The Bioscan 8(3): 887-892, 2013
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

CHANGES IN INSTRUMENTAL AND SENSORY CHARACTERISTICS OF TILAPIA FISH STEAKS DURING COLD BLANCHING AND COOKING TREATMENTS

K. DHANAPAL[1]*, G.V.S. REDDY[1], B.B. NAYAK[2], G. VENKATESHWARLU[2], A. BALASUBRAMANIAN[1], A. DEVIVARAPRASAD REDDY[1] AND S. BASU[2]
[1]College of Fishery Science, Muthukur, Nellore District, Andhra Pradesh - 524 344, INDIA
[2]Central Institute of Fisheries Education, Mumbai - 400 061, INDIA
e-mail: kdhanpal@gmail.com

KEYWORDS
Texture
Sensory
Blanching
Cooking
Tilapia

Received on :
26.02.2013

Accepted on :
22.05.2013

***Corresponding author**

ABSTRACT
Color and texture of the food are considered as the prime qualities evaluated by the consumers either by perception or consumption. The present study was conducted to find out the changes in color and texture of tilapia meat while cold blanched with the 5% salt solution, 10% salt solution and 15% salt solution for 30, 60 and 90 minutes respectively followed by steam cooking at different time intervals such as 1, 2, 3, 4, 5, 6 and 7 minutes. The samples were analyzed for color characteristics like lightness (L*), redness (a*), yellowishness (b*), Hue color and saturation index. Besides, textural characteristics like hardness, adhesiveness, resilience and stringiness and sensory characteristics of fish meat were analyzed. The a* value and hue color turned from negative to positive value at the fifth minute of cooking. L*, b* and saturation index values increased little up to fifth minutes and later the values were retained. 5 minutes steam cooking yielded good textural parameters than other cooking periods. The fish steaks dipped for 60 min in 10% salt concentration and 5 minutes steam cooked exhibited the excellent color and textural characteristics. Under this process, obtained color values such as L*, a*, b*, Hue angle and Saturation index were 70.64 ± 1.20, -1.19 ± 0.62, 12.20 ± 0.36, -16.74 ± 17 and 12.27 ± 0.36 respectively and the textural characteristics of Hardness (gf), Adhesiveness (gs), Stringiness (mm) and Resilience were 82.10 ± 27.27, -13.10 ± 2.27, 9.23 ± 0.06 and 0.24 ± 0.29 respectively. The study revealed that the cooked products had good consumer acceptance.

INTRODUCTION

Tilapia is the lacustrine fish which are widely cultured in tropical and subtropical regions of the world as they have good export potential. They are ranked as third largest group among the farmed fin-fishes, with an annual growth production of 11.5% (El-sayed 1999). Farmed fish tilapia serves as a substitute for traditional white fish species. The global fish production has been greatly influenced by rapid expansion of Nile tilapia (*Oreochromis niloticus*) and Mossambique tilapia (*O. mossambicus*) which are cultured in China, Philippines and Egypt (Hempel 2002). In India, tilapia is grown in natural freshwater bodies unintentionally. In India, good demand for tilapia exists due to its low cost. Besides, tilapia has rich source of protein, essential fatty acids, vitamins and minerals that are essential for nutritional solidity in human beings (Dhanapal *et al.,* 2010).

In consumer point of view, the overall quality of seafood comprises both wholesomeness and sensory acceptability (Mallick et al., 2010). Thermal processing of fish and fishery products account the changes in appearance, flavor, odor, taste, texture and nutritive value. In the thermal process, numerous volatile compounds are formed which cause meaty flavor. Among all the sensory characteristics, the color of the food surface is treated as a prime quality parameter by the consumers and it determines acceptance of the product, before it is being tasted (Leon *et al.,* 2006). The consumer uses the color of the food surface as a tool for accepting or rejecting the food. The observation of color thus allows the detection of certain anomalies or defects that may present in food items (Abdulla et al., 2004; Du and Sun 2004; *Hatcher* et al., 2004; Leon *et al.,* 2006).

