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Biochemical and Microbiological Evaluation of Tuna Loin Processing Waste

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Abstract

The study conducted on the yellow fin tuna loin processing showed a sizeable portion as waste in the form of belly flap, off cut meat, off cut mince from the bone, meat mince, blood meat, head, gut, tail, skin and bone. Analysis of proximate composition of processing waste showed protein content ranging between 18.72 and 23.95%. The fat content was highest in belly flap (7.52%) and lowest in head meat (0.23%). The appreciable amounts of protein (18.73 to 23.95%) and low fat content (0.23 to 1.92%) of off-cut mince, bone meat, head meat and blood meat make them suitable for value addition if other quality parameters are within the acceptable level. Microbiological quality of the tuna processing waste was found acceptable whereas histamine content was on the higher side. Implementation of Good Management Practices (GMP) and Hazard Analysis Critical Control Point (HACCP) system right from capture to processing would facilitate effective utilization of tuna processing waste for value addition.

Key words: Yellowfin tuna, tuna loins, processing waste, proximate composition, quality, histamine

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Introduction

The meat of tuna, popularly known as the chicken of the sea is relished by consumers world over both for taste and for the health benefits due to ω-3 fatty acid content. Yellow fin tuna is commercially the second most important species of tuna accounting for 27.1% of the total world tuna catch in 2008 (FAO, 2008). Tuna exports from India were mainly in the form of frozen tuna (34 049 t), followed by chilled tuna (553 t), canned tuna (318 t) and dried tuna (27 t) (MPEDA, 2008). A rapid progress in tuna fishery in Andhra Pradesh was visible since 2000 and Visakhapatnam has emerged as the nerve centre for tuna fishing along the east coast of India (Rao & Prathiba, 2008). Yellow fin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*) and little tunny or kawa kawa (*Euthynnus affinis*) are the important tuna species landed by the fishing vessels in Visakhapatnam.

Tuna meat is processed for tuna meat loins which fetches money in the international market. After removing the head and intestines, the tuna is filleted. The skinless fillets are cut in the centre into two pieces. Dark meat is trimmed off and the tuna loins are frozen, weighed, labeled and packed for export. Processing of tuna as loins generates lot of waste in the form of belly flap, off cut meat, off cut mince from the bone, meat mince, blood meat, head, gut, tail, skin and bone. The wastes from yellow fin tuna processing can be used for preparation of by-products such as tuna silage, tuna meal and tuna protein hydrolysate which can be used as protein supplement in animal feeds (Sultanbawa & Aksnes, 2006). Waste utilization is an important issue for the seafood industry both from a regulatory standpoint as well as one that has potential economic impacts.

Therefore, the present study was undertaken to assess the nutritional, biochemical and microbiological aspects of tuna processing waste.

Materials and Methods

Yellowfin tuna (*T. albacares*) processing waste was procured from commercial tuna loins processing unit *viz*., an EU approved plant at Visakhapatnam, Andhra Pradesh. A composite sample of tuna loin was also collected for analysis of nutritional components. The processing waste was immediately transferred to the laboratory in chilled condition (<4°C). Fresh yellowfin tuna meat (composite meat that was a mixture of light and red meat) was analysed for the proximate composition. Moisture, protein, fat, ash, calcium, potassium, sodium and iron were determined as per standard methods (AOAC, 1990). Phosphorus was determined colorimetrically (Fiske & Subbarow, 1925). Total volatile base nitrogen (TVBN) was determined by the Conway micro diffusion method using trichloro acetic acid extract (Conway, 1947). Peroxide value (PV) was determined after extracting the fat from the fish meat using chloroform (AOAC, 1990). Histamine content in the meat was estimated colorimetrically (470 nm) employing cotton acid succinate column and diazonium salt (AOAC, 1975). Mercury content was estimated using Mercury Analyzer (MA5840, Electronic Corporation of India, Hyderabad) which works on the principle that mercury vapour (atoms) absorbs resonance radiation at 253.7 nm. Cadmium and copper were analysed following the method of AOAC (AOAC, 2000). The samples were digested with 7 ml of HNO_3 and 3 ml of H_2O_2 for 60 min at 95^0C under pressure in microwave digester (CEM Corporation, North Carolina, USA). The digested samples were analysed using atomic absorption spectrophotometer (Varian Spectra AA 220, Australia). Aerobic Plate Count (APC), MPN total coliforms, MPN faecal coliforms, MPN *Escherichia coli*, coagulase positive *Staphylococci*, *Vibrio cholera* and *Salmonella* were determined as per standard methods (BAM, 1995).

