EFFECT OF DIFFERENT HEAT TREATMENTS ON PHYSICO- CHEMICAL PROPERTIES OF YELLOWFIN TUNA (*Thunnus albacares*) LIGHT MUSCLE

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Abstract

Yellowfin Tuna (Thunnus albacares) is a large pelagic fish which accounted for around 10% of total marine catch of Sri Lanka in 2014. Light Meat (LM) of Yellowfin Tuna (YFT) can be consumed by subjecting it to thermal processing techniques such as boiling, frying and canning. Therefore it is necessary to evaluate the effect of different thermal processing techniques on the physical, chemical and organoleptic properties of YFT LM. Loins of YFT LM were collected from Ceylon Fresh Seafood Private Limited in Ja-Ela, Sri Lanka. Three major steps of the study were raw fish quality determination, preliminary heat treatment study and final heat treatment study. Approximately 3×2.5×1 cm sized fish chunks marinated overnight with 2% salt were used for deep frying, boiling and canning. Significant ($P<0.05$) increase in lightness (L^*), water holding capacity (WHC) and fat content of LM were observed with all three treatments. Moisture content significantly reduced with all heat treatments. Canning resulted in a pH value of 6.35±0.03, which was significantly higher compared to other treatments. Water activity of fried LM was significantly lower than other treatments (0.941±0.003). Organoleptic properties of heat treated samples revealed that taste of the fried LM had a significantly higher acceptance ($P=0.026$) compared to canned LM. Frying can be recommended as the best heat treatment considering most of the physical, chemical and organoleptic properties.

Keywords: *Yellowfin Tuna, Muscle Quality, Thermal Processing*

INTRODUCTION

Fish protein consumption has shown an increase during past few years due to the improvements in coastal and off shore marine production in Sri Lanka (Department of Fisheries and Aquatic Resources, 2012).According to the food balance sheet by Agriculture and Environment Statistics Division (2014) the fresh fish catch from the ocean accounts for a per capita availability of 5.38 g of protein/day in Sri Lanka. Jack, Trevallies, Spanish mackerel, Wahoo, Skipjack tuna and Yellowfin tuna are major fish types that contribute to above protein supply. Among them, YFT is harvested in high quantities by Sri Lankan fishermen (Department of Fisheries and Aquatic Resources, 2012).

According to Department of Fisheries and Aquatic Resources (2014), a catch of 459,300 metric tons of such marine fish were recorded in Sri Lanka. Yellowfin Tuna (*Thunnus albacares*) is included in large pelagic fish catch of Sri Lanka and it composed 10% of total marine catch in 2014 (Department of Fisheries and Aquatic Resources, 2014). Generally fish muscles are categorized according to the colour as red, pink and white (Ramel, 2008). Most fish have two or three types of muscle, but keep the types in discrete groupings (Ramel, 2008).YFT has both dark and light muscles. Normally the ratio of light and dark muscle varies with the fish activity, type and age of fish. Since YFT is migratory species, need more energy as fat. Therefore, it contains dark muscles of about 48% of total body weight and remaining is the LM (Zapata and Alvarez,2007).

YFT is popular due to its nutritional value and taste. Common thermal processing techniques such as boiling, frying and canning are used to prepare fish flesh for consumption. Although many studies have been conducted to determine the initial quality of YFT flesh, still the quality changes with the different thermal processing techniques are not much studied (Karunarathna and Attygalle, 2010; Zapata et al., 2011). Therefore the objective of this study was to evaluate the effect of different thermal processing techniques on the physical, chemical and organoleptic properties of YFT LM.

MATERIAL AND METHODS

Loins of YFT LM were collected from Ceylon Fresh Seafood Private Limited in Ja-Ela and transported with gel ice at 4°C to the Industrial Technology Institute (ITI). Three major steps of the study were fresh fish quality determination, preliminary heat treatment study and final heat treatment study. Fish sample was divided in to three portions and at -18°C until it used for the study.

One portion of the sample was used for fresh fish quality determination. Physical properties such as colour (Minolta Chroma meter CR-200, Japan), texture (as firmness using GUSS fruit texture analyser, United States of America) and water holding capacity (Elkhalifa et al., 2004) of six fish chunks (approximately 3×2.5×1 cm in size) were analyzed. Remaining part of sample portion was minced using mincer (HV 8 COMBI, Moulinex, France) and stored in -18ºC chemical quality analysis.

For each chemical analysis minced and frozen fish samples were thawed overnight in the refrigerator and weighed with analytical balance (AG 204, Mettler Toledo, Switzerland). Analytical grade chemicals were used for all experiments. Proximate composition including moisture, ash, crude protein and crude fat were determined AOAC official method (2002). Water soluble protein content was determined according to AOAC (2002) official method 932.08 using Kjeldhal apparatus. Water activity was determined at 26.1ºC (Series 3 TE, AquaLab®, USA). pH of 10% (w/v) solutions of LM was determined at 26ºC (pH 510, EUTECH instruments, Singapore).

