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Ready to Serve Mackerel Curry (Goan Style) in Retortable Pouches

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Flexible retort pouch is an ideal alternative to metal containers for heat-processed foods. Mackerel fish curry prepared in Goan style was processed and packed in indigenously developed retortable pouches having three-layer configuration of 12.5μ polyester/12.5μ aluminium foil/ 85μ cast polypropylene. About 140g fish and 90g of curry medium were packed in retort pouch of size 17x15.5 cm. Air inside the pouch was exhausted by steam injection, heat-sealed and processed at 121.1°C to F_0 values of 7, 8 & 9 minutes. Product processed to all the three F_0 values were analyzed for their instrumental color, texture, shear force, commercial sterility and sensory attributes. Based on these observations, a sterilization value of 8 minutes was found to be optimum for mackerel curry with good acceptability. Processed mackerel curry in goan style was kept for storage study during which instrumental color, texture, shear force, chemical parameters like TBA, pH and sensory attributes were analysed for a period of one year at ambient temperature (28±2°C). The product remained sterile throughout the storage period. Shelf life studies showed that samples stored at ambient temperature (28±2°C) had good sensory attributes and were acceptable even after a period of one year.

Key words : Mackerel curry in goan style, retort pouch, heat penetration, F_0 value & storage characteristics

Introduction

Value addition and diversification to satisfy the ever changing and diverse demands from the importing countries as well as urban consumers at home are some of the major challenges faced by the Indian fish processing industry. Value addition is of utmost importance in the fish processing industry these days because of the increased realization of foreign exchange and high unit value of such products. With the growing demand for convenience, the need for off the shelf, ready to cook and ready to eat packaged food is constantly on the rise. The industry has also to pay attention to the factors such as, the demand for portable ready to eat packaged foods, which can be carried home, or to the work place, use of safe packaging material, use of recyclable and environment friendly biodegradable materials.

Fish curries have only limited storage life of a day or two at normal conditions of temperature in our country as no preservatives are used in such preparations. At refrigerated temperatures (2 to 3°C) they may exhibit shelf life of a further couple of days. One method of long term preservation of fish curry is by freezing. Discoloration, desiccation and rancidity are the common problems met with in frozen storage. Another method of long term preservation is by canning. Fish in curry in a ready to consume form processed in metal cans is an item in the overseas markets. Sardine seer, mackerel, herring etc are available in curried form in cans. However the metal cans used as containers impose several restrictions on the viability of the process. Firstly, metal can impart an undesirable taste to the product on storage. Secondly, as far as India is concerned, tinplate for making cans is imported and hence it is disadvantageous economically. Flexible pouches available in the country were not heat stable and suffered from several other disadvantages like poor

seal strength, poor barrier properties, pin holing etc. Studies conducted by CIFT has shown that flexible retortable pouches having three-layer configuration of Polyester/ aluminium foil/ cast polypropylene are suitable for preserving fish curries in acceptable condition for more than one year at ambient storage (Vijayan *et al.*, 1998; Srinivasa Gopal *et al.*, 1998; Sonaji *et al.*, 2002; Srinivasa Gopal *et al.*, 2002; Ravishankar *et al.*, 2002).

Mackerel curry is a delicacy in Goa. The special ingredients which are used in its preparation makes it very unique. This paper deals with the standardization of process parameter for the development of ready to serve mackerel curry in Goan style in indigenous retortable pouches which can be stored at ambient temperatures for longer periods.

Materials and methods

Fresh Indian mackerel (*Rastralleger kanarguta*) from local landing centre was brought to the laboratory in iced condition (0-2° C). The fishes were beheaded, gutted and cut into steaks. Steaks were then washed in potable water and drained well. The ingredients used for the preparation of fish curry are given in Table 1.