The organoleptic qualities of the food materials are very important for the consumers either to accept or reject them. It is established that the sensory characteristics like appearance, color, taste, texture, odor, and flavor are changed during thermal processing. The determination of color and texture can be carried out by visual inspection or using an instrument. The method of human inspection is quite robust even in various degrees of illumination. Here, the determination of color is subjective and extremely variable from observer to observer. It can only be overcome by employing the trained researchers. Color standards are often used as reference material to carry out a color analysis in detail. As the visual inspection method is time consuming and requires specially trained observers, the instrumental method is recommended for carrying out the color analysis. At present, color spaces and numerical values are used to create, represent and visualize colors in two and three dimensional space (Leon et al., 2006; Trussel *et al.,* 2005).

Texture is also one of the important properties of thermally processed food. The classification of textural terms for solids and semi solids gives rise to a profiling method of texture description known as Texture Profile Analysis (TPA). It is applicable for both sensory and instrumental measurements (Mallick et al., 2010). For sensory method, the evaluation takes place outside and inside the mouth in several stages. The stages comprise of first bite through mastication followed by swallowing with a residual feeling in the mouth and throat. Texture is a very important parameter while preparing a food product either from fish or shellfish. Coppes *et al.,* (2002) studied extensively the texture measurement of different fish and fishery products. Toughness and hardness are important critical textural attributes in meat and seafood products. The properties depend on the connective tissue containing collagen which are responsible for tensile strength and the myofibrils consisting of myosin and actin (Mallick et al., 2010).

The commercially important and most commonly available species, Tilapia (*O. mossambicus*) was chosen for this study. The present work was carried out to study the effect of thermal processing at different duration and cold blanching of fish at various salt concentrations on the organoleptic characteristics of fish meat and analysis of color and texture using the instrument.

MATERIALS AND METHODS

Raw material

Samples of Tilapia Fish (*O. mossambicus*) were collected from the natural waters of Muthukur, Andhra Pradesh, India and brought using an insulated container. The fish were washed with potable iced water and their total length and weight were measured from 18 - 26 cm and 200 - 250g respectively. The fish were dressed into steaks of 2cm size, using steak cutter and washed with chilled water. Steaked tilapia pieces were subjected to steam cooking for 1, 2, 3, 4, 5, 6 and 7 minute duration of further study. Cold blanching was also carried out before cooking with the 5% salt solution, 10% salt solution and 15% salt solution for 30, 60 and 90 minutes respectively. It was mainly to improve the cooking stability of meat texture/ firmness of the muscle during thermal processing and later.

Moisture

The moisture content of raw and cooked meat of tilapia was determined by using an automatic moisture analyzer (Denver Moisture Analyzer, model IR 120, Colourado, Germany). The sample was heated up from an initial temperature of 100°C to 170°C. The difference in the weight loss of the sample yields moisture content of the meat.

Sodium chloride

Sodium chloride content was determined by the method described in AOAC (2000). In this process, 5 g of fish meat sample was taken and minced by adding 50 milli litre (ml) of distilled water. The minced filtrate was made up to 100 ml with distilled water. Of which 10 ml of filtrate was taken and added to 5 ml strong nitric acid. Further, the filtrate was added to 5 ml of saturated ferric alum as indicator followed by 10 ml of N/10 $AgNO_3$ solution. The mixture of solution was titrated against N/10 potassium thiocyanate till reaching the permanent brick red color. A blank was also run simultaneously with 10ml of distilled water and difference in the volume of N/10 $AgNO_3$ used was determined. 1 ml of rundown during titration is equivalent to 0.058 g of NaCl.

Sensory test

The changes in the sensory characteristics of the tilapia fish samples were evaluated by an experienced panel comprising of 8 persons of the Institute based on a 10 - point scale suggested by Vijayan (1984). The panelists were asked to assign a score of 1 to 10 (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately,4 = dislike slightly, 5 = neither like nor dislike, 6 = light slightly, 7 = like moderately, 8 = like very much, 9 = like extremely, 10 = excellent) for appearance, color, flavor, odor, taste, texture, and overall acceptability. The contents of the samples were placed in coded white enamel plates and served to panelists in separate booths equipped with proper illumination. Water was provided to panelists for use before and after evaluation of each sample, to restore their taste sensitivity.

