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Textural and Colour Changes of Mackerel (*Rastrelliger kanagurta*) Thermal Processed at Different Retort Temperatures

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Abstract

The effect of different processing temperatures on the textural and colour properties of canned mackerel was studied. Mackerel was packed in brine medium in polyester coated, easy open end, tin free steel cans of 6 oz capacity (307 x 109) and processed at 115, 121 and 126ºC in a stationary retort to a F_0 value of 8. Heat penetration was recorded using Ellab TM 9608 temperature recorder cum process value integrator. Instrumental texture analysis was done using a food texture analyzer and compared with taste panel studies for sensory attributes. The panelists preferred the products processed at 126ºC than those processed at 121 and 115ºC. The acceptability was attributed to the soft texture that developed at high temperature processing. Instrumental readings supported this observation and the values for different textural parameters like hardness, cohesiveness, springiness and chewiness were lower in 126ºC processed sample compared to 121 and 115ºC. The colour became slightly darker with increasing temperatures.

Keywords: Mackerel, tin free steel can, heat penetration, F_0-value, cook value, texture profile analysis

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Introduction

Texture is rated as an important quality attribute of meat. The importance of texture on the overall acceptability of foods is well known and it directly affects the acceptance by consumers. Texture is defined as the composite of those properties, which arises from the physical and structural elements and the manner in which it registers with the physiological senses. It is the mechanical property that can be classified under the rheology of the solid foods. Texture is influenced by intrinsic and extrinsic factors (Barraro et al., 1998; Sigurgisladottir et al., 1997; Mackie, 1993; Love, 1983). Ali et al. (2005) studied the textural changes of oil sardine processed in retort pouch and aluminum cans at different F_0 values and commented that product packed in retort pouch had better hardness, cohesiveness, springiness and chewiness than those packed in cans. They also reported that the various texture profile parameters decreased with increase of F_0 value. Tanaka et al. (1985) compared the firmness of mackerel canned at three different retort temperatures of 110, 115 and 120°C and reported that thermal processing at higher temperature produces firmer products. Textural quality of thermal processed shrimp in metal cans by sensory and instrumental methods was studied by Ma et al. (1983). They found a direct relationship between sensory perception of toughness and instrumental shear force measurements in canned shrimp processed at 124°C. Texture of meat foods is not static but changes during processing and due to process variables such as moisture content of the product, time and temperature of processing. Dunajski (1979) reported that cooking of fish muscle at about 60°C leads to loss of original structure of collagen fibers and they become solubilized and thus any textural change above this temperature is solely due to heat denaturation of myofibrillar proteins. Matz (1962) recorded the following changes during canning; initially there is an irreversible destruction in the selective permeability of cell membranes which takes place at 150ºF. The internal pressure is lost which results in the permanent loss of crispiness and similar textural attributes. Opacity of fish flesh increases during cooking due to thermal denaturation and precipitation of sarcoplasmic proteins (Aitken & Connell, 1979). They also reported that unless supported by sensory texture evaluations, instrumental methods are of limited use, and are of value only to processors and researchers for studying textural changes. Exertion of pressure was also found to increase tenderness of meat by disrupting the myofilaments. One of the problems encountered with fish and fish products is that the muscle is very heterogeneous making measurements and samplings difficult to reproduce. No agreement exists to which methods are best for measuring the texture of fish, and there is no universally recommended method (Heia et al., 1997). Instrumental texture analysis values, though reliable and repeatable, needs to be correlated with human liking. Therefore objective measurements need to be correlated with subjective measurement. In this paper, texture profile of mackerel packed in brine medium processed at different retort temperatures was assessed and changes in colour were also compared.

