

## Study on the Effect of Different Levels of Heat on the Quality of Dark muscle of Yellow Fin Tuna *Thunnus albacares*

L.L.S.L. Jayasinghe, W.M.N.M. Wijesundara, N.P.P. Liyanage  
Uva Wellassa University, Badulla, Sri Lanka

and

S.S.K. Madage  
Industrial Technology Institute, 363, Baudhaloka Mawatha, Colombo 7. Sri Lanka

### Introduction

Coastal and off shore marine production in Sri Lanka has an increasing trend. According to Department of Fisheries and Aquatic Resources, a catch of 417,220 metric tons was recorded in 2012. Yellow fin Tuna (*Thunnus albacares*) is included in large pelagic fish catch of Sri Lanka and it composed 10% of total marine catch in 2012. Yellow fin tuna (YFT) is mainly exported as Loins, Steaks, Centre cuts, Cubes, Medallions and *Saku* in processed form. Currently there are 27 European Union approved fish processing factories in Sri Lanka. Considerable parts of fish are removed as by-products during processing; this includes dark muscle, fins, skin, head and viscera parts. The amount of by-products produced during fish processing is vary between 40-75% of the total weight of fish according to the way of processing (Shahidi (1994), cited in Zapata *et al.*, 2011). Though some value addition is done to these by-products there are plenty of opportunities to add value to by-products like YFT dark muscle. Thermal preservation is one of the current techniques used in value addition. Therefore, it is very important to know the quality changes of YFT dark muscle when they undergo thermal preservation techniques. Although many studies have been conducted to determine the initial quality of this muscle, still the quality changes with the different heat treatments are not studied. Therefore, objectives of this study were to evaluate the effect of different levels of heat treatments on the physical, chemical and organoleptic properties of YFT Dark muscle (DM).

### Methodology

DM of YFT fish processed at Ceylon Fresh Seafood Private Limited in Ja-Ela were collected and transported with gel ice at 4°C to Industrial Technology Institute (ITI) and stored in -18 °C until used for the experiment. Experiment was conducted as three stages as fresh fish quality determination, pre-trial and heat treatment study using 0.5 kg, 1.5 kg and 2 kg amounts respectively. For fresh fish quality determination, physical properties including colour (Minolta Chroma meter CR-200, Japan), texture (as firmness using GUSS fruit texture analyser, United States of America) and water holding capacity and chemical properties including moisture, ash, crude protein, crude fat, water soluble protein content, pH of 10% muscle solution and water activity (AquaLab® apparatus-Series 3 TE, USA) of fresh muscle were determined by following respective AOAC methods. Colour and texture of approximately 3×2.5×1 cm sized undisturbed muscle chunks were recorded. Sensory evaluations (acceptance test with five point hedonic scale) were conducted with seven trained panellists of sensory panel of ITI using fish chunks as pre-trials. Those chunks were marinated overnight with 2% salt, to determine the best deep frying and boiling durations. As time durations 05, 10 and 15 minute durations were selected and frying was done in coconut oil at 185 °C while boiling was performed at 100 °C. For the heat treatment study, fish chunks were prepared as in pre-trial and those were boiled and deep fried for five minutes. Fish chunks were canned in A-1 sized cans with 2% salt solution at 121.1 °C for ten minutes. Finally the chemical and physical properties of heat treated DM were determined. Final organoleptic quality of the heat treated DM was evaluated by nine trained panellists of ITI using acceptance test with nine point hedonic scale. Physical and chemical quality data were analysed using one way analysis of variance procedure in Minitab 16

statistical package. Sensory evaluation data were analysed using Friedman non parametric test in SPSS 22.0 statistical package. All mentioned significant differences are given at  $P < 0.05$ .

## Results and Discussion

The five minute heating time was selected for frying and boiling, as the acceptance test results did not show any significant difference for texture, colour, odour, appearance, taste and overall acceptance for three different time durations of cooking except for odour of fried DM ( $p=0.013$ ).

All the heat treatments lead to significant reduction of final moisture content of DM (Table 1). Frying was resulted approximately a 30% loss of moisture. All heat treatments lead to a significant increase of protein content. Frying resulted in significantly higher protein, fat and ash contents with compared to boiling and canning. Both frying and boiling have significantly increased the ash contents. Stephen *et al.* (2009) observed an increase in fat content and a decrease in moisture content of canned, fried and boiled Skipjack tuna. Gall *et al.* (1983) for fried Grouper, Red snapper and Pompano has observed an increase in the fat, ash and protein content and a reduction in moisture content due to heat treatment. pH of DM significantly reduced with heat treatments. Dulce, Paredes and Baker (1988) observed a reduction in pH of Catfish and an increase in pH of Ocean perch and Pollock with the canning. Lower pH will prevent muscle cells from microbial contamination. Frying caused a significant reduction in the water activity with compared to boiling and canning. It could reduce the susceptibility of the fried samples from the activity of *Pseudomonas*, *Escherichia* and *Proteus etc.* Canning and boiling significantly decreased the water soluble protein content of DM. Sarcoplasmic proteins which are dissolved in water with caning and boiling are identified as water soluble proteins. Frying is the best treatment for DM according to the changes in chemical properties.

Table 1: Means of physical and chemical characteristics of YFT DM.