Instrumental Analysis of Color

The color of the meat was measured using a Hunter - Lab scan XE – spectrocolorimeter (Hunter Associates Laboratory, Reston, USA.). The samples were analyzed for quantifying the Commission Internationale de L 'Eclairage's lightness or luminance (L*) redness (a*), yellowness (b*) and hue angle (arcton, b*/a*), which describes hue or color of the ground meat and saturation index $(a^{*2}+b^{*2})^{0.5}$ which depicts the brightness or vividness of color (Hunt 1991). Apart from the analysis of the above parameters, textural characteristics like hardness, adhesiveness, resilience and stringiness were also analyzed. In color analysis, L* is given as a measure of lightness which includes the value from '0' (considered as black) to the maximum 100 (considered as white). Whereas, a* is a measure of redness which ranges the value from - 60 (considered as green) to + 60 (considered as red). In the case of b* which indicates yellowishness of the meat and it also carries similar value as redness from – 60 (blue) to + 60 (yellow). However, the nature of color for respective values varies between blue to yellow. All values were determined from the mean of eight measurements of each fish steak at 28 ± 2°C using the A/10° observer. The spectrocolorimeter was standardized using white (L* = 100), and black (L* = 0) standard tiles and working standards, before being used. The results of the color profile analysis were tabulated using EasyMatch software (EasyMatchQC, Version 4).

Instrumental Analysis of Texture

Compression tests were carried out by placing the samples of fresh and cooked fish streak meat on the base plate of the TA-XT2i Texture Analyzer (Stable Microsystems, UK). After compressing the streaks twice, the Texture Profile Analysis (TPA) was carried out using a cylindrical stainless steel probe of 5mm diameter provided in the texture analyzer. The load cell used was of 50 kg capacity with the following test conditions viz., pre test speed: 1.0mm/s, test speed: 0.5 mm/s, post-test speed: 10.0 mm/s, distance: 3 mm/s for fish steaks, trigger force: 5 g, return distance:15 mm and contact force: 5 g. Force by the time data for each test was used to calculate mean values for the TPA parameters. The values for hardness, cohesiveness, springiness, stringiness, adhesiveness, resilience, gumminess and chewiness were determined at 28 ± 2^0C as described by Bourne (Bourne 1978). The results of TPA were tabulated using Texture Expert Exceed software.

Statistical analysis

The SPSS 10.00 statistical package was used for analysis of the experimental results. Sufficient numbers of samples were carried out for each analysis. The results were expressed as mean ± standard deviation (SD).

RESULTS AND DISCUSSION

Color and Texture

The stability of the fresh tilapia steaks and fresh tilapia steaks after steam cooking for 1, 2, 3, 4, 5, 6 and 7 min and their consequent changes occurred in color and textural characteristics of the meat are presented in Table 1. The a* value and hue color changed from negative to positive value in 5 min. cooking and L*, b* and saturation index values slightly increased and become irregular after fifth minutes. The hardness of the meat started decreasing trend from 2 min. cooking. Based on sensory evaluation, it was found that 5 min. steam cooked tilapia steaks yielded good texture parameters than the other cooking period (Table 2). This is in accordance with the studies conducted by Nalan *et al*. (2004) who reported that the fish dipped in boiling water for 5 minutes showed optimum texture quality. Olafsdottir *et al*. (2004) demonstrated that the fresh cod stored in ice underwent significant changes in the colour values measured ventrally (L*) or dorsally (a* and b*). However, all sets of colour values show a fairly good linear relationship with both the QIM (Quality Index Method) values.