Preliminary heat treatment study was conducted to find out best time duration for boiling and deep-frying before conduct final heat treatment study. Fish chunks with approximate size of 3×2.5×1 cm were prepared from second portion of sample and washed once. These chunks were marinated overnight with 2% salt and subjected to different heat treatments as deep frying (at 185ºC in Coconut oil) and boiling at 100ºC for 5, 10 and 15 minutes respectively. Sensory evaluations were conducted with seven panellists of trained sensory panel of ITI using samples prepared above. For each panellist heat treated samples were presented using coded plates as one sample per plate and requested to evaluate the samples for odour, colour, texture, taste, appearance and overall acceptance using five point hedonic scale.

Third portion of sample was prepared for heat treatment study following the same procedure in preliminary heat treatment study. There for fish chunks were boiled and deep fried separately for five minutes based on the results obtained from preliminary trial. Fish chunks were packed in A-1 sized cans with 2% salt solution and subjected to heating at 121.1ºC for ten minutes. Colour, texture, water holding capacity (WHC), moisture content, ash, crude protein, crude fat, water soluble protein contents and pH of heat treated LM were determined as previously. Organoleptic properties (odour, colour, texture, taste, appearance and overall acceptance) of the heat treated LM were evaluated by eight trained panellists of sensory panel of ITI using nine point hedonic scale. Physical and chemical quality data were analysed using one way ANOVA using Minitab 16 statistical package. Sensory evaluation data were analysed using Friedman test in SPSS 22.0 statistical package. Significance levels of results were determined based on 0.05 probability level.

RESULTS AND DISCUSSION

Acceptance test results of preliminary heat treatment study did not show any significant difference for texture, colour, odour, appearance, taste and overall acceptance for three different time durations of thermal processing. Considering the energy used for heating, five minute heating time was selected for final heat treatment.

Table 1 illustrated the physiochemical quality of raw, boiled, fried and canned YFT LM. Karunarathna and Attygalle (2010) have observed lower moisture content (72.44±1.41 g/100g) in fresh YFT LM with compared to current study. Stephen et al. (2009) observed an increase in fat content and a decrease in moisture content of canned, fried and boiled Skipjack tuna. Grouper, Red snapper and Pompano have shown an increasing of fat and ash content and a reduction of moisture content due to frying (Gall et al., 1983). Current study also revealed that all the heat treatments lead to significant reduction in final moisture content and significant increase of fat content (Table 1). Harvard Health Publications, (2015) indicate, good health effects can be obtained by frying using oil with high levels of unsaturated fats instead of oil with high levels of saturated fats. However, frying resulted in significantly lower moisture content with compared to raw boiled and canned samples (Table 1). During frying water is partially lost by evaporation due to high temperature (Saguy and Dana, 2003). Even though other two treatments and raw sample were remains with comparatively high moisture content. According to the dry weight basis, significantly lower protein content was found in fried sample (Table 1). Results of the study showed that fat content of the fried samples were at a significantly higher level (Table 1).

During the frying process oil can be absorbed in to the flesh and this will be the reason for significant increasing of fat content in fried sample with compared to other treatments (Saguy and Dana, 2003). Increasing of fat in a dry unit of a sample has resulted the reduction of protein percentage (Saguy and Dana, 2003).

Table 1: Means of physical and chemical properties of Yellowfin Tuna Light Meat

Parameter[1]	Raw	Fried	Boiled	Canned
Moisture (g/100 g)	75.99 ± 0.26^{a}	49.63 ± 0.47^{d}	72.09 ± 0.43^{c}	74.62 ± 0.19^{b}
Protein (g/100 g)[2]	93.77 ± 1.07^{a}	76.31 ± 0.24^{c}	89.92 ± 0.23^{b}	91.51 ± 0.88^{b}
Fat (g/100 g)[2]	1.75 ± 0.14^{c}	14.92 ± 0.45^{a}	4.52 ± 0.16^{b}	4.28 ± 0.70^{b}
Ash (g/100 g)[2]	4.63 ± 0.06^{c}	9.26 ± 0.10^{a}	7.15 ± 0.44^{b}	4.37 ± 0.02^{c}
pH (at 26 ºC)	6.26 ± 0.02^{a}	6.24 ± 0.02^{a}	6.21 ± 0.03^{a}	6.35 ± 0.03^{b}
a_w (at 26 ºC)[3]	$0.986\pm0.003^{a,b}$	0.941 ± 0.003^{c}	0.981 ± 0.001^{b}	0.992 ± 0.002^{a}
Water soluble protein (g/100 g)	8.68 ± 0.08^{c}	12.37 ± 0.08^{a}	6.79 ± 0.08^{d}	9.66 ± 0.10^{b}
WHC (g water/ 1 g sample)	0.046 ± 0.010^{c}	0.357 ± 0.046^{a}	$0.332\pm0.050^{a,b}$	0.222 ± 0.069^{b}
Texture (kg)[4]	0.39 ± 0.08^{c}	2.10 ± 0.20^{a}	1.00 ± 0.05^{b}	0.47 ± 0.08^{c}
L* (Lightness)[3]	29.18 ± 1.14^{d}	37.25 ± 1.91^{c}	45.05 ± 0.88^{b}	53.00 ± 1.62^{a}
a* (Redness)[3]	$6.64\pm0.73^{a,b}$	7.10 ± 1.30^{a}	3.96 ± 0.53^{c}	$4.93\pm0.23^{b,c}$
b* (Yellowness)[3]	2.60 ± 0.53^{b}	12.97 ± 2.81^{a}	5.79 ± 0.78^{b}	12.31 ± 1.57^{a}