For the preparation of curry medium, red chilly, coconut, coriander and garlic were made into a paste. About 1000 ml water was mixed with the paste and kept for boiling. Crushed Teefal (*Zanthoxylum rhetsa*) skin and green chilly were added. After 5 minutes of heating *kukum* was added. Salt was added as per requirement and the curry was diluted with the remaining water to the desired level. Fish pieces were cold blanched in 10% brine solution for 10 min to improve the texture.

Table 1. Ingredients used in goan style mackerel curry

Ingredients	Quantity
Dressed fish	1000 g
Red Chilly whole	80 g
Grated Coconut	3 Nos
Garlic	25 g
Ginger	25 g
Split green chillies	50 g
Skin of Teffal Berry *(Zanthoxylum rhetsa)*	2.5 g
Kukum (*Garcinia indica*)	40 g
Coriander (whole)	20 g
Turmeric powder	5 g
Water	3000 ml
Salt	20 g

Retort pouch with three-layer configuration of 12.5 μ-polyester/12.5μ aluminium foil/85μ cast polypropylene with a size of 17 x 15.5 cm was used. 140 g of fish and 90 g of curry medium were filled manually in each pouch. Air from the filled pouch was exhausted by steam flushing (Madhwaraj *et al.*, 1992) and sealed immediately using an impulse heat-sealing machine. For each batch of processing, 5 pouches were fixed with thermocouple glands, tips of which were introduced into the centre of fish piece. Retort temperature was maintained at 121.1°C and heat processing was done in an over pressure autoclave (John Fraser & Sons Ltd. Model No. 5682) to three F_0 values of 7, 8 and 9 min. The time temperature data was measured using an Ellab data recorder (Ellab A/S, Roedovre,Denmark, Model TM 9608). Heat penetration data were plotted on a semi log paper with temperature deficit i.e. Retort temperature – Core temperature (RT-CT) on log scale against time. Lag factor for heating (J_h), slope of heating curve (f_h), time in minutes for sterilization at retort temperature (U), lag factor for cooling (J_c), final temperature deficit (g) and cook value (C_g) were determined. The process time (B) was calculated by mathematical method (Stumbo, 1973). Total process time was determined by adding process time (B) and the effective heating period during come up time i.e. 58% of come up time of the product. Pouches processed to three F_0 values were tested for commercial sterility according to IS 2168 (1971). For the purpose of standardizing the optimum process conditions for the Goan curry in retortable pouches, samples processed at three F_0 values were subjected to

instrumental analysis of color, texture profile, shear force and sensory analysis. Afterwards, goan curry was prepared and processed in large scale according to the chosen F_0 value and kept for storage studies, during which samples were taken on monthly basis and were analyzed for instrumental color, TPA, shear force, TBA, pH and sensory characteristics.

Analysis of colour

The colour of the mackerel meat was analyzed using Hunter lab colorimeter (Model No: Miniscan-XE plus, Hunter associates laboratory, Virginia, USA). The L*, a* & b* or CIE Lab colour space is an international standard for colour measurement adopted by the Commission Internationale d' Eclirage (CIE) in 1976. L* is the luminance or lightness component which ranges from 0-100 & parameters a* (from green to red) & b* (from blue to yellow) are the two chromatic components (Papdakis *et al.*, 2000). Mackerel meat was made free of skin and bones and finely homogenized in a food homogenizer (Kenstar Kitchen Appliances India Limited, Aurangabad, India) and then loaded inside the sample holder for determination of the CIE L*, a* & b* values which corresponds to lightness, redness & yellowness respectively. Three samples were taken for each stage and each sample was analyzed in triplicates and the average values were taken.