Parameter	Raw	Fried	Boiled	Canned
Moisture (g/ 100 g)	75.73±0.15 <sup>a</sup>	45.60±0.41 <sup>d</sup>	71.21±0.06 <sup>c</sup>	74.32±0.46 <sup>b</sup>
Protein (g/ 100 g)	20.54±0.30 <sup>d</sup>	41.36±0.05 <sup>a</sup>	26.81±0.21 <sup>b</sup>	22.97±0.12 <sup>c</sup>
Fat (Wet weight basis) (g/ 100 g)	0.62±0.02 <sup>c</sup>	8.73±0.07 <sup>a</sup>	1.64±0.12 <sup>b</sup>	0.68±0.02 <sup>c</sup>
Ash (g/ 100 g)	1.13±0.02 <sup>c</sup>	5.26±0.08 <sup>a</sup>	2.24±0.09 <sup>b</sup>	1.26±0.03 <sup>c</sup>
pH (at 26 °C)	6.75±0.02 <sup>a</sup>	6.54±0.01 <sup>c</sup>	6.61±0.04 <sup>b</sup>	6.67±0.02 <sup>b</sup>
aW (at 26 °C)	0.988±0.001 <sup>a,b</sup>	0.930±0.002 <sup>c</sup>	0.985±0.002 <sup>b</sup>	0.992±0.002 <sup>a</sup>
Water soluble protein (g/ 100 g)	9.32±0.65 <sup>a</sup>	8.98±0.06 <sup>a</sup>	4.10±0.08 <sup>c</sup>	7.04±0.08 <sup>b</sup>
WHC (g water/ 1 g sample)	0.207±0.017 <sup>c</sup>	0.380±0.031 <sup>b</sup>	0.330±0.031 <sup>b</sup>	0.507±0.046 <sup>a</sup>
Texture (Kg)	0.85±0.22 <sup>b,c</sup>	2.75±0.56 <sup>a</sup>	1.36±0.11 <sup>b</sup>	0.54±0.04 <sup>c</sup>
L* (Lightness)	21.07±1.08 <sup>b</sup>	15.24±0.12 <sup>c</sup>	15.14±2.11 <sup>c</sup>	29.51±1.07 <sup>a</sup>
a* (Redness)	5.55±1.64 <sup>b</sup>	2.22±0.10 <sup>c</sup>	4.30±0.42 <sup>b,c</sup>	8.68±0.48 <sup>a</sup>
b* (Yellowness)	0.99±0.71 <sup>b</sup>	1.20±0.08 <sup>b</sup>	1.46±0.13 <sup>b</sup>	7.15±1.05 <sup>a</sup>

Mean ± standard deviation of triplicates is given in table. Within a row, values with different superscript letters are significantly different ( $p < 0.05$ ).

The values of L\*, a\* and b\* coordinates for tuna DM were lower than those reported by Zapata *et al.* (2011) for YFT. L\*, a\* and b\* coordinates were significantly increased with canning. Higher Myoglobin content of DM (5.3 to 24.4 mg/gram) is the reason for the higher dark colour. DM has shown a significant reduction in L\* value with boiling and frying. Canning is the best treatment for DM considering the light colour produced. WHC of raw tuna DM was lower than those reported by Zapata *et al.* (2011). All three heat treatments lead to significant increases in the WHC of DM. Canning resulted in the highest WHC compared to all treatments. Firmness has reduced significantly with the frying treatment. According to texture and WHC

results frying can be recommended as the best treatment for DM. From the studied organoleptic properties of heat treated samples, only colour of the canned DM has shown a significantly higher acceptance ( $P=0.045$ ) with compared to fried DM. This is described by the increase in  $L^*$  value of canned DM due to denaturation of Myoglobin.

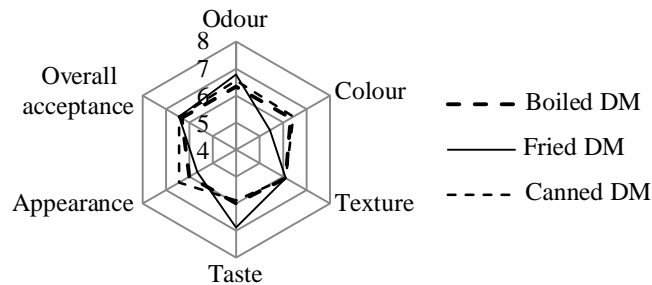


Figure 1. Organoleptic quality of boiled, canned and fried DM

In all heat treatments texture and appearance were liked slightly and odour and overall acceptance were closed to moderate likeness (Figure 1). Colour of the canned DM suggests that it is the best heat treatment. Taste of fried muscle was close to moderate likeness which may be due to the formation of Sodium glutamate.

### Conclusion

Frying can be recommended as the best heat treatment and canning is the least preferred treatment for YFT dark muscle by considering most of the physical and chemical properties. Both frying and canning can be further developed using ready to fry DM products and canned products respectively to increase the consumer preference for the YFT dark muscle.

### References

- Dulce, M., Paredes, C. and Baker, C., 1988. Physical, chemical and sensory changes during thermal processing of three species of canned fish. *Food Processing and Preservation*, 12(1), 71-81. Retrieved September 15, 2013, from the World Wide Web: <http://onlinelibrary.wiley.com/doi/10.1111/j.1745-4549.1988.tb00068.x/pdf>.
- Gall, K. L., Otwell, W. S., Koburgier, J. A. and Appledorf, H., 1983. Effects of four cooking methods on the proximate, mineral and fatty acid composition of fish fillets. *Food Science*, 48(4), 1068–1074.
- Stephen, N.M., Shakila, R.J., Jeyasekaran, G. and Sukumar, D., 2009. Effect of different heat treatments on chemical changes in Skipjack tuna steaks, *Food Science Technology*, 47(2), 174-181.
- Zapata, E.S., Amensour, M., Oliver, R., Zaragoza, E.F, Navarro, C., Lopez, J.F., Sendra, E., Sayas, E. and Alvarez, J.A.P. 2011. Quality characteristics of dark muscle from yellowfin tuna (*Thunnus albacares*) to its potential application in the food industry, *Food and Nutrition Sciences*, 2(1), 22-30.