Fishery Technology 51 (2014) : 38 - 42

Extraction and Quality Evaluation of Yellowfin Tuna Bone Powder

L. Narasimha Murthy[1]*, B. Madhusudana Rao[1], K. K. Asha[2] and M. M. Prasad[1]

[1] *Research Centre of Central Institute of Fisheries Technology, Andhra University P. O., Visakhapatnam - 530 003, India*

[2] *Central Institute of Fisheries Technology, P. O. Mastyapuri, Cochin - 682 029, India*

Abstract

Commercial processing of tuna either as canned tuna or tuna loins generates considerable quantities of waste and a sizeable quantity of this waste constitutes bones. Yellowfin tuna bone was prepared by three methods *viz*., by using 0.5% KOH, 1% KOH and 0.5% NaOH and the proximate analysis, elemental composition and fatty acid composition were evaluated in comparison to control prepared without the addition of alkali. The powder was found rich in calcium (19 400 to 26 300 mg 100 g^{-1}) and phosphorus (7797 to 8291 mg 100 g^{-1}) with calcium-phosphorus ratio ranging between 2.5 and 3.3:1. The proportion of polyunsaturated fatty acids (PUFA), particularly, docosahexaenoic acid (DHA) content was distinctly higher in tuna bone powder prepared after boiling in 0.5% KOH. Palmitic acid, oleic acid and DHA were the common saturated fatty acid, monounsaturated fatty acid and polyunsaturated fatty acid respectively. Heavy metals like Cd and Hg were not detected in the developed bone powder.

Keywords: Yellowfin tuna, *Thunnus albacares*, bone powder, waste utilization

Received 06 July 2013; Revised 13 September 2013; Accepted 23 October 2013

* *E-mail: drlnmurthy@gmail.com*

Introduction

World over, tuna is one of the most widely consumed fish and is marketed as chilled, frozen, canned, smoked, breaded and battered, salted and dried forms. Commercial processing of tuna either as canned tuna or tuna loins generates significant quantities of waste. The yield of yellowfin tuna (*Thunnus albacares*) loins was 45% and the remaining 55% was processing 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. Nutrition is an important modifiable factor in the development and maintenance of bone mass and for the prevention and treatment of osteoporosis (Ilich & Kerstetter, 2000). Increased calcium intake results in increased bone mineral status in children (Dibba et al., 2000) and whole small bony fish are known to be rich sources of calcium (Larsen et al., 2000; Chattopadhyay et al., 2004). Bones of bigger fish like tuna have also been proposed as sources of calcium (Xavier et al., 2003; Gopal et al., 2008). The health benefits of ω-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are well established (Flick & Martin, 1992). EPA content in yellow fin tuna meat ranged from 5.6 to 5.9 g $100g^{-1}$ and DHA ranged from 47.6 to 53.4 g $100g^{-1}$ (Mumthaz et al., 2010). However, there is paucity of information on the complete beneficial effects of yellowfin tuna bones for human health. The present study was envisaged to elucidate the nutritional composition of yellowfin tuna bone powders and understand the effect of alkali treatment on the composition of tuna bone powder.

Materials and Methods

Yellowfin tuna bones were collected from a commercial tuna loins processing unit (EU approved plant, Visakhapatnam, Andhra Pradesh, India). Four different batches of yellowfin tuna bone powder (BP) were prepared. BP-0.5% KOH was prepared by boiling tuna bones in an aqueous solution of 0.5% KOH (w/v); quantity of water sufficient enough to completely submerge the bones. BP-0.5% NaOH was prepared by boiling tuna bones in 0.5% NaOH (w/v) and BP-1% KOH was prepared using 1% KOH (w/v). Bone powder prepared by boiling tuna bones in potable water was used as control (BP-control). Meat adhering to tuna bones was manually separated. Alkali treated bones were thoroughly washed to remove residual alkali. Washed tuna bones were dried and pulverised to a fine powder.

Freshly prepared tuna bone powders were analysed for moisture, protein, fat, ash, calcium, potassium, sodium and iron as per standard methods (AOAC,2000). Phosphorus was determined colorimetrically (Fiske & Subbarow, 1925). Fatty acids were analysed according to the method of AOAC (2000) using gas liquid chromatography (Varian CP 3800, USA). Mercury (Hg) 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 253.7nm. Cadmium (Cd), copper (Cu) and zinc (Zn) were estimated following AOAC (2000). Initially, the samples were digested with 7 ml of HNO_3 and 3 ml H_2O_2 for 60 min at 95^0C under pressure in microwave digester (CEM Corporation, North Carolina, USA). Digested samples were analysed using atomic absorption spectrophotometer (Varian Spectra AA 220, Australia).

Data was subjected to statistical analyses as per standard methods (Snedecor & Cochran, 1967).