Analysis of Texture profile analysis (T.P.A) and Warner-Bratzler shear force of mackerel

Raw and Mackerel pieces processed to three F_0 values and the samples kept for storage study were analyzed for the various texture profile attributes and Warner-Bratzler shear force using Food texture analyzer (Lloyds Instruments, U.K; model LRX Plus) with software Nexygen. T.P.A (Texture Profile Analysis) involves compressing the test samples twice between two parallel surfaces during which many textural parameters like hardness-1, hardness-2, cohesiveness, springiness, gumminess and chewiness are recorded from the force-deformation curve. Fish pieces of 2 X 2 cm size were placed on a flat platform and were subjected to double compression in a direction perpendicular to the orientation of muscles by a cylindrical probe of 50 mm diameter. The test was conducted at a speed of 12mm/ minute using a 50 N load cell. The sample was allowed for a double compression of 40% with a trigger force of 0.5 kg during which the various textural parameters were determined. A typical force by time curve for the determination of various TPA parameters is given in Fig 1. Five samples were drawn from the batches processed to different F_0 values for the analysis of TPA parameters and the average was taken. The shear force test measures the force in Newtons required to shear a piece of sample. It was done with 50 N load cell fitted with Warner-Bratzler shear attachment. The shearing speed was set at 50 mm/ sec and the shearing direction was set perpendicular to the orientation of muscle.

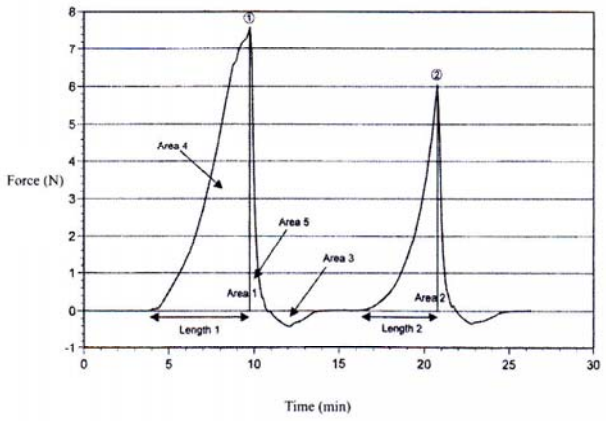

Fig. 1. Typical force by time curve plot to determine texture profile analysis parameters.

Peak force 1 and 2 is hardness 1 & 2; cohesiveness= (Area2/Area1); gumminess= (hardness 1x cohesiveness); springiness= (Length 2/ Length1); chewiness= (hardness x springiness x cohesiveness)

Analysis of TBA, pH and sensory characteristics

Storage studies were carried out at ambient temperature (28±2°C). The product was analyzed periodically every month for changes in TBA, pH and sensory

characteristics. TBA value was determined spectrophotometrically (Tarladgis *et al.*, 1960). pH was determined using a digital pH meter (Cyber Scan, Model No: 510) after making the product into a homogenate. Sensory analysis was carried out by a trained sensory panel of 10 panelists using a nine point hedonic scale based on colour, texture, appearance and flavour as described by Peryam and Pilgrims (1957). A sensory score of 4 was taken as the limit of acceptability.

Results and Discussion

The F_0 recommended for fish products ranges from 5-20 (Frott & Lewis, 1994). Thermal processing of mackerel curry in Goan style was done to F_0 values of 7, 8 and 9 min. The Come up time (CUT) was in the range of 6 min. The process time (B) taken to reach F_0 7, 8 & 9 were 32, 34 and 36 min. The cook value aimed at obtaining an optimal tenderness in the finished product increased with F_0 value and was 82.6, 91.09 & 95.4 min respectively. The total process time was 35, 37 & 40 min which was found out by adding 58% of CUT to B. Upon sterility test, goan curry processed to three F_0 values were found to be sterile. Thermal processing data of mackerel curry processed to all the three F_0 values is presented in Table 2. Heat Penetration data with regard to F_0 value and cook value is shown in Fig 2. Among the three different F_0 values 7, 8 and 9 tried, the product with F_0 value of 8 min was found to have better instrumental color,

