGINAL ARTICLE

Retort pouch processing of Chettinad style goat meat curry – a heritage meat product

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Revised: 15 December 2009 / Accepted: 24 December 2009

Abstract Chettinad style goat meat curry, a heritage meat product, was thermal processed in retort pouches having 4 layer configurations. Physical properties of retort pouches indicated that they are suitable for processing. Pouches filled with 150 g of goat meat and 100 g of curry medium were retorted to a F_O value of 12.1 min. Retort cooked products were tested for sterility and quality characteristics. Retorting decreased the product pH, thiobarbituric acid reactive substances and shear force values. Retort processed products had significantly lower *L*, a*, b** and chroma values. Product was superior in all sensory attributes. It is concluded that Chettinad style goat meat product retorted to a F_O value of 12.1 min, had acceptable sensory quality characteristics.

Keywords Retort pouch processing · Chettinad style goat meat · Lethality rate · Quality evaluation · Hunter colour · Texture profile

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Introduction

Among the varieties of Indian recipes, Chettinad style of preparation holds a special place for food lovers and offers hot and spicy non-vegetarian foods and is famous in the southern region of Tamil Nadu. The delicious products are chicken Chettinad curry, Chettinad goat meat curry, Chettinad chicken or mutton fry and Chettinad chilly chicken fry (Rajkumar et al. 2007) and they are considered as heritage meat products. They are traditionally based on judiciously blended local raw materials and are designed for daily consumption and have unique flavour and taste (SFFB 2007).

Indian goat population is 124.9 million in the world next to China with 199.0 million and the goat meat production was 0.54 MT in the year 2006 (FAO 2008). Indian meat processing is focusing on export and looking for unique shelf stable meat products for national and international consumers. There are many methods of preservation and thermal processing is one of the promising methods of processing food (Karel et al. 1975). Among thermal processing, retort pouch processing is very popular and has several advantages over canning. Presently, consumption of canned foods is declining (Nair and Girija 1994, Dileep and Sudhakara 2007) due to high cost of tin for making cans acceptable to the market (Srivasta et al. 1993). Retort pouch can be imprinted, its size and shape are flexible, and it can be displayed on shelves. Foods can be cooked faster in flexible pouches than in cans and it also helps to reduce the cost of delivery and storage (Dushyanthan 2002).

Researchers reported the desirability of using retortable pouches for various products. Shelf stable traditional Kerala style fish curry (Gopal et al. 2001), seer fish curry (Shankar et al. 2002), ready to eat mussel meat (Bindu et al. 2004), mutton meat curry (DRDO 2004), tuna in oil (Ali et al. 2006), ready-to-eat black clam (Bindu et al. 2007), ready to eat squid masala (Sreenath et al. 2007), ready-to-eat pearlspot fish curry (Pandey et al. 2007) and prawn kurma (Mohan et al. 2008) were prepared by retort pouch

processing. Patents have been awarded for retort pouch processing of broiled fish product (Sugisawa et al. 1989), meat paste food (Shoichi 1993), meat with vegetables and rice (Masaki 2001), sliced meat (Hiroyuki et al. 2002) and retort meat quality improver (Kenichi et al. 2007). Although retort processing of fish was conducted by several workers, report on traditional and heritage Indian meat products were deficient and therefore, an attempt was made to standardize the retort pouch processing of ready-to-eat Chettinad style goat meat curry.

Materials and methods

Male goats (~2 years of age) were transported and slaughtered as per the approved ethics of the university after 18 h of fasting with free access to potable water. Dressed carcasses were hand deboned, trimmed-off separable fat and connective tissue after 2–3 h of slaughter. Knife separable lean packed in high-density polyethylene (HDPE) bags were stored at –20 ± 2°C till further use. Partially thawed meat on the day of experiment was cut into small cubes of 3–4 cm^2 using automatic meat slicer (Sirman, Italy) before use.

Indigenously manufactured retort pouches (Pradeep Laminators, Pune, India) having 4 layer configuration (from the inner surface the layers are 1. Cast poly propylene, 2. Biaxially oriented nylon, 3. Aluminium foil and 4. Polyester) and a dimension of 20 cm × 15 cm were used for this study. Physical properties were assessed for the suitability of retort pouches for thermal processing (Table 1), by using Universal Testing Machine (stable micro systems Ltd, England) as per the standard procedure reported by Mohan et al. (2008).