The moisture and salt content exchange during cold blanching of steaks at various salt concentrations in different durations are given in Table 3. The moisture and salt content of the fish steaks dipped in 10 % salt concentration for 60 min were found optimum in improving the color and textural quality based on sensory evaluation and they were 79.64±0.43 % and 0.96±0.04 % respectively (Table 3). The color and instrumental texture characteristics of cold blanched fish steaks, steam cooked for 5 min are shown in Table 4. The cold blanched fish steaks were steam cooked for 5 min and examined for color, instrumental texture and organoleptic characteristics. The color values L*, a*, b*, Hue angle and Saturation index were 70.64±1.20, -1.19±0.62, 12.20±0.36, -16.74±17 and 12.27±0.36 respectively for the fish steaks dipped in 10% salt concentration for 60 min and after 5 min steam cooking. However, the fish steaks dipped in 10% salt concentration for 60 min and 5 min steam cooking was found to exhibit the following textural characteristics: hardness (gf), Adhesiveness (gs), Stringiness (mm) and Resilience of 82.10±27.27, -13.10±2.27, 9.23±0.06 and 0.24±0.29 respectively.

Organoleptic evaluation carried out for attributes like appearance, color, texture, flavor, taste and the overall acceptability are presented in the Table 5. The sensory parameters of fish steaks dipped in 10 % salt concentration

Table 1: Changes of color and texture in fresh Tilapia meat during various cooking durations

Parameters	Cooking Duration (Minutes)						
	1	2	3	4	5	6	7
L*	63.92±6.82	75.23±0.90	74.72±1.45	68.22±2.84	71.34±3.21	70.97±2.8	74.49±4.53
a*	-1.90±0.91	-1.34±0.33	-1.69±0.42	-0.01±0.89	0.15±0.741	0.56±0.35	0.72±0.0.45
b*	5.45±1.72	10.15±1.32	10.53±1.18	14.48±2.13	12.75±0.781	13.1±0.93	13.60±0.79
Hue angle	-5.53±.63	-7.94±2.01	-6.63±2.23	35.95±86.00	21.67±17.451	28.66±16.22	29.09±22.82
Saturationindex	5.87±1.52	10.24±1.30	10.68±1.11	14.51±2.12	12.78±0.767	13.11±0.94	13.63±0.78
Hardness (gf)	90.25±16.38	159.52±6.36	126.89±3.51	72.63±23.62	35.04±2.12	27.52±0.45	25.22±0.45
Adhesiveness (gs)	-10.66±2.67	-4.99±0.18	-3.60±1.96	-2.14±0.07	-3.53±0.62	-1.65±0.30	-5.26±0.30
Stringiness (mm)	8.80±0.00	7.95±0.00	7.80±0.00	8.68±0.32	9.40±0.07	9.33±0.25	9.59±0.25
Resilience	0.22±0.06	0.14±0.08	0.08±0.01	0.13±0.09	0.07±0.00	0.31±0.27	0.38±0.27

Table 2: Sensory characteristics of fresh Tilapia meat during various cooking durations

Steam cooking duration in minutes	Appearance	Color	Flavor	Odor	Taste	Texture
1	7.13±0.42	7.42±0.55	7.00±0.5	7.14±0.45	6.6.29±0.37	5.48±1.21
2	7.52±0.41	7.67±0.52	7.35±0.76	7.33±0.82	6.69±0.63	5.92±1.41
3	7.85±0.52	7.54±0.55	7.63±0.63	7.39±0.75	7.20±0.55	6.17±0.52
4	7.94±0.89	7.79±0.84	7.67±0.82	7.65±1.10	7.4±0.56	6.44±0.75
5	8.19±0.43	8.17±0.42	7.98±0.75	7.84±0.89	8.00±0.31	7.19±0.46
6	8.00±0.56	7.98±0.52	7.87±0.41	7.67±0.52	7.88±0.82	6.92±0.63
7	7.51±0.5	7.54±0.55	7.68±0.72	7.60±0.85	7.56±0.92	6.9±0.45

Table 3: Exchange of Moisture and salt during Salt dipping (cold blanching) treatment of tilapia steaks