Results and Discussion

In yellowfin tuna, as in most big fish, meat adheres very tightly to the bone and its separation is a challenge. The meat adhering to tuna bones was separated with relative ease in all the alkali treated bones suggesting that 0.5% KOH or 0.5% NaOH was sufficient instead of employing 1% KOH.

The proximate and mineral composition of alkali treated and control yellowfin tuna bone powders were analyzed and the results are presented in Table 1. All the tuna bone powders were rich in protein and fat. Crude protein content ranged between 20.5 and 21.76%. The crude protein content of BP-0.5% KOH and BP-1% KOH was relatively lower than BP-0.5 NaOH and BP-control, possibly due to better deproteinisation efficacy of KOH. Fat content of the tuna bone powders ranged between 13.39 and 17.26%. The fat of tuna meat is rich in beneficial ω-3 fatty acids *viz.,* EPA and DHA (Mumthaz et al., 2010) and the same can be assumed of the fat in tuna bone powder. However, high fat content makes tuna bone powders extremely susceptible to oxidative rancidity and hence adequate precaution is vital for facilitating extension of shelf life. Further studies on vacuum packaging or addition of antioxidants are needed. It is pertinent to note that an antioxidant peptide has been isolated from tuna backbone protein (Je et al., 2007). The total ash content of tuna bone powders ranged from 48.14 to 54.31%. The ash content of BP-1 KOH was distinctly higher than other treatments and is in accordance with earlier reports (Xavier et al., 2003) and the use of alkali at lower concentrations seem beneficial. Toppe et al. (2007) also observed that marine fatty fishes have a higher crude fat content and lower protein content in their bones. Liaset et al. (2003) reported that salmon bone powder had a protein content of 33% and lipid content of 9.6%.

Table 1. Proximate and mineral composition of different yellowfin bone powders

	Yellowfin Tuna Bone Powders			
	BP-0.5% KOH	BP-0.5% NaOH	BP-1% KOH	BP-Control
Moisture, %	6.44 ± 0.03	6.95 ± -0.08	6.19 ± -0.06	6.59 ± -0.45
Crude protein, %	20.6 ± -0.39	21.76 ± 0.24	20.455 ± 0.19	21.75 ± 0.24
Crude fat, %	17.26 ± 0.36	13.39 ± 0.31	14.32 ± 0.15	13.83 ± 0.17
Ash, %	48.14 ± 0.01	49.94 ± 0.25	54.31 ± 0.19	47.71 ± 0.50
Ca, mg 100 g^{-1}	22936 ± 2.83	26300 ± 3.30	22983 ± 3.10	19400 ± 5.30
P, mg 100 g^{-1}	8291.54 ± 105.51	7898.22 ± 48.63	7871.4 ± +60.46	7797 ± 91.04
Fe, ppm	46.75 ± 0.81	45.12 ± 0.29	41.91 ± 0.75	41.42 ± 1.56
Na, mg 100 g^{-1}	372.5 ± 37.48	609 ± 77.78	275 ± 9.89	518 ± 6.90
K, mg 100 g^{-1}	360 ± 16.97	195.5 ± 3.54	447 ± 1.41	427 ± 18.38

Values expressed as Mean ± SD, n = 3

Table 2. Fatty acid composition of different yellowfin bone powders

Fatty Acid		Yellowfin Tuna Bone Powder			
Number	Name	BP-0.5% KOH	BP-0.5% NaOH	BP-1% KOH	BP-Control
C12	Lauric acid	0.032	0.038	0.0428	0.0831
C13	Tridecyclic acid	0.042	0.038	0.0428	0.05
C14	Myristic acid	3.921	3.507	4.47	4.802
C15	Pentadecanoic acid	1.332	1.178	1.4	1.545
C16	Palmitic acid	28.131	24.981	30.476	33.333
C17	Heptadecanoic acid	2.6	2.317	2.785	2.758
C18	Stearic acid	0.053	10.75	0.057	12.596
C20	Arachid acid	0.983	0.785	1.128	1.097
C22	Behenic acid	0.645	0.544	0.671	0.698
C14:1	Myristoleic acid	0.095	0.076	0.1	0.1
C16:1	Palmitoleic acid	6.034	5.077	6.569	7.162
C18:1 n9	Oleic acid	21.558	19.904	24.92	24.926
C20:1 n9	Gadoleic acid	2.6	2.418	0.286	2.792
C24:1 n9	Nervonic acid	1.353	1.203	1.471	1.446
C18:2 n6	Linoleic acid	1.733	1.443	1.842	1.147
C18:3 n6	Gamma linolenic acid	0.021	0.203	0.229	0.15
C18:3 n3	Alpha linolenic acid	0.824	0.747	0.914	0.881
C20:4	Arachidonic acid	3.276	2.545	0.276	0
C20:5 n3	Eicosapentaenoic acid	0.053	3.773	4.013	1.014
C22:6 n3	Docosahexaenoic acid	24.717	18.473	18.308	3.423