Materials and Methods

Mackerel (*Rastrelliger kanagurta*) collected from Cochin fisheries harbour was brought to laboratory in iced condition (0 - 2°C). They were gutted, cleaned and cut into 40 mm length and dipped in 10% brine at 10^0C for 30 min. Polyester coated easy open-end TFS cans (307 x 109) of 6 Oz capacity procured from M/s Am-Tech packs Ltd, Mysore, India, were used as containers. The cans were thoroughly washed to remove adhering impurities and dried well. Before filling the cans, a thermocouple was fixed at about one third from the bottom of the can to record the core temperature. A specially designed Polyoxymethylene packing gland (type GKJ-13009-C042, Ellab A/S, Roedovre, Denmark) was used to enable penetration of thermocouples into the can. Fish was packed vertically in the cans, adjusting the pack weight to give a final drained weight of 65% of the water holding capacity of the can. The cans were then precooked in steam at 100^0C for 30 min. The precooked cans were drained and filled with 2% brine leaving a headspace of 6 mm. Air from the filled can was exhausted using steam and immediately seamed using double seaming machine (Super seam, Model No.24 DS, Chennai).

For the standardization of F_0 value, mackerel was processed in brine to three F_0 values of 7, 8 and 9 and was analyzed for sensory attributes by a panel of trained judges. Based on sensory panel results, F_0 value of 8 min was found to be optimum. Cans were heat processed to the selected F_0 value (Sterilization value) of 8 in an overpressure autoclave (John Fraser and Sons Ltd, model no- 5682) at three different temperatures of 115, 121.1 and 126^0C. Heat penetration data were recorded for every minute of processing using Ellab (TM 9608, Denmark) Temperature Recorder cum Process Value Integrator and plotted on a semi logarithmic paper with temperature deficit (Retort temperature – Core temperature) on log scale against time. Lag factor for heating (J_h), slope of the heating curve (fh), time in minutes for sterilization at retort temperature (U), lag factor for cooling (j_c), final temperature deficit (g) and cook value (cg) were determined. Total process time was calculated by the mathematical method of Stumbo (1973). Actual process time was determined by adding process time (B) and the effective heating period during come-up time i.e., 58% of the come up time (CUT).

Texture profile analyses of canned mackerel were carried out using the food texture analyzer (Lloyd Instruments, U.K. Model LRX plus F.T-39 No-2) with the help of Nexygen software and the test was carried out at a speed of 12 mm sec^{-1} using 500 N load cell with a 50 mm diameter cylindrical probe with 40% compression. Colour measurements were done using a Hunter lab Colorimeter Model No D/8-S (Miniscan XE Plus) with geometry of diffuse / 8° (sphere 8 mm view) and an illuminant of D65/10 deg. Meat was blended and the colour was measured after standardization and expressed as the mean value. Sensory evaluation based on characterization and differentiation of the various sensory characters such as colour, flavour, texture and overall acceptability were evaluated by a panel of 10 trained judges on a 10-point scale (IS 6273 (II) 1971). The panelists were asked to assign a score of 1–10 as prescribed by Vijayan (1986). A sensory score of 4.0 was taken as the margin of acceptance.

Results and Discussion

Effect of different retort temperatures on the heat penetration characteristics of brined mackerel in tin free steel cans are presented in Table 1. Time taken to reach the retort temperature (Come Up Time) varied between 3-5 min. Time required to attain 1 log cycle reduction (fh- Value) was 18.5, 17 and 16.5 min respectively for 115, 121 and 126°C temperatures. The minimum lag factor of heating

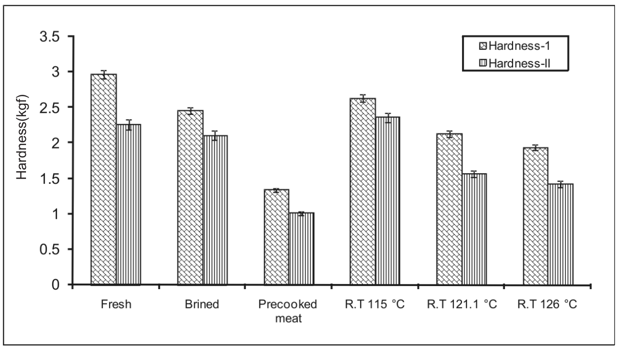
Table 1. Heat penetration data of thermal processed mackerel in brine at different retort temperatures.