Table 1 Physical properties of retort pouch used

Parameters	Results
Total thickness	106.0 µm
a. Thickness of aluminium foil	9.0 µm
b. Thickness of cast poly propylene	70.0 µm
c. Thickness of polyester layer	12.0 µm
d. Thickness of biaxially oriented nylon	15.0 µm
Pouch length	200 mm
Pouch width	150 mm
Pouch weight	7.95 gm
Seal width, side and bottom	10 mm
Tensile strength, kg cm^{-2}	
a. Machine direction	521.4 ± 0.05
b. Cross direction	493.6 ± 0.02
Heat seal strength, kg/ 15 mm	
a. Machine direction	6.5 ± 0.11
b. Cross direction	5.9 ± 0.08
Bond strength, g/15 mm	540.00 ± 0.39
Bursting strength, psig	31.00 ± 0.05
Migration residue	
a. Water extract, mg dm^{-2} at 121°C	0.50 ± 0.06
b. n-Heptane (66°C for 2 h)	2.56 ± 0.10
Water vapour transmission rate, g m^{-2}/24 h at 90% RH	0.18 ± 0.02
Odour test	Odour free

The formulation for the Chettinad style goat meat curry was standardized based on the information collected verbally by interaction from the region of Chettinad and from the popular Chettinad restaurants of Tamilnadu. The information on recipe of Sietsema (2004) was also considered. Based on the information collected, one formulation (Table 2) was standardized at the laboratory. Freshly prepared good quality green and dry spices available from the local market of Chennai, India were utilised for the study. For the easy filling of retort pouches and to maintain the flavour, curry medium was prepared separately and added to the pouch containing goat meat.

Chettinad style goat meat curry medium was prepared by heating the chopped onion in sunflower oil till the colour

Table 2 Ingredient composition % of Chettinad style goat meat product

Goat meat	60.02
Green spice mixture	
Coconut paste	4.50
Onion paste	6.24
Ginger paste	1.20
Garlic paste	0.90
Tomato paste	3.60
Curry leaves	0.15
Dry spice mixture	
Cinnamon	0.18
Clove	0.09
Cumin	0.30
Anise	0.30
Black pepper	0.15
Chili powder	0.42
Turmeric powder	0.30
Kuskus (*Papaver somniferum*)	0.06
Mustard seeds	0.15
Cardamom	0.15
Coriander	0.45
Bay leaf	0.06
Lichens (*Parmeliaceae* sp.)	0.06
Annasi poo (*Illicium verum*)	0.06
Nutmeg	0.06
Others	
Salt	1.08
Refined vegetable oil	4.50
Water	15.01

became golden yellow. Sliced tomatoes were added and continued heating in a liquid pressure gas burner for 3 min. Freshly prepared ginger and garlic pastes were added and heated for another 3 min. Then the powdered dry spice was added and heated and finally the ground coconut pulp was added with potable water. The total process was completed in 10–12 min and the curry medium (semi-solid) was allowed to cool before it was added to the retort pouches.

Goat meat cubes (150 ± 2 g) in pouches were filled with 100 ± 2 g curry medium using a specially designed stainless steel funnel to avoid spillage. Residual air was removed by steam flush technique and sealed by an impulse sealing machine (Sun Ray industries Pvt. Ltd., Mysore, India). Adequate numbers of pouches were fixed with glands, and thermocouples were carefully introduced to the core of goat meat and cold point temperatures were monitored using data recorder (Ellab, Denmark) to study the cold process control parameters. The filled and sealed packets were laid flat on trays in a laboratory model overpressure autoclave (25 pouch capacity retort, Lakshmi Engineering, Chennai, India). The thermo dynamics of the product processing was calculated as per the formula described by Stumbo (1973).