Parameters	Initial value	30 min	60 min	90 min	
5% Salt solution	Moisture (%)	79.849±0.496	79.13±0.24	79.8±0.52	80.39±0.46
	Salt (%)	0.578±0.01	0.49±0.02	0.70±0.03	0.76±0.02
10% Salt solution	Moisture (%)	79.849±0.496	80.2±0.31	79.64±0.43	78.6±0.43
	Salt (%)	0.578±0.01	0.82±0.03	0.96±0.04	1.59±0.02
15% Salt solution	Moisture (%)	79.849±0.496	80.39±0.42	78.69±0.39	78.0±0.37
	Salt (%)	0.578±0.01	0.958±0.03	1.204±0.05	1.952±0.03

Table 4. Changes in color and texture of fresh tilapia meat in cold brine blanching at different concentrations and cooking for five minutes

Parameters	5% Salt solution			10% Salt solution			15% Salt solution		
	30min	60min	90min	30min	60min	90min	30min	60min	90min
L*	67.35 ± 7.56	63.67 ± 5.47	67.73 ± 1.88	66.07 ± 2.13	70.64 ± 1.20	67.40 ± 0.99	64.30 ± 4.54	69.66 ± 2.50	67.36 ± 1.39
a*	-0.40 ± 0.66	-0.89 ± 0.75	-2.00 ± 0.38	-1.29 ± 0.33	-1.19 ± 0.62	-2.44 ± 0.31	-0.45 ± 1.38	-2.46 ± 0.12	-1.94 ± 0.35
b*	12.74 ± 0.99	13.72 ± 0.93	11.34 ± 0.87	11.01 ± 0.84	12.20 ± 0.36	11.21 ± 1.05	13.53 ± 2.82	10.30 ± 0.27	10.76 ± 1.04
Hue	-7.04 ± 20.4	16.52 ± 55.56	-5.81 ± 1.06	-9.00 ± 2.72	-16.74 ± 17	-4.69 ± 1.03	-23.74 ± 46	-4.20 ± 0.23	-5.78 ± 1.81
SI	12.75 ± 0.99	13.76 ± 0.91	11.52 ± 0.88	11.09 ± 0.84	12.27 ± 0.36	11.48 ± 0.98	13.59 ± 2.83	10.59 ± 0.27	10.95 ± 0.98
Hardness (gf)	66.08 ± 8.85	76.75 ± 10.73	77.35 ± 19.86	80.72 ± 15.22	82.10 ± 27.27	84.06 ± 26.12	78.79 ± 7.57	72.50 ± 14.20	68.65 ± 10.09
Adhesiveness (gs)	-5.51 ± 1.09	-11.04 ± 1.39	-8.51 ± 3.27	-16.70 ± 7.25	-13.10 ± 2.27	-11.61 ± 3.74	-13.52 ± 2.29	-15.92 ± 4.68	-11.73 ± 3.27
Stringiness(mm)	9.08 ± 0.20	9.07 ± 0.43	8.92 ± 0.16	9.21 ± 0.16	9.23 ± 0.06	9.10 ± 0.35	9.18 ± 0.10	9.32 ± 0.23	9.00 ± 0.28
Resilience	0.05 ± 0.00	0.10 ± 0.05	0.06 ± 0.01	0.07 ± 0.03	0.24 ± 0.29	0.15 ± 0.14	0.05 ± 0.02	0.12 ± 0.12	0.12 ± 0.11

Table 5: Sensory evaluation of steam cooked tilapia fish for 5 min with different salt concentrations