Temperature (^{0}C)	fh (min)	J_h	J_c	fh/U	g (^{0}C)	Cg (min)	B (min)	Process time (min)
115	18.5	0.814	1.051	0.506	0.055	129.3	49.609	53.089
121	17.0	1.161	1.086	2.125	2.160	78.77	28.314	31.790
126	16.5	0.919	1.029	6.450	6.642	57.28	18.243	22.303

(Slope of the heating curve (fh), Lag factor for heating (J_h), lag factor for cooling (J_c), time in minutes for sterilization at retort temperature (U), final temperature deficit (g), Cook value (cg), total process time (B))

(J_h) was noted for mackerel processed at 115°C followed by a higher value of 1.161 at 121°C and processing at 126°C had a J_h of 0.919. The lag factors of cooling (Jc) values ranged from 1.029 - 1.086 for different retort temperatures and all values were above 1. U- value is the lethality of a process expressed in terms of time at retort temperatures, which differed significantly with temperature. Hence time needed for obtaining lethality at higher temperature is less. Thus the values for fh/U increased with increasing temperature. Final temperature deficit (g) also showed the same trend. The value was higher at higher process temperatures indicating that there is still scope for attaining better heat penetration into the food at these temperatures. Cook value (Cg) is used for the theoretical evaluation of the sensory and nutritional changes of the product during thermal processing. The cook value was found to exhibit an inverse relationship with processing temperature and was maximum at 115°C and minimum at 126°C. A reduction of 39 and 55.7% in cook value could be attained by thermal processing mackerel in brine at 121°C and 126°C, respectively, when compared to that at 115°C. Cook value- lethality ratio also followed the same trend. The highest values were associated with the lowest processing temperatures, which indicate a great level of quality loss. Time required for processing mackerel to a F_0 value of 8 at different retort temperatures ranged from 18.24 to 49.61 min. Actual process time required for processing mackerel to the desired F_0 level ranged from 22.30 to 53.09 min. The minimum time required to process at F_0 8 with brined mackerel in TFS cans was 22.30 min at 126° C. Processing mackerel at 121.1°C required 31.79 min to achieve the required F_0 value. This value is 42.5% higher than processing at 126°C. Time required to process mackerel at 115°C to F_0 value of 8 was 53.09 min and this value is 138% higher than processing at 126°C.

Texture profile analysis has provided values for hardness-I, hardness-II, cohesiveness, springiness, and chewiness. The main external factors affecting the texture of fish are temperature profile during storage, temperature of cooking and the presence of sodium chloride (Johnston, 1999; Dunajski, 1979). Hardness II and hardness II of thermal processed mackerel at different stages of processing are shown in figure-1. Fresh mackerel showed 2.97±0.27 kgf hardness. Precooking mackerel at 100°C for 30 min reduced its hardness to 1.34 and this was increased to 2.63 during thermal processing at 115°C. Retort temperatures above 115°C reduced hardness with increasing retort temperature. In general, the hardness-1 of mackerel during thermal processing increased to certain level and then decreased at higher temperatures. Hardness-II values are always less than those values obtained at first compression. This is because of the non-compressed sample having a firm texture compared to the compressed sample. Among the samples processed at different retort temperatures, higher values for hardness were obtained for the mackerel processed at 115^{0}C,



R.T- Retort temperature

Fig. 1. Hardness values of mackerel during different stages of handling and after thermal processing at different retort temperatures in tin free steel cans. * (R.T- Retort temperature)

followed by the processing temperatures 121.1 and 126^{0}C. Texture of the fish meat is influenced by the collagen content of the meat (Sato et al., 1986). During precooking, the core temperature reaches 92^{0}C and hence the collagen content of the meat is denatured and converted to gelatin. The lowering of the hardness values on thermal processing is due to the effect of temperature on the collagen and the resultant softening of the muscle.

Cohesiveness, springiness and chewiness values of thermal processed mackerel in brine in tin free steel cans to a F_0 value of 8 at different retort temperatures is represented in Fig. 2. Cohesiveness value of fresh mackerel decreased during brining and increased after precooking. During thermal processing, cohesiveness value of 0.28 ± 0.02 was obtained for mackerel processed at 115^{o}C. Mackerel processed at 121^{0}C reduced the cohesiveness value to 0.25 than the value obtained for 115^{o}C. The higher retort temperature viz., 126^{o}C reduced cohesiveness value to 0.20. The cohesiveness of thermally processed foods decreases with increasing temperatures (Deng, 1981; Ma et al., 1983). When thermal-processing temperatures increase, the springiness values show a decreasing trend. At higher temperatures, the intensity of heat treatment was more, thus the recovering properties after the first compression was less than that of lower thermal processing temperatures. Chewiness of fresh mackerel was 0.36 kgf.mm and it reduced during brine treatment.