Values expressed as Percentage FA / Total FA

Approximately, 80–90% of bone mineral content comprised of calcium and phosphorus. All the tuna bone powders were rich in calcium (19400 to 26300 mg 100 g^{-1}) and phosphorus (7797 to 8291 mg 100 g^{-1}) with calcium-phosphorus ratio ranging between 2.5 to 3.3:1. Fish bone contains proper balance of calcium and phosphorus, is rich in dicalcium phosphate and can be used as calcium food supplement (Chatterjee & Shinde 1995; Sultanbawa & Aksnes 2006). Tuna bone powders had appreciable quantities of potassium and iron. Potassium content in tuna bone powder under study was high when compared to hoki bone powder and salmon bone powder (Liaset et al., 2003). Khasim et al. (2010) suggested popularization of potassium enriched fish products in human diet as a means to address hypertension problem.

Though all the tuna bone powders were rich in fat, the fatty acid composition in the final products varied with different treatments. Alkali treated tuna bone powders *viz.,* BP-0.5% KOH (62.26%), BP-0.5% NaOH (55.86%) and BP-1% KOH (58.93%) had higher unsaturated fatty acids. PUFA content was distinctly higher in BP-0.5% KOH (30.63%) than in BP-0.5% NaOH (27.18%) and BP-1% KOH (25.58%). PUFA content was very low (6.61%) in BP-Control (Fig. 1).

The proportion of individual fatty acids in different tuna bone powders is presented in Table 2. Palmitic acid (C16) was the most abundant saturated fatty acid, oleic acid (C18:1 n9) was the most common monounsaturated fatty acid and docosahexaenoic acid (C22:6 n3) was the principal polyunsaturated fatty acid in all the tuna bone powders. DHA content was distinctly higher in BP-0.5 KOH (24.7%) than in BP-0.5% NaOH (18.5%) and BP-1% KOH (18.3%). PUFA content was very low (3.4) in BP-control. Similar trend of high palmitic, oleic and

Table 3. Heavy metals content in different yellowfin bone powders

Bone Powder	Cd (ppm)	Cu (ppm)	Zn (ppm)	Hg (ppm)
BP-0.5% KOH	ND*	0.48	7.72	ND
BP-0.5% NaOH	ND	0.50	5.81	ND
BP-1% KOH	ND	0.70	4.99	ND
BP-Control	ND	0.72	5.24	ND

* Not detected

DHA content was observed in smoked tuna (Yathavamoorthi et al., 2010). Palmitic acid was reported as the major saturated fatty acid in yellowfin tuna meat (Mumtaz et al., 2010) and oleic acid was reported as the major monounsaturated fatty acid in white meat of tuna (Gopakumar, 1997). PUFAs play an essential role in human health and nutrition, as they can reduce the risk of coronary disease, prevent certain cancers, and improve immune function.

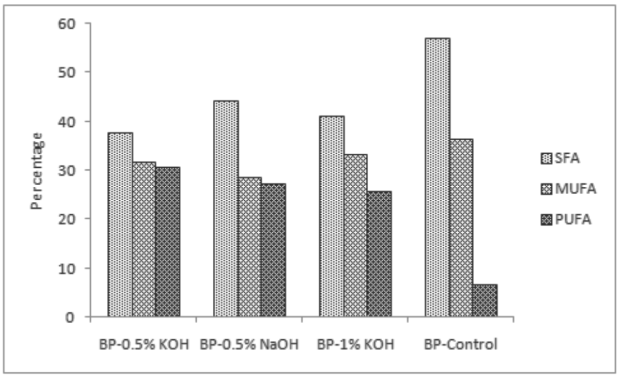

Fig. 1. Proportion of different fatty acids in yellowfin tuna bone powders

Bigger fish tend to accumulate toxic metals in their bones and it is of absolute importance that the content of undesirable metals is low. Cd, Hg, Cu and Zn levels in tuna bone powders are presented in Table 3. Cd and Hg were not detected in any of the bone powders but Cu and Zn were detected in all the tuna bone powders. Cu was found in higher quantity in control sample, where as higher quantity of Zn was observed in 0.5% KOH treated sample. However in all the samples, the level of heavy metals was below the maximum permissible limit.

Study on the nutritional composition of yellowfin tuna bone powders showed that tuna bone powder was rich in protein, beneficial fat, calcium and phosphorus and can be used as fortifying agent. Further studies on stability and shell life of the product have to be undertaken before commercialization efforts can be made.

Acknowledgements

We express our thanks to Dr T.K. Srinivasa Gopal, Director, CIFT, Cochin for the encouragement and Dr P.T. Lakshmanan, Head, B&N Division, CIFT for his support. Technical assistance rendered by K.V.S.S.S.K. Harnath, B.K. Panda, A.K. Panigrahi, N. Venkata Rao, P. Radha Krishna, Prasanna Kumar and S.N.Disriis gratefully acknowledged.