Salt conc. (%)	Dipping period (min)	Appearance	Color	Flavor	Odor	Taste	Texture
5	30	7.83±0.41	8.00±0.89	7.50±0.55	7.50±0.55	6.67±0.52	6.83±1.17
	60	7.83±0.41	8.17±0.75	7.67±0.82	7.67±0.52	7.00±0.89	7.33±1.21
	90	7.5±0.55	7.83±0.75	7.17±0.75	7.50±0.55	7.00±0.63	6.67±0.82
10	30	7.33±0.82	8.00±0.63	7.33±0.82	7.50±0.84	7.50±0.84	7.33±0.82
	60	8.17±0.41	8.17±0.41	7.67±0.82	7.83±0.41	8.50±0.84	8.33±0.52
	90	7.67±0.52	7.83±0.75	7.17±0.41	7.67±0.52	7.33±0.82	7.33±0.82
15	30	7.5±0.84	7.67±0.82	7.33±0.52	7.50±0.55	7.00±0.89	7.50±0.55
	60	7.33±0.5	7.67±0.82	7.00±0.63	7.33±0.82	6.00±1.10	7.17±0.75
	90	7.333±0.82	7.67±0.82	6.83±0.75	7.50±0.55	6.00±1.41	7.50±0.55

Table 6. Changes in color and texture characteristics of Tilapia muscle during steam cooking

Parameters	Fresh muscle	Cooked muscle
Colour characteristics:		
L*	49.72±0.05	72.25±0.03
a*	4.35±0.01	0.35±0.01
b*	12.15±0.04	10.94±0.02
Hue colour(b/a)	2.80±0.01	31.48±0.56
Saturation Index($(a^2+b^2)^{0.5}$)	12.91±0.04	10.95±0.02
Texture characteristics:		
Hardness(gf)	112.80±1.78	57.95±5.15
Adhesiveness(gs)	1.55±0.37	0.05±1.62
Stringiness(mm)	1.13±0.05	1.39±0.06
Cohesiveness	0.60±0.01	0.52±0.02
Resilience	0.43±0.02	0.34±0.01
Springiness	1.02±0.01	1.18±0.02
Gumminess	68.08±1.09	30.36±3.92
Chewiness	69.37±1.45	35.66±4.51

for 60 min with 5 min steam cooking, have received higher scores in appearance, color, taste and texture than other treatments. Comparison of all the parameters like color, texture and organoleptic characteristics of different treatments, the cold blanched fish steaks dipped in 10 % salt solution for 60 min rendered superior performance in firmness/hardness. It could be justified by the report of Balachandran (2001) who described that the fish washed with 8-10% salt for about an hour was sufficient to remove the slime and to harden the meat. Similarly, Gopakumar (2002) reported that cold blanching of dressed fish pieces in 10 % brine for 15 min. Inhibited enzyme reactions, the imparted firm texture of the meat and ensured shrinkage of the raw material to permit adequate filling in the can. Bhandary (1971) recommended a brining time of 15 min. in saturated salt solution to get a salt content of 1.1 to 1.6 % as NaCl in the finished product of freshwater fishes. Telles-Siqueira *et al.* (1975) observed that the salt content in canned marine and freshwater fish to be 1.6 % and 1.75 % as NaCl respectively. Nair *et al.* (1977) reported that the processes of cold blanching of dressed sardine in brine, smoking followed by drying in hot air or cooking in steam for canning yielded good organoleptic properties. Balachandran and Vijayan (1988) accounted that it was necessary to undertake cold blanching of skinless, boneless meat of rohu in 15% brine containing 0.25% calcium chloride for 10 min for imparting a proper firm texture to the meat. The study affirmed that cold blanching in brine become essential and general practice to be followed before thermal processing of fish meats. In many companies, own sensory schemes tailor made for their special purposes have been developed. However, evaluation of raw fillets is also done in secondary processing before further processing and in retail before packaging (e.g. MAP) and labelling for sale (Olafsdottir et al., 2004).

Comparison of color and texture of fresh and cooked tilapia meat

The changes in the color and texture of fresh and cooked tilapia meat are presented in the Table 5. The values of L* and Hue angle rose immediately after steam cooking. The values of a*, b* and saturation index of the steam cooked meat were lower than a fresh one. The textural parameters of tilapia meat like hardness, gumminess, adhesiveness, resilience, chewiness and cohesiveness decreased after cooking except the springiness and stringiness.