R.T- Retort temperature

Fig. 2. Cohesiveness, springiness and chewiness values of mackerel during different stages of handling and after thermal processing at different retort temperatures in tin free steel cans

Pre-cooking at 100^{o}C for 30 min improved its chewiness property to 0.35 kgf. mm. During thermal processing, it increased to a maximum value of 1.12 kgf. mm in mackerel processed at 115^{o}C whereas it reduced to 0.65 kgf. mm and 0.52 kgf. mm for retort temperatures of 121 and 126^{0}C respectively.

Table 2 represents the colour readings of mackerel at different stages of thermal processing. During precooking, the colour of the raw material was improved to white. Fresh mackerel had 38.85, 3.45 and 7.62 values respectively for L*, a* & b* values. L* value represent the lightness of the material,

Table 2. Colour readings of thermal processed mackerel at different temperatures

Colour value	Raw material	Precooked (100^{0}C)	Retort temperature 115^{0}C	121.1^{0}C	126^{0}C
L*	38.85± 0.55	44.33 ± 0.64	43.90 ± 1.52	43.84 ± 0.84	38.10 ± 0.58
a*	3.45± 0.26	1.31 ± 0.02	1.12 ± 0.05	1.08 ± 0.07	0.92 ± 0.12
b*	7.62± 0.06	10.48 ± 0.21	10.40 ± 0.17	10.12 ± 0.18	8.15 ± 0.17

Table 3. Sensory score of mackerel in brine processed at different temperatures

Retort temp (^{0}C)	Colour	Flavour	Texture: Chewiness	Succulence	Toughness	Fibrosity	Overall Acceptability
115	7.0±0.24	7.4±0.19	7.2±0.15	6.3±0.17	6.7±0.15	7.4±0.15	7.2±0.32
121	7.49±.16	7.6±0.22	8.0±0.26	7.5±0.42	7.4±0.22	7.8±0.22	7.8±0.35
126	8.1±0.25	7.9±0.35	8.2±0.33	8.6±0.24	8.3±0.35	8.2±0.32	8.4±0.33

which increased from 38.85 to 44.33 during precooking at 100°C for 30 min. This is due to the leaching out of muscle pigments along with the pre-cook exudates during precooking (Haard, 1992). Raw mackerel meat had an a* value of 3.45 due to the presence of the muscle pigments which decreased during precooking. Fresh meat had a b* value of 7.62 which increased to 10.48 during pre-cooking. Tarr (1952) reported a brown discolouration in white fleshed fish upon heating. Precooked mackerel meat had lightness (L*) value of 44.33 ± 0.64 and this was reduced during thermal processing. The extent of reduction was negligible at 115°C and 121.1°C, but the change in lightness was higher in thermally processed mackerel at 126°C. The increase in L* value during cooking of fish muscle may be due to the leaching of white connective tissue containing collagen located between the segments of muscles (Dunajski,1979; Sikorski et al., 1984; Kimura et al., 1988). Pre-cooked mackerel had a redness value of 1.31, which reduced to 0.92 during retort processing. The a* values decreased with increasing temperature of processing. This may be due to the heat-induced denaturation of myoglobin and oxidation of carotenoid pigments (Haard, 1992). Among the thermal processed samples, a* value substantially increased with increase of processing time or decrease in processing temperature. Mackerel processed at 115°C possessed a value of 10.48 for b* which was reduced to 10.12 during processing at 121°C while, at high temperature processing (126° C) yellowness reduced by 24% than the value obtained at 121°C. Bhattacharya et al. (1994) reported that increasing the processing temperature or time increased the visual lightness, but reduced both the redness and the yellowness of salmon muscle. The sensory values for mackerel processed in different temperatures are given in Table 3. It can be seen that mackerel in brine processed at 126°C recorded highest scores with respect to all the sensory attributes analysed.

Thermal processing temperature highly influenced the process time and physical quality parameters like texture and colour. The present study indicated that fish processed at 126^0C had better quality since it had shorter cook value.

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