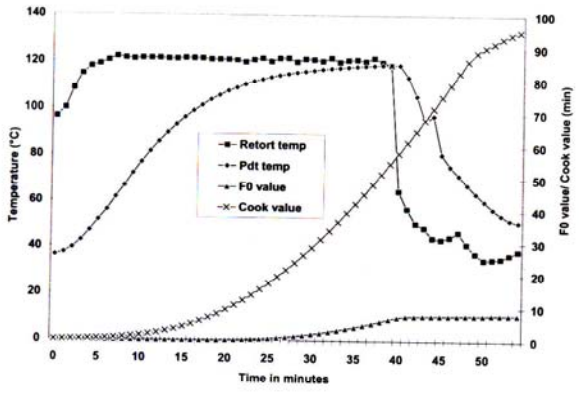

Fig. 2. Heat Penetration characteristics with respect to F0 value Cook value of mackerel processed to F0 8.

TPA, shear force and scored high in terms of sensory attributes. The product had very good appearance and the bones were soft and hence that particular F_0 value was chosen for large-scale production and storage studies. Samples processed to the selected F_0 of 8 were stored at ambient temperature of 28 ± 2°C for storage studies.

Table 2. Thermal processing data of Goan mackerel curry

Parameter	F_0 7	F_0 8	F_0 9
j_h	1.12±0.05	1.413±0.03	1.491±0.04
j_c	1.18±0.043	1.193±0.026	1.194±0.018
f_h (min)	24±0.45	24±0.26	25±0.55
U	7.042±0.32	8.158±0.29	8.97±0.35
f_h/u	3.43±0.43	2.94±0.28	2.787±0.15
g	3.97±0.09	3.378±0.19	3.166±0.022
Cg (min)	82.63±1.25	91.09±1.40	95.4±1.3
B (min)	32±0.55	34±0.45	36±0.38

Results are presented as mean ± standard deviation (SD) of 3 replications

Jh-Lag factor of heating; jc-Lag factor of cooling; fh-Slope of heating curve; U-Time in min for sterilization at retort temperature; g-Final temperature deficit; B-Ball's process time; TPT-Total Process Time; CV-Cook value

Instrumental color (L*, a* & b*) values.

a. Mackerel processed to different F_0 values

The color of the meat is an important attribute influencing its consumer acceptance. Baardseth *et al* (1988) reported that differentiation among individual foods by consumer is based primarily upon the appearance which in turn influences the purchase and the wide use of the product. Table 3 summarizes the L*, a* & b* values of mackerel meat processed to F_0 7, 8 and 9. On thermal processing, the L* value got reduced with increase in duration of processing and were 64.16, 62.28 & 60.68 for mackerel processed to F_0 7, 8 and 9, respectively. This clearly indicates that the L* value of mackerel meat is affected by the duration of exposure to heat processing. The a* value which corresponds to the redness of the product was highest for mackerel processed to F_0 9 and lowest for the samples processed to F_0 7. This is because of the fact

Table 3. L*, a* & b* Color values of Goan style mackerel curry processed to different F_0 values

Parameter	F_0 7	F_0 8	F_0 9
L*	64.16±0.31	62.28±0.29	60.68±0.38
a*	1.83±0.28	2.22±0.34	2.39±0.36
b*	11.07±0.34	10.85±0.27	10.56±0.32

Results are presented as mean ± standard deviation (SD) of 3 replications

DATA SPECIFICATIONS:

Instrument geometry: D/8 (SPHERE)
Illuminant /observer: D65/10 DEG
Instrument color scale: CIE LAB
Area of view: 12 mm
Instrument Model: Miniscan-XE Plus (Mfd by M/S Hunterlab)

that increased duration of exposure to retorting made the product darker in case of F_0 9. The b* values which indicates the yellowness, of mackerel processed to F_0 7, 8 and 9 were 11.07, 10.85 and 10.56 respectively.

b. Change in L*, a* & b* values on storage

The L*, a* & b*color values of mackerel meat was analyzed periodically during its one year of storage period. The changes in the instrumental color values of mackerel meat is given in Fig.3. The lightness of the product (L*) which was 62.28 at the beginning of the storage study decreased to 61.15 on the 6th month and on the 12th month, further decreased to 55.00. The a* value of the product on the first month of storage was 2.22 and there after a showed an increasing trend and reached 2.81 on the 12th month of storage. The b* values on the first, sixth and 12th months of storage were 10.85, 10.64 and 10.48, respectively there by exhibiting a decreasing trend. Thus it can be seen that the L* & b* values of mackerel meat decrease whereas the, a* value increases with storage at room temperature.