This might be attributed to the denaturation of protein and uncoiling of polypeptide chains during cooking (Hamm, 1960). Cooked fish usually tend to become soft in texture compared to raw fish since the heat induces the conversion of collagen into gelatine in the meat. The cooked meat was significantly lighter, less red and more yellow than the raw meat, as observed by Fletcher *et al*. (2000) in poultry cooked meat. Further, the variation (standard error of the mean) and range of color in raw meat were dramatically reduced after cooking. Cooking often results in the darkening of the fish muscle due to the maillard's reaction. Tarr (1962) reported a brown discoloration in white-fleshed fish upon heating. A change in the salmon color pigments upon heating was observed by Naughton *et al*. (1956). Tarr (1958) stated that free ribose accounted for many of the maillard's type of reaction when fish meat was heated in the presence of carbohydrates. The crosslink formation and related changes during heating decreased the water-holding capacity of the muscle which resulted in loss of muscle tenderness (Devadasan, 2001). In general, cooking process reduces the excess moisture, thus the sensory, physical and chemical qualities of the product are improved which in turn enhances the shelf life of the product (Aubourg 2001). Schubring (2002) monitored the textural changes in cod stored in melting ice using an easily-applicable, hand-held and non-destructive shore A hard-ness tester. Johnston *et al*. (2000) reported the strategy for selecting high fibre density and, hence, favourable ''firmness'' and colour visualisation traits of the fillet would be to identify broodstock with high fibre number. For freshness determination of raw fillets, colour and smell are evaluated, but for cooked fish schemes like the Torry scheme are in use. Sensory evaluation of raw fillets is diûcult and therefore, it is likely that the fish industry would welcome a reliable and easy to use multi-sensor device for that evaluation (Olafsdottir *et al*., 2004).

CONCLUSION

Fish steaks dipped in 10 % salt concentration for 60 min with 5 min. steam cooking was found as a paramount treatment in improving the quality of the meat among the treatments tested. It could be explained through the high scores acquired for the treatment in sensory parameters like appearance, color, taste and texture compared to other treatments. Cooking develops good color and texture and hence it augments the consumer preferences.

REFERENCES

Abdulla, M .Z., L.C. Guan, K.C. Lim and Karim, A. A. 2004. The application of computer vision and tomographic radar imaging for assessing physical properties of food. J. Food Eng. **61**:125-135.

AOAC, 2000. Official Methods of Analysis of AOAC International, 17th Edition, Suite 500, 481 North Frederick Avenue, Gaithersburg, Maryland 20877-2417 USA.

Aubourg, S. P., 2001. Review: Loss of quality during the manufacture of canned fish products. Food Science and Technology International. **7:** 199-215.

Balachandran, K. K. and Vijayan, P. K. 1988. Development of a process for canning fresh water fish rohu (*Labeo rohita*). Fishery Technology. **25 (1):** 40-43.

Balachandran, K. K. 2001. Post Harvest Technology of Fish and Fish Products, Daya Publishing House, New Delhi, p. 427.

Bhandary, M. H. 1971. The quality aspects of different important varieties of freshwater fish canned in oil, brine or in curried form. M.F.Sc. Dissertation, University of Mysore.

Bourne, M. C. 1978. Texture profile analysis. Food Technology **22:** 62-66.

Coppes, Z., Pavlisko, A. and De Vecchi, S. 2002. Texture measurement in fish and fish products. J. Aquatic Food Product Technol. **11:** 89-105.

Devadasan, K. 2001. Retort pouch packaging of fish curry. Fishing chimes **20(10&11):** 44-46.

Dhanapal, K., Reddy, G.V.S., Nayak, B.B., Basu, S., Shashidhar, K., Venkateshwarlu, G. and Chouksey, M.K. 2010. Quality of ready to serve tilapia fish curry with PUFA in retortable pouches. J. Food Sci. **75(7):** 348- 354.

Du, C. and Sun, D. 2004. Recent development in the applications of image processing techniques for food quality evaluation. Trends in Food Sci. and Technol. **15:** 230-249.

El-sayed, A. F. M. 1999. Alternative dietary protein sources for farmed tilapia, *Oreochromis* spp. Aquaculture. **179:** 149-168.