For thermal processing, the retort temperature was maintained at 121.1°C. The processing time was determined as per the method of Gopal et al. (2001). Pressure was maintained at 20 ± 1 psi throughout the process, using steam- air mixture while heating and water - air mixture was used while cooling. Rapid cooling was accomplished by re-circulating cooling water. Cold point temperatures were monitored using T type copper thermocouples (Ellab, Denmark). The coldest point was taken as the point that takes the longest time to sterilize the retort pouch filled with 250 g of Chettinad style goat meat product. Three thermocouples were placed in 3 different locations including geometric centre of pouch. Time needed to reach the target temperature of 121.1°C was recorded. The experiment was repeated 4 times and the coldest point was identified by locating the thermocouple, which showed the longest time needed to reach the target temperature. After processing to the required F_0 value, they were cooled rapidly, till the core temperature of the product reached 60°C (T_c) by pumping water into the retort and recirculating it. The lag factor for heating (J_h), slope of the heating curve (f_h), time in min for sterilization at retort temperature (U) and lag factor for cooling (J_c) were calculated. The parameters f_h/U, final temperature deficit g, process time B and total process time (T_B) were calculated by the mathematical method. The parameters were determined by plotting temperature deficit (RT – T_c) on semi log paper. RT is the retort temperature and T_c is the product core temperature. Total process time (T_B) was determined by adding process time (B) to the effectiveness of the come up time (CUT).

$$\text{The lag factor for heating } (J_h) = (T_r \times T_{pih}) / (T_r \times T_{aih})$$

where, T_r – temperature of retort, T_{pih} – Pseudo (corrected) initial heating temperature,

T_{aih} – Actual intitial heating temperature and f_h = time in min required for the straight line heating curve to transverse one log cycle which is numerically equal to the reciprocal of the slope of the straight line.

$$\text{The lag factor for cooling } (J_c) = (T_r \times T_{pic}) / (T_r \times T_{aic})$$

$$\text{Process time } (B) = \text{Total process time} - \text{CUT}$$

After processing, all the pouches were wiped dry and kept in a dust proof cabinet at ambient temperature (25–30°C) after packing them in plain secondary duplex carton having grammage of 300 GSM (grams per square meter) and a thickness of 265 µm. The product yield was calculated before the quality studies were carried out to know the loss in weight due to retort processing.

Product quality evaluation: Changes in physico-chemical, microbiological and sensory traits of meat product on retort processing were studied. Each time one packet from each trial was randomly taken out for microbiological examination first, followed by physico-chemical traits. Remaining parts of samples were used for sensory evaluation.

Moisture, fat, protein and ash contents in the product were determined (AOAC 1995). The pH was determined (Agnihotri and Pal 1997) by triturating 10 g of samples with 90 ml of distilled water and recorded by digital pH meter (Systronics, µ pH system 361). Thiobarbituric acid reactive substances (TBARS) value was estimated as per the method described by Tarladgis et al. (1960). The absorbance was measured at 538 nm (ELICO systems, Bangalore). The optical density was multiplied by factor 7.8 to get mg malonaldehyde/ kg of sample (Konecko 1979). Tyrosine value (TV) was determined by the modified method of Strange et al. (1977). Cholesterol content of fresh and cooked meat product was determined using cholesterol test kit (Span Diagnostics Ltd., India) as described by Rajkumar et al. (2004). The shear force values (SFV) of cooked product were assessed using Warner Bratzler Shear Press (Manhattan, U.S.A.). Then the SFV was recorded as per method of Rao et al. (1999) and expressed in kg/cm^2.

Sterility tests were done as per ISI (1971). In addition, the total viable, anaerobic, coliform, staphylococcal, streptococcal, clostridial and yeast and mould counts of fresh and cooked meat products samples were determined (APHA 1984). Each time, a representative 10 g mashed meat product sample was withdrawn and homogenized (Stomacher, Seward, West Sussex, United Kingdom) aseptically using 90 ml 0.1 % sterile peptone water (Agnihotri and Pal 2000) and serial dilutions were made using 0.1% sterile peptone water. The enumeration procedures as described in ICMSF (1988) were followed.