Texture profile analysis (TPA)

a. Raw and mackerel processed to different F_0 values

The TPA of mackerel pieces processed to F_0 7, 8 and 9 min in comparison with that of raw mackerel is given in Fig.4. The various parameters analyzed were Hardness 1, Hardness 2, Cohesiveness, Gumminess, Springiness & Chewiness. Hardness I & 2 are the resistance at maximum compression during the 1st and 2nd compression respectively. The hardness 1 value will always be higher than hardness 2 value as the non-compressed sample has a firm texture compared to an already compressed one. The hardness 1 & 2 values for raw mackerel were 4.03 kgf and 3.51 kgf respectively. Among the thermally processed samples, the hardness 1 & 2 were found to decrease with

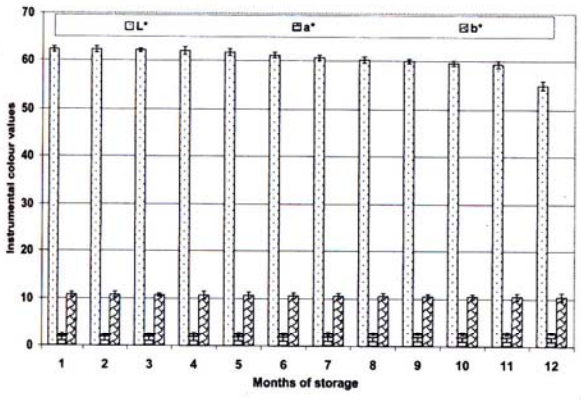

Fig. 3. Changes in the L*, a*, b* color values during storage

Results are presented as mean (standard deviation (SD) of 3 replications

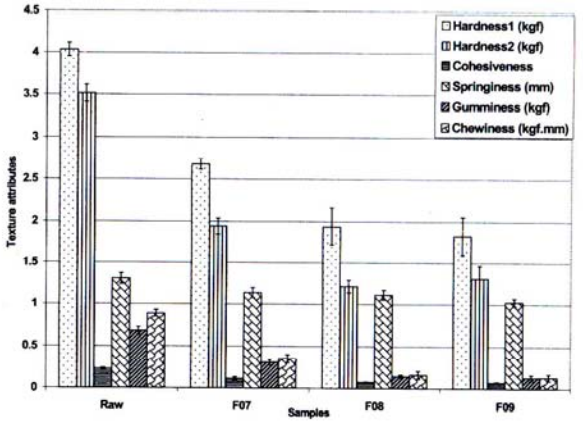

Fig. 4. Texture profile attributes of raw and mackerel processed to F0 7, 8 & 9

Results are presented as mean ± standard deviation (SD) of 3 replications

increase in F_0 value and were 2.67 & 1.94, 1.93 & 1.31 and 1.80 & 1.21 kgf for mackerel processed to F_0 7, 8 and 9 min respectively. Cohesiveness, the ratio of positive force area during the 2nd compression to that during 1st compression of raw mackerel was 0.23 which on thermal processing, got reduced to 0.12, 0.075 & 0.072 on thermal processing to F_0 7, 8 and 9 mins respectively. Gumminess which is the amount of energy required to disintegrate a semisolid food product to a state ready for swallowing also showed the same trend with raw mackerel recording higher value (0.68 kgf) than thermal processed meat. On heat processing, the values decreased to 0.31, 0.14 & 0.13 kgf for F_0 7, 8 and 9 min respectively. Springiness which refers to the height that the food recovers during the time that elapses between the end of 1st compression and the start of 2nd compression was 1.30 mm, 1.3 mm, 1.11 mm & 1.03 mm for raw, and mackerel processed to F_0 7, 8 and 9 mins respectively. Chewiness values for raw, and mackerel thermally processed to F_0 7, 8 and 9 mins were 0.89, 0.60, 0.55, 0.33 & 0.13 kgf.mm respectively. All the texture parameters decreased upon thermal processing and among the thermally processed samples, the decrease in TPA corresponds to the increase in F_0 value (heating time) and cook value.