Fletcher, D. L., Qiao M. and Smith. D. P. 2000. The Relationship of Raw Broiler breast Meat Colour and pH to Cooked Meat Colour and pH. Poultry Sci. **79:**784-788.

Gopakumar, K. 2002. Text Book of Fish Processing Technology. Indian Council of Agricultural Research, New Delhi.

Hamm, R. 1960. Biochemistry of meat hydration. In: C.O. Chichester (Ed). Advances in Food Research., Academic press. **10:** 356-463.

Hatcher, D. W., Symons, S. J and Manivannan, U. 2004. Developments in the use of image analysis for the assessment of Oriental noodle appearance and color. J. Food Eng. **61:** 109-117.

Hempel, E. 2002. Tilapia the new white fish. Seafood International **10:** 16-23.

Hunt, R. W. G. 1991. Measuring Color (2nd Ed.). New York, Ellis Horwood. pp. 313.

Johnston, Ian A., Alderson, Richard., Sandham, Claire, Dingwall, Alistair., Mitchell, David, Selkirk, Craig., Nickell, David., Baker, Remi., Robertson, Billy., Whyte, David. and Springate, John. 2000. Muscle fibre density in relation to the colour and texture of smoked Atlantic salmon (*Salmo salar* L.). Aquaculture **189:** 335-349.

Leon, K., Mery, D., Pedreschi, F. and Leon, J. 2006. Colour measurement in L*a*b* units from RGB digital images. Food Research Int. **39:** 1084-1091.

Mallick, A.K., Srinivasagopal, T.K.. Ravishankar, C.N.. Vijayan P.K. and Geethalakshmi, V. 2010. Changes in instrumental and sensory properties of Indian white shrimp in curry medium during retort pouch processing at different F0 values. J. Texture Studies. **41:** 611-632.

Nair, U. T. S., Balachandran, K. K. and Madhavan, P. 1977. Canning of smoked sardine. Fishery Technology. **14(1):** 49-52.

Nalan, G., Yerlikaya P. and EmelCengiz. 2004. Effects of cooking methods on the proximate composition and mineral contents of rainbow trout (*Oncorhynchus mykiss*). J. Food Chemistry. **84(1)**: 19-22.

Naughton, J. J., Frodyma, M. M. and Seitlin, H. 1956. Nature of green or off-colour condition in pre-cooked yellowfin tuna. U.S Fish.Wildlife.Serv.Spec.Sci.Rept., No.197. Cited: Broek, C.J.H., 1965. p. 7.

Olafsdottir, G., Nesvadba, P., Di Natale, C., Careche, M., Oehlenschla¨ger, J., Tryggvado´ ttir, S.V., Schubring, R., Kroeger, M., Heia, K., Esaiassen, M., Macagnano, A. and Jorgensen, B.M. 2004. Multisensor for fish quality determination. *Trends in Food Science & Technology*. **15:** 86-93.

Schubring, R. 2002. Texture measrurement on gutted codduring storage in ice using a hand-held instrument. Inf. Fischwirtsch. *Fischereiforsch.* **49(1):** 25-27.

Tarr, H. L. A. 1958. Biochemistry of fishes. *Annual Reviews in Biochemistry*. **27:** 223-244.

Tarr, H. L. A. 1962. Cause of the browning of certain heat processed fish products. Fisheries research board, Canada. *Progr. Repts. Coast. Sts. No.* **92:** 23-24.

Telles-Siqueira, F.J., Vieira-Fernandes R. H. S. and Vieira-Fernandes, G. H. 1975. Industrialization of marine and fresh water fish, 2. Processing of canned products. *Arq. Cienc. Mar*. **15(2):** 111-113.

Trussel, H. J., Saber, E. and Vrhel, M. 2005. Colour image processing. *IEEE Signal Processing Magazine*. **22(1):** 14–22.

Vijayan, P.K. 1984. Report on Training Program on Retort Pouch Processing of Fish and Fish Analysis at Tropical Development and Research Institute and METAL Box (R & D), UK, Central Institute of Fisheries Technology, Cochin, India.