Instrumental colour value: Colour of sample was evaluated using Hunter lab Mini scan XE plus spectro colorimeter (Reston Virgenia, USA) with geometry of diffuse / 80 (sphere – 8 mm view) and an illuminant of D65/10 degree as described by Bindu et al. (2007). Values are expressed using the standard Hunter $L^*a^*b^*$ system. L^*, a^*, and b^*

values (non- dimensional units) refer to the three axes of the system: a lightness axis (white – black, L^*); and two axes representing both hue and chroma, one red-green (a^*) and the other blue-yellow (b^*). The instrument was calibrated with black and white tile ($L^* = 94$, $a^* = 1.10$ and $b^* = 0.6$) every time before the colour measurement was taken. Colour was expressed as L^* (brightness), a^* (redness) and b^* (yellowness). The hue (relative position of colour between redness and yellowness) and chroma (colour intensity) was calculated as follows.

$$\text{Hue} = \tan^{-1}(b^*/a^*); \text{Chroma} = \sqrt{(a^*)^2 + (b^*)^2}$$

Average value for each colour parameter was determined by taking observation from five different cooked pieces from the same pouch.

Texture profile analysis (TPA): TPA was conducted using a Stable Microsystems Texturometer (Stable Micro systems Ltd., England, UK) model TA-HD plus texture analyser attached to software, texture expert as per Bourne (1978). Triplicate samples in each trial (2 cm height and 3 cm diameter) were compressed twice to 40% of their original height to form a "two bite" work force compression curve. The test was carried out at a speed of 12 mm/sec using a 500 kg load cell attached with a cylindrical probe of 75 mm diameter. The parameters like hardness of the first and second compression (hardness 1 and 2), springiness (mm), cohesiveness, gumminess and chewiness (kgf/mm) were determined.

Sensory evaluation: Meat product was subjected to organoleptic evaluation by 6 semi-trained panelists using 9-point Hedonic scale (9=like extremely; 1=dislike extremely) (Pal and Agnihotri 1996). Meat products at 30–35°C were assessed under incandescent light for appearance, colour, flavour, juiciness, texture and overall acceptability. Drinking water was provided after tasting each sample to cleanse the palate.

Statistical analysis: Analysis of variance was done to find the effect retort processing on meat product quality traits. Differences between means were tested by critical difference (Snedecor and Cochran 1994).

Results and discussion

Retort pouch characteristics: Retort pouches used in the study had a thickness of 106 µm with 20 × 15 cm length and width (Table 1). In its 4 layer configuration, biaxially oriented nylon of 15 µm was included for improving the barrier properties, which was not reported previously (Shankar et al. 2002, Bindu et al. 2007, Mohan et al. 2008). The other 3 layers were aluminium foil, cast poly propylene and polyester of 9, 70 and 12 µm thickness, respectively. The seal width was of standard size and the tensile strength indicating the rupture and breakage of the material was higher in the machine direction. Heat seal strength, an indicator of shelf life was higher in machine and cross direction. Bursting strength is an indicative of delamination of pouches due to thermal processing (Vijayalakshmi et al. 2003) and it was 31 psig (Pressure /in^2/g), which is in the prescribed limits. The migration residues were well below the limits described for a food contact material (FDA 1983). Water vapour transmission was lower indicating suitability of thermal processing of the pouches and the findings are in accordance with results described by Vijayan et al. (1998) and Mohan et al. (2008). They reported that the product had more shelf life with less water transmission rate.