b. Change in TPA on storage

Changes in the various textural parameters of mackerel on storage is presented in Fig. 5. It can be seen that all the textural parameters increased with storage period. The increase was more pronounced towards the latter stages of storage period. This can be attributed to the lowering of pH as described by Howgate (1977).

Warner-Bratzler shear force

a. Raw and mackerel processed to different F_0 values

The shear force for raw and thermally processed mackerel is given in Fig 6. It can be seen that shear force also followed the same trend of texture profile. It was found that the raw mackerel were tougher than the thermally processed samples. Among the heat processed samples, higher shear force values were associated with Mackerel processed to lowest F_0 value due to the reduced time of exposure to thermal processing. The shear values for mackerel processed to F_0 7, 8 and 9 mins were 6.3 N, 5.86 N & 5.46 N respectively.

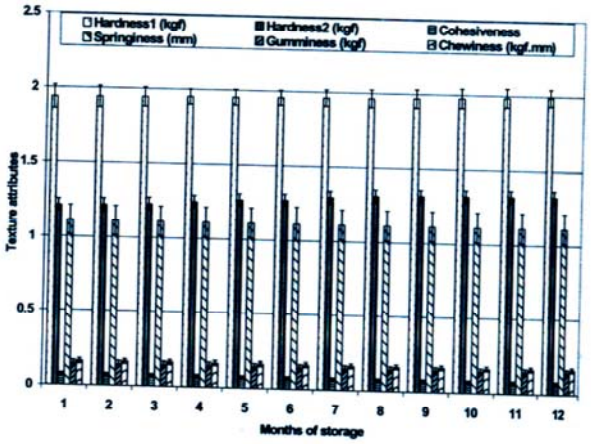

Fig. 5. Changes in the texture profile attributes during storage

Results are presented as mean ± standard deviation (SD) of 3 replications

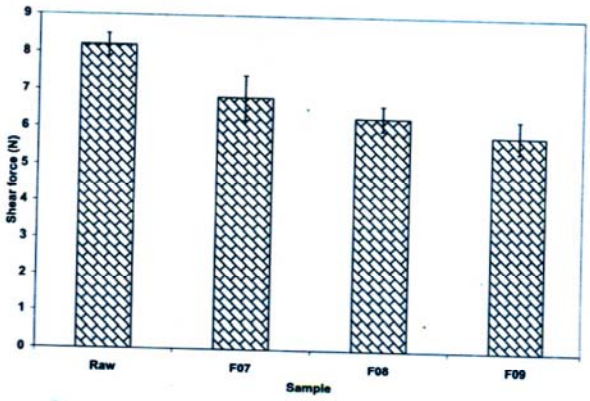

Fig. 6. Shear force of raw and mackerel processed to F_0 7, 8 & 9

Results are presented as mean ± standard deviation (SD) of 3 replications

b. Change in shear force on storage

On storage, the shear force values were found to increase as can be seen from the Fig 7. On the first month of storage, it was 6.35 N, which gradually increased and on the

12th month, the shear force value was 6.38 N. This agrees with the hardness values of TPA, indicating that the product is getting tougher with storage. This increase in shear values with storage period can again be related to the drop in pH of the product.