The data were subjected to statistical analysis as per standard methods (Snedecor & Cochran, 1967).

Results and Discussion

Analysis of proximate composition of fresh yellowfin tuna meat (composite meat that was a mixture of light and red meat) indicated that yellow fin tuna meat was rich in protein (22.59%) while fat content of the composite meat was 0.64% (Table 1). The red meat of tuna was reported to be nutritionally comparable with white meat (Mumthaz et al., 2010). The protein values were slightly lower than the values (26-28%) reported for tuna species (Gopakumar, 1997; Mumthaz et al., 2010).

Table 1. Nutritional composition of yellowfin tuna meat (composite)

Moisture (%)	73.25 ± 0.49
Protein (%)	22.59 ± 0.6
Fat (%)	0.64 ± 0.17
Ash (%)	1.83 ± 0.13

Results are average of triplicate determinations ± SD
Values were on wet basis

The protein content of tuna loin processing waste ranged from 18.72 to 23.95% (Table 2). There was appreciable amounts of protein (22.83 to 23.95%) and low fat content (0.23 to 1.93%) in off-cut mince, bone meat, head meat and blood meat of the processing waste. However, belly flap had high fat content (7.52%) when compared to other processing waste constituents. The oil extracted from the fat rich tuna bone meat mince appears to be a promising supplement of Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) as Mumthaz et al. (2010) reported EPA and DHA in yellowfin tuna meat ranging from 5.6 to 5.9 g 100 g^{-1} and from 47.6 to 53.4 g 100 g^{-1} respectively. The health benefits of ω-3 fatty acids are well established (Flick & Martin, 1992).

Table 2. Proximate composition of different constituents of tuna processing waste

Constituents	Moisture (%)	Crude protein* (%)	Fat* (%)	Total ash* (%)
Off cut mince	74.07 ± 0.15	22.85 ± 0.35	1.93 ± 0.04	1.39 ± 0.06
Bone meat	74.54 ± 0.25	23.19 ± 0.02	1.92 ± 0.01	1.12 ± 0.46
Head meat mince	72.57 ± 0.42	22.83 ± 0.11	0.23 ± 0.07	4.75 ± 0.49
Belly flap	72.17 ± 0.02	18.72 ± 0.06	7.52 ± 0.13	1.37 ± 0.04
Blood meat	73.4 ± 0.38	23.95 ± 0.1	0.57 ± 0.03	1.12 ± 0.01

Results are average of triplicate determinations, Mean ± SD
* Values are on wet basis

Mineral composition of different constituents of tuna processing wastes given in Table 3 showed good complement of sodium, potassium, phosphorus and iron. Extensive variation in the sodium levels was observed between the different constituents of waste from 37 mg 100 g^{-1} to 2035 mg 100 g^{-1} while phosphorous content varied over a relatively narrow spectrum of 783 mg 100 g^{-1} to 1373 mg 100 g^{-1} and potassium from 378 to 1506 mg 100 g^{-1}. Higher levels of iron was seen in the head meat mince *viz.*, 213.8 ppm (Table 3).

TVBN content of belly flap was 30.18 mg100 g^{-1} (Table 4) which was at the border level of acceptability *viz.*, 30 mg 100 g^{-1} as per Connell (1975). Bone meat, head meat, off cut mince and blood meat had acceptable levels of TVBN (< 30 mg 100 g^{-1}). The PV values of the different constituents of processing waste ranged between 10.59 and 21.81 meq kg^{-1} of fat (Table 4) which was above the preferred value of 10 meq kg^{-1} of fat (Connell, 1975). The reason for high PV in the present study was the improper handling of 'waste' due to its low economic value and also due to the importance given only to loins. This can be improved by implementing GMP in handling tuna waste.

Levels of histamine in different portions of tuna processing waste ranged between 65.7 and 269.3 ppm (Table 4). Except head meat, all the remaining samples had histamine content of above 200 ppm. The US Food and Drug Administration guidelines specify 50 ppm (5 mg 100 g^{-1}) as the defect action level (FDA, 2011). European Union (EU) regulations require nine samples to be taken from each batch of fish and no sample must contain more than 100 ppm of histamine. However, two failures at levels between 100-200 ppm are allowed but any sample above 200 ppm will necessitate the batch to be destroyed (EU, 2005). The results of the present study indicated higher histamine level which might be due to improper handling of yellowfin tuna waste. Establishment of chill rooms (< 4°C), cold store (-18°C) and maintaining cold chain are essential to maintain the quality of the raw material as histamine fish poisoning is attributed to the ingestion of fish containing high levels of histamine.