Thermal processing of Chettinad style goat meat product: The retort pouches in the present study were processed to a *Fo* value of 12.1 min and it was as per the recommended *Fo* value for meat products, which was 8-20 min (Frott and Lewis 1994). As per the sterility test and microbiological characteristics test conducted, the results indicated that the retort pouches received sufficient thermal processing temperature to achieve commercial sterility. The retort temperature and the product core temperature before processing was 30°C and reached its first lethality rate of 0.001, when the core temperature was 90°C and the retort temperature was 121.1°C (Fig. 1). To reach the first lethality, CUT was 23 min. The CUT percentage of retort processed Chettinad style goat meat product was 50.1%, which was above the CUT values of 42% reported by Ranganna (2000). The total heating time was recorded as 22 min based on the time taken for the product core temperature to reach 121.1°C. Cooling time was 10 min after attaining necessary product core temperature of 121°C. After cooling, the retort temperature was 45°C and the product core temperature was 60°C. The above results are in agreement with Bindu et al. (2007). Total lethality (F_O) received for the product was 12.1 min and the results are in agreement with the findings of Ranganna (2000), who reported F_O values between 8 and 12 min for meat products. Gopal et al. (2001) reported F_O values of 6.56 and 8.43 in Kerala style fish curry and Shankar et al. (2002) recorded F_O value of 11.5 min in heat processed seer fish curry. The heat penetration characteristics of the product are presented in Table 3. Heating rate index (f_h) of product was 32 min and the results of the study were in accordance to the findings of Shankar et al. (2002) and f_h of 25 to 32 min indicates that the heat penetration was by both convection and conduction. Heating lag factor (J_h) was 1.13. The observations were in accordance to the findings of Mohan et al. (2008) who reported that heating lag factor (J_h) of 1.44 and 1.0 for canned and pouch processed prawn *kurma,* respectively. Cooling lag factor (J_c) of 1.48 was observed for the product and the results are similar to that recorded by Shankar et al. (2002) in sheer fish curry in retort pouches and Bindu et al. (2004) in ready to eat mussel meat in retort pouches. The J_h and J_c values in this study are within the range of 0.8 to 1.5 which is similar to that indicated by Ranganna (2000) and these values may vary with the type of product and size of retort used.

Cook value of the product was 75.35 min and it is a measure of heat treatment with respect to nutrient degradation

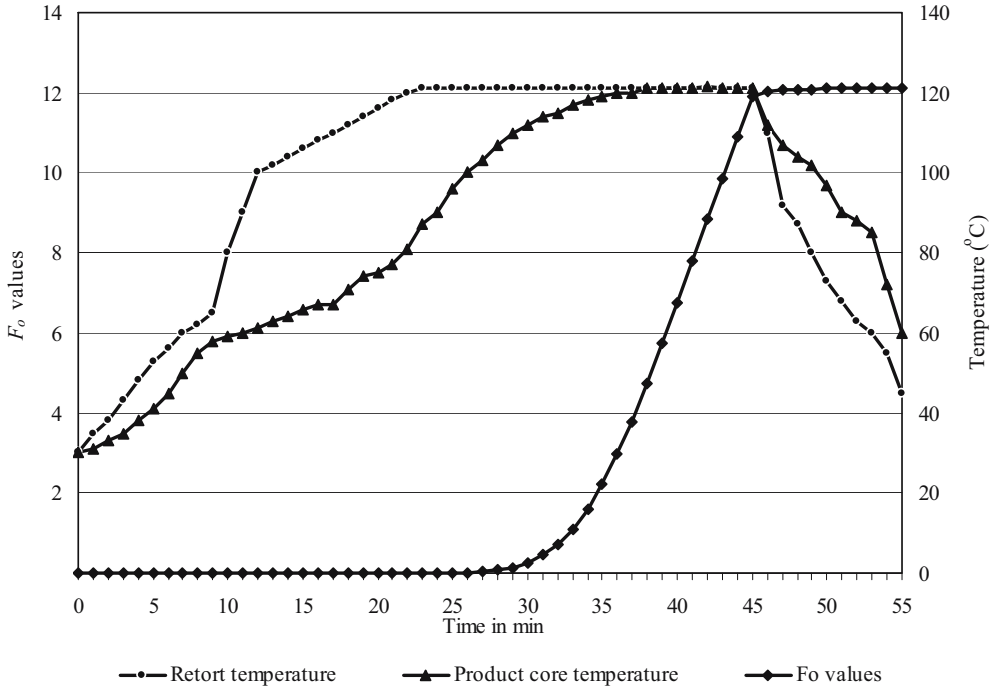

Fig. 1 Fo value and thermal processing characteristics of Chettinad style goat meat product

Table 3 Heat penetration characteristics of Chettinad style goat meat product in retort pouch