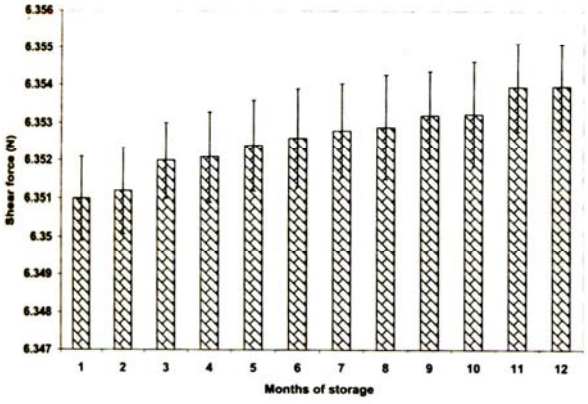

Fig. 7. Changes in the shear force during storage
Results are presented as mean ± standard deviation (SD) of 3 replications

Changes in TBA value, pH and sensory scores

Changes in TBA value, which is a measure of oxidative rancidity during storage at ambient temperature is presented in Fig. 8. Results of chemical analysis indicate that TBA values decreases when stored at ambient temperature, as also observed by Aubourg & Medina (1997) and Medina *et al.*, (1999). This decrease may be due to the fact that the secondary oxidation products may be lost from the muscle into the aqueous curry medium and TBA being a reactive substance can react with other reactive compounds like amino groups, which can cause its reduction (Pokorny, 1981; Maruf *et al.*, 1990 and Aubourg *et al.*, 1995). Analysis of pH revealed that the product had a pH of 5.5 in the first month of storage. This is due to the influence of the ingredients used in curry preparation. With storage, it showed a decreasing trend and on the 12 th month of storage it was 5.25. The results of the periodic analysis of the pH of goan curry are depicted in Fig 9.

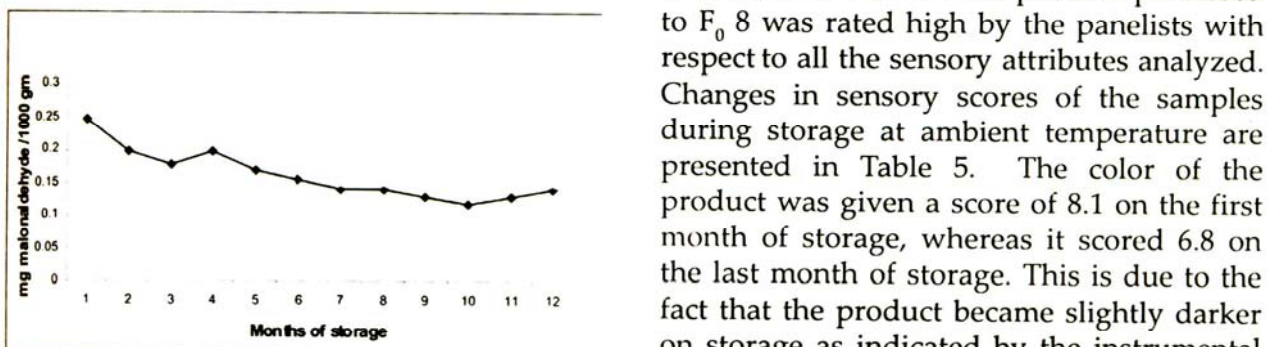

Fig. 8. Changes in TBA value during storage
Results are presented as mean of 3 replications

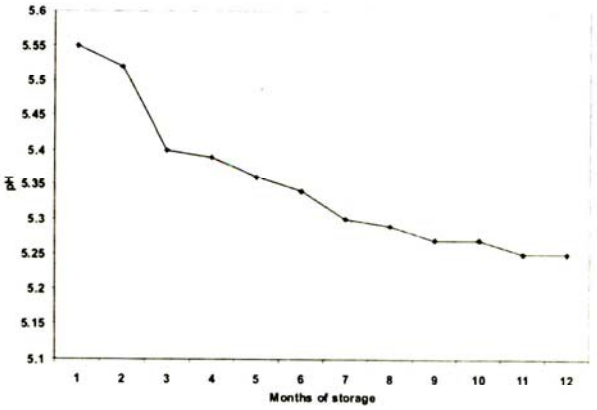

Fig. 9. Changes in pH value during storage
Results are presented as mean of 3 replications