[1] Mean ± standard deviation of triplicates is given in table.
Within a row, values with different superscript letters are significantly different ($P< 0.05$);
[2] Protein, fat and ash are given on dry weight basis;
[3] Water activity (aw), Colour (L*, a*, b*);
[4] Texture measured as firmness

It also observed that both frying and boiling have significantly increased the ash content compared to raw and canned samples. Boiling significantly decreased the water soluble protein content of LM whilst canning and frying significantly increase it. This could be due to the solubility of sarcoplasmic proteins in water with boiling (Paredes and Baker, 1988).

The pH of LM significantly increased with canning while pH of other two treatments remained nearly similar to the raw muscle (Table 1). Paredes and Baker (1988) observed an increase in pH of Ocean perch and Pollock with the canning. Current study revealed that frying has reduced a_w significantly compared to other treatments and raw sample. At a a_w of 0.95, the most xerotolerant meat spoilage bacteria are inhibited even at their optimum temperatures (Leistener et al., 1981, cited in Lowry and Gill, 1984). Lower pH and $a_w$are important to reduce microbial growth on the food product (Feiner, 2008).

Colour was analysed using the CIE L*, a*, b* system. Mohan et al. (2013) reported higher values for L* and b* for YFT raw LM compared to this study. LM has shown a significant increment in L* value with all three treatments (Table 1). The increase in lightness value could be due to the leaching out of muscle pigments along with the exudates during thermal processing (Mohan et al., 2013). Frying and canning resulted a significant increase in b* value. It could be due to the heat induced denaturation of myoglobin and oxidation of carotenoid pigments (Mohan, et al., 2013). Colour combination formed by +a*, +b* and moderate L* values in fried fish flesh would increase the appetite of the consumer. All three heat treatments lead to significant increases in the WHC of LM. Frying and boiling resulted in a higher WHC compared to canning. Firmness has reduced significantly with the frying and boiling treatments with compared to canning.

According to results from the texture analyser, texture of the LM has increased significantly with the frying and boiling treatments (Table 1). Canning did not make a significant change to the fresh muscle texture. Increased texture values can be interpreted as a reduction of the firmness of LM. This reduction of firmness would increase the acceptance of the heat treated fish flesh.

According to the organoleptic properties of heat treated samples, only taste of the fried LM has shown a significantly higher acceptance (P=0.026) compared to canned LM. "Liked moderately" was selected for colour, texture, appearance and overall acceptance in boiling and frying heat treatments (Figure 1). Fried LM has shown an improved taste; which may be due to the formation of Sodium glutamate (Evanuarini and Purnomo, 2011).

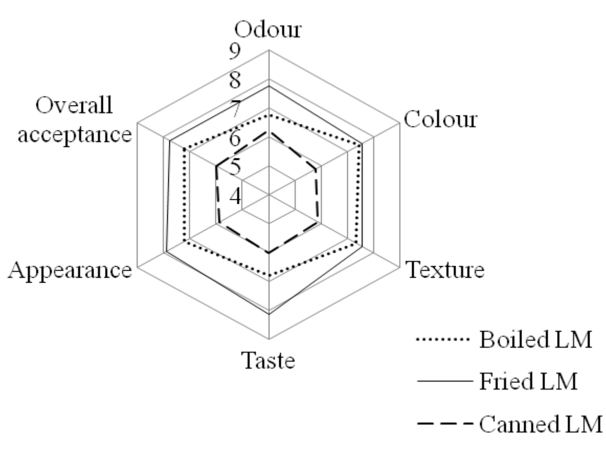

Figure 1: Organoleptic quality of boiled, canned and fried LM

CONCLUSION

Frying of YFT LM gives most of the favourable physical, chemical and organoleptic properties compared to other heat treatments.

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