Heating rate index (f_h) min	32.00
Heating lag factor (J_h)	1.13
Cooling lag factor (J_c)	1.48
Process time, min	33.00
Cook value, min	75.35
Time for sterilization (U) or heating time, min	22.00
f_h/U	1.45

and textural changes that occur during processing, and this was also determined by measuring the extent of cooking and nutritional loss during processing (Bindu et al. 2007). It was determined by measuring the extent of cooking and nutritional loss during processing in a manner similar to the D value, except that the reference temperature was 100°C instead of 121°C, and the z value is 33°C, which is required for the denaturation of thiamine (Ranganna 2000). Cook values and the thermal processing parameters are presented in Fig. 2. Manju et al. (2004) reported that seer fish moilee in retort pouch had a very good appearance and the bones were soft with a cook value equal to that reported for the meat product in this study and Ali et al. (2006) reported a cook value of 75.55 min for tuna in oil processed in retort pouches. Mohan et al. (2008) reported that prawn *kurma* had a cook value of 83.19 min in 17 × 30 cm retort pouch which was slightly higher than the cook values observed in the study and it may be due to the differences in the capacity of the thermal processor used for the experiment. The f_h/U ratio was 1.45 and it is the lethal value conferred during cooling is accounted for the equation of the heating curve through the relationship of this ratio (Ranganna 2000). Ali et al. (2006) reported similar f_h/U ratio for tuna in oil. There was no loss in the product yield of Chettinad style goat meat product due to processing and the results are in agreement with Bindu et al. (2004, 2007), who reported that the loss of water in retort pouch processing was very negligible.

Quality evaluation: Lower moisture and higher fat, protein and ash contents were noticed in the cooked product (Table 4) and the results were in accordance with Abdullah (2007). Decreased pH, TBARS values and SFV and higher TV and cholesterol contents were noticed in the product due to retort processing (Table 4). Mittal and Blaisdell (1984) reported a pH increase of 0.16–0.30 units during cooking. In addition to the above results, pH of the product was in accordance with Hamm and Deatherage (1960), Kauffman et al. (1964), Rajkumar et al. (2007) and Vasanthi et al. (2007). The pH changes during heating may be caused by charge changes or hydrogen bonding or both, taking place within myofibrillar proteins (Hamm 1966), by splitting of hydrogen bonds, which releases additional positive charges. The heating may also cause the formation of new hydrogen bonds around the isoelectric point of actomyosin. During heat coagulation of tissue myofibrils, actomyosin and the number of dye binding acidic groups of protein decreases (Correia and Mittal 1991). In the range of 55–80°C new cross linkages may have been formed and the loss of acidic groups was observed (Hamm and Deatherge 1960). The SFV, TBARS value and TV contents of the product were in accordance

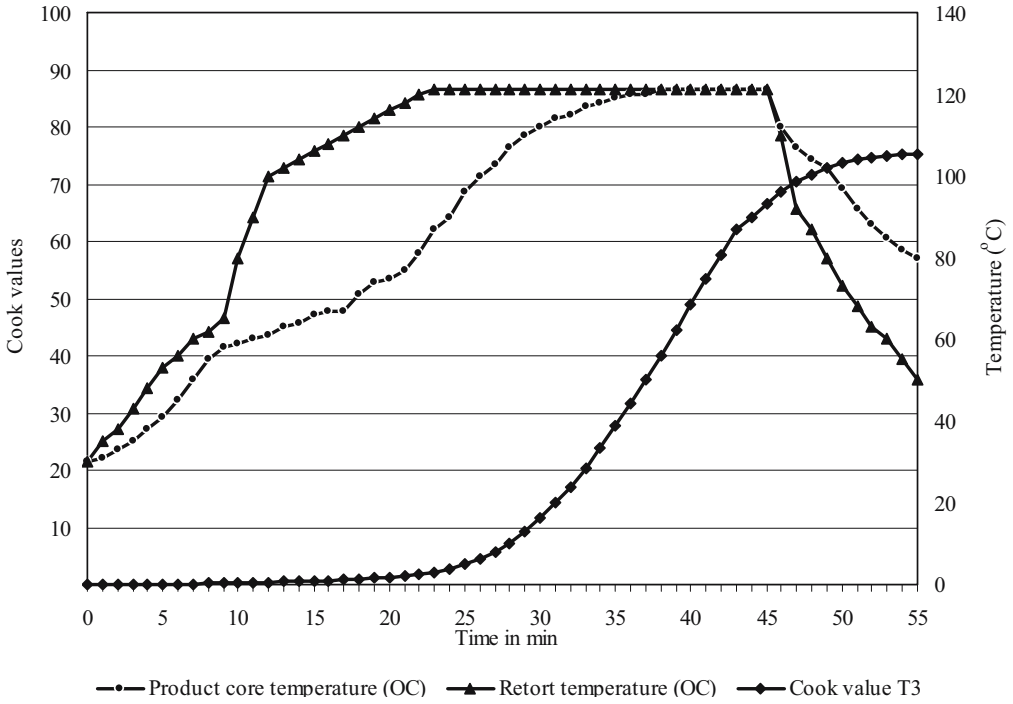

Fig. 2 Cook value and thermal processing characteristics of Chettinad style goat mea product