Heavy metals *viz.*, cadmium, mercury and copper were detected in some of the portions of the processing waste but all the values were less than 1 ppm, which is below hazardous level (Table 4). All the three metals were detected in bone meat while none of them was detected in blood meat (Table 4).

The total microbial load ranged between 430 cfu g^{-1} and 2 27 000 cfu g^{-1} (Table 5) and all the counts were far below legal limits of 5 00 000 cfu g^{-1} (EIC, 1995). Even though total coliforms and faecal coliforms were detected in off-cut mince, bone meat, head meat and blood meat, unacceptable levels of *E.coli* was detected only in head meat (210 MPN g^{-1}) as *E.coli* level of < 20 g^{-1} is acceptable in raw frozen fish (EIC, 1995). Human pathogens *viz.*, *Salmonella* and *Vibrio cholerae* were not detected in any of the samples. Coagulase positive *Staphylococci* were detected only in belly flap but at a low level of 20 cfu g^{-1}, which was within the acceptable limit of 100 cfu g^{-1}. Hence, the off-cut mince, bone meat and blood meat met the stipulated requirement whereas head meat was unfit. This might be due to improper handling. The results indicated that except head meat, other constituents of the yellow fin tuna processing waste were of acceptable microbiological quality.

The study indicated that the waste in the form of belly flap, off cut meat, off cut mince from the bone,

Table 3. Mineral composition of different constituents of tuna processing waste

Constituents	Potassium* (mg%)	Sodium* (mg%)	Phosphorus* (mg%)	Iron* (ppm)
Off cut mince	1506 ± 16.5	2035 ± 49.5	852 ± 1.37	75.7 ± 0.39
Bone meat	1470 ± 16.0	1842 ± 32.5	783 ± 1.93	54.1 ± 0.79
Head meat mince	378 ± 12.5	1512 ± 48.5	1373 ± 20.6	213.8 ± 5.7
Belly flap	1342 ± 70.5	39 ± 3.0	874 ± 4.01	75.2 ± 1.15
Blood meat	1251 ± 66.0	37 ± 2.0	897 ± 3.89	85.2 ± 1.3

Results are average of triplicate determinations, Mean ± SD
* Data based on dry weight basis

Table 4. Chemical quality of different constituents of tuna processing waste

Constituents	TVBN* (mg 100g^{-1})	Peroxide Value (PV)* (meq kg^{-1} of fat)	Histamine* (ppm)	Heavy metals		
				Cadmium (ppm)	Mercury (ppm)	Copper (ppm)
Off cut mince	20.84±0.31	21.81±0.6	200.7±5.0	0.17	0.03	nil
Bone meat	19.83±0.49	17.45±0.21	269.3±2.7	0.23	0.05	0.23
Head meat mince	26.25±0.67	15.41±0.20	65.7±3.5	0.029	0.02	nil
Belly flap	30.18±0.35	16.68±0.32	224.8±11.5	nil	0.03	nil
Blood meat	23.15±0.68	10.59±0.59	261.7±3.6	nil	nil	nil

* Values are average of triplicate determinations, Mean ± SD

Table 5. Microbiological quality of different constituents of tuna processing waste

Constituents	APC cfu g^{-1}	Total Coliforms MPN g^{-1}	Faecal Coliforms MPN g^{-1}	*Escherichia coli* MPN g^{-1}	Coagulase positive *Staphylococci* cfu g^{-1}	*Vibrio cholerae* in 25 g	*Salmonella* in 25 g
Off cut mince	36 000	93	93	<3	0	Absent	Absent
Bone meat	1 54 000	43	43	<3	0	Absent	Absent
Head meat mince	430	210	210	210	0	Absent	Absent
Belly flap	80 000	<3	<3	<3	20	Absent	Absent
Blood meat	2 27 000	23	9.2	<3	0	Absent	Absent

meat mince, blood meat, head, gut, tail, skin and bone generated from tuna loin processing factory contains appreciable amounts of protein and low fat content. Microbiological quality of the tuna processing waste was acceptable while the histamine content was on the higher side. Even though appreciable amounts of protein and low fat content in the tuna processing waste make it suitable for value addition, the higher histamine content prevents its utilization. HACCP system should be implemented from catching to processing stages and storage so as to prevent biological and chemical hazards in processing wastes so that it can be used as suitable raw material for value addition.

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