Mackerel curry processed to three F_0 values of 7, 8 and 9 were analyzed by a panel of judges for the analysis of various sensory attributes. The scores given by the judges after analyzing the samples is given in Table 4. It can be seen that the product processed to F_0 8 was rated high by the panelists with respect to all the sensory attributes analyzed. Changes in sensory scores of the samples during storage at ambient temperature are presented in Table 5. The color of the product was given a score of 8.1 on the first month of storage, whereas it scored 6.8 on the last month of storage. This is due to the fact that the product became slightly darker on storage as indicated by the instrumental color values. The mackerel muscle became tougher on storage and as a result the sensory scores reduced from 7.9 in the first

Table 4. Sensory scores of Goan style mackerel curry processed to F_0 7, 8 & 9

Parameters	Standardization of F_0 value		
	F_0 7	F_0 8	F_0 9
Colour	7.9±0.52	8.1±0.25	7.6±0.36
Odour	8.0±0.35	8.3±0.34	7.7±0.55
Flavour	8.1±0.65	8.5±0.16	7.9±0.43
Taste	8.2±0.42	8.6±0.24	8.0±0.29
Texture			
Firmness	8.0±0.35	8.2±0.33	7.8±0.46
Fibrousness	7.3±0.26	7.4±0.16	7.0±0.75
Succulence	7.2±0.43	7.6±0.24	7.1±0.24
Toughness	7.6±0.65	7.9±0.29	7.3±0.46
Overall acceptability	7.8±0.82	8.1±0.37	7.6±0.65

Results are presented as mean ± standard deviation (SD) of 3 replications

sensory scores, samples stored at ambient temperature were found to be acceptabl even after 12 months.

Conclusion

The results shows that the indigenous retortable pouches of 12.5μ polyester/12.5μ aluminum foil/80μ cast polypropylene are suitable for packing mackerel curry. The above packaging material did not impart any undesirable flavor to the fish curry. The physical properties of the pouch, bacteriological and sensory characteristics of the product were satisfactory. Mackerel curry in Goan style processed to F_0 value 8 was found to be ideal with respect to all the parameters. The product was found to have storage stability of 12 months at ambient temperature with desirable organoleptic characteristics.

Table 5. Changes in Sensory scores

Parameters	Months of storage				
	Initial	3	6	9	12
Colour	8.1±0.25	8.0±0.46	7.5±0.50	7.2±0.36	6.8±0.26
Odour	8.3±0.34	8.1±0.35	7.9±0.45	7.6±0.44	7.0±0.39
Flavour	8.5±0.16	8.2±0.23	8.0±0.25	7.9±0.59	7.7±0.47
Taste	8.6±0.24	8.2±0.45	8.0±0.34	7.8±0.40	7.5±0.56
Texture					
Firmness	8.2±0.33	8.2±0.65	8.0±0.75	7.6±0.80	7.0±0.48
Fibrousness	7.4±0.16	7.2±0.54	7.0±0.63	7.0±0.75	6.8±0.23
Succulence	7.6±0.24	7.5±0.87	7.0±0.19	7.0±0.32	6.8±0.35
Toughness	7.9±0.29	7.8±0.47	7.3±0.48	6.7±0.24	6.7±0.38
Overall acceptability	8.1±0.37	7.9±0.44	7.2±065	6.9±0.68	6.5±0.65

Results are presented as mean ± standard deviation (SD) of 3 replications

month to 6.7 in the 12th month. This agrees well with the instrumental TPA hardness values. The over all acceptability score decreased from 8.1 on the first month to 6.5 on the 12th month of storage. Based on

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