Table 4 Quality characteristics of Chettinad style goat meat product before and after retort pouch processing

	Before processing	After processing
Chemical Moisture	73.2 [a] ± 0.40	66.5 [b] ± 0.50
Fat	4.6 [a] ±0.26	8.4 [b] ± 0.21
Protein	20.6 [a] ± 0.43	22.7 [b] ± 0.49
Ash	1.6[a] ± 0.10	2.1 [b] ± 0.12
pH	6.3 [a]± 0.04	6.7 [b] ± 0.01
TBARS	0.4[a] ± 0.02	0.97 [b] ± 0.04
Tyrosine value mg/100g	5.1[a] ± 0.18	6.8 [b]± 0.12
Cholesterol mg/100g	62.9 [a] ± 1.99	71.3 [b] ± 2.44
Hunter colour		
L	51.3[a] ± 0.30	44.3[b] ± 0.22
*a**	14.6[a] ± 0.06	11.9[b] ± 0.11
*b**	43.0[a] ± 0.24	34.9[b] ± 0.30
Hue	71.2 ± 0.12	71.1 ± 0.22
Chroma	45.4[a] ± 0.23	36.9[b] ± 0.29
Instrumental texture Hardness 1, kgf	1.93 [a] ± 0.02	0.97 [b] ± 0.01
Hardness 2, kgf	1.27 [a] ± 0.02	0.73 [b] ± 0.02
Cohesiveness	0.56 [a] ± 0.01	0.32 [b] ± 0.01
Springiness, mm	0.75 [a] ± 0.01	0.53 [b] ± 0.02
Chewiness, kgf/mm	0.82 [a] ± 0.02	0.43 [b] ± 0.01

with the results of Dushyanthan et al. (2001), Rajkumar et al. (2004) and Sureshkumar et al. (2006). Rajkumar et al. (2004) reported increase in cholesterol content of meat ($p<0.05$) by cooking due to decrease in moisture content and similar result was observed in the present experiment.

Instrumental colour values: The lower *L*, a*, b** and chroma values were noticed in the product due to retort pouch processing (Table 4). Similar results were recorded by Correia and Mittal (1991) and Bindu et al. (2007). The decrease in *L*, a*, b** and chroma values due to retort processing can be attributed to the reduction in light reflection influenced by heating. Bindu et al. (2007) were of the opinion that Maillard reaction between sugar and amino acid could have reduced the colour scores of the retort processed product.

Texture profile analysis (TPA): Lower hardness 1, hardness 2, cohesiveness, springiness and chewiness values were noticed in the product due to retort processing (results not shown). Similar TPA values were also observed in the reports of Manju et al. (2004), Bindu et al. (2007), Sreenath et al. (2007) and Mohan et al. (2008). This can be attributed to the gelatinization of muscle collagen and destruction of muscle cells during the cooking (Ando 1997).

The mean sensory scores of cooked product were in the range of 8.0–8.4 and panelists rated the product as highly acceptable.

Conclusion

Retortable pouch having 4 layer configurations of aluminium foil, cast poly propylene polyester and biaxially oriented nylon of 9, 70, 12 and 15 μm thickness, respectively and having a length and width of 20 × 15 cm is suitable

for processing Chettinad style goat meat product. Packaging material did not impart any undesirable flavour to the product. Observations show that *Fo* value of 12.1 and cook value of 75 min were found to be optimum for processing of Chettinad style goat meat product in retortable pouch. The technology will help in popularization and proper utilization of heritage meat products and also ensure a steady supply of ready-to-eat convenience products of heritage value throughout the year.

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