References

AOAC (2000) Official Methods of Analysis. 17th edn., Association of Official Analytical Chemists, Washington, DC, USA

Chantachum, S., Benjakul, S. andSriwirat, N. (2000) Separation and quality of fish oil from precooked and non-precooked tuna heads. Food Chem. 69: 289-94

Chatterjee, M.N. and Shinde, R. (1995) Text Book of Medical Biochemistry. Jaypee Brothers Medical Publishers, New Delhi

Chattopadhyay, A.K., Rao, B.M. and Gupta, S. (2004) A simple process for the utilization of seasonal surplus catches of small bony fish as edible fish powder. Fish. Technol. 41: 117-120

Dibba, B., Prentice, A., Ceesay, M., Stirling, D.M., Tim J Cole, T.J. and Poskitt, M.E.J. (2000) Effect of calcium supplementation on bone mineral accretion in Gambian children accustomed to a low-calcium diet. Am. J. Clin. Nutr. 71: 544-549

EC 1881 (2006) Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. Official J. European Union. L 364/19 p

Fiske C.H. and Subba Row, Y. (1925) The colorimetric determination of phosphorus. J. Biol. Chem. 66: 375-400

Flick, J.R. and Martin, R.K. (1992) The implications of omega 3 fatty acids in human health. In: Advances in Seafood Biochemistry Composition and Quality, pp 69-91, Technomic Publishing Co, Inc., Basel, Switzerland

Gopakumar, K. (1997) Biochemical Composition of Indian Food Fish. 44 p, Central Institute of Fisheries Technology, Cochin

Gopal, T.K.S., Ravishankar, C.N., Bindu, J. and Ashok Kumar, K. (2008) Processing and product development from tuna. In: Harvest and Post-harvest Technology for Tuna (Joseph J., Boopendranath, M.R., Sankar, T.V., Jeeva, J.C. and Kumar, R., Eds), pp 104-127, Society of Fisheries Technologists (India), Cochin

Ilich, Z.J. and Kerstetter, J.K. (2000) Nutrition in bone health revisited : a story beyond calcium. J. Am. Coll.Nutr. 19: 715-737

Je, J.Y., Qian, Z.J., Byun, H.G. and Kim, S.K. (2007) Purification and characterization of an antioxidant peptide obtained from tuna backbone protein by enzymatic hydrolysis. ProcessBiochem. 42: 840-846

Khasim, D.I., Rao, B.M. and Chattopadhyay, A.K. (2010) Potassium supplemented fish products. In: Coastal Fishery Resources of India: Conservation and Sustainable Utilisation (Meenakumari, B., Boopendranath, M.R., Edwin, L., Sankar, T.v., Gopal, N. And Ninan, G., Eds), pp 679-683, Society of Fisheries Technologists (India), Cochin.

Larsen, T., Thilsted, S.H., Katja Kongsbak, K. and Hansen, M. (2000) Whole small fish as a rich calcium source. Br. J. Nutr. 83: 191-196

Liaset, B., Julshamn, K. and Espe, M. (2003) Chemical composition and theoretical nutritional evaluation of the produced fractions from enzymic hydrolysis of salmon frames with Protamex. Process Biochem. 38: 1747-1759

Mumthaz, V.R., Yathavamoorthi, R., Anju, T., Remya, J., Suseela, M. and Gopal, T.K.S. (2010) A comparative evaluation of the biochemical composition of three tuna species. In: Coastal Fishery Resources of India: Conservation and Sustainable Utilization (Meenakumari, B., Boopendranath, M.R., Edwin, L., Sankar, T.V., Gopal, N. and Ninan, G., Eds), pp 742-753, Society of Fisheries Technologists (India), Cochin

Snedecor, W.G. and Cochran, W.G. (1967) Statistical Methods. 6th edn., Oxford & IBH publishing Co., Calcutta, India

Sultanbawa, Y. and Aksnes, A. (2006) Tuna processing waste – an unexploited resource. Infofish International. 3: 37-40

Toppe J., Albrektsen S., Hope B. andAksnes A. (2007) Chemical composition, mineral content and amino acid and lipid profiles in bones from various fish species. Biochem Physiol. B Biochem. Mol. Biol. 146: 395-401

Wongsakul, S., Prasertsan, P., Bornscheuer, U.T., Kittikun, A.H. (2003) Synthesis of 2-monoglycerides by alcoholysis of palm oil and tuna oil using immobilized lipases. Eur. J. Lipid Sci. Tech. 105: 68-73

Xavier, K.A.M., Prabhu, U.A., Nair, K.G.R. and Mathew, P.T. (2003) Utilization of fish bone as calcium supplement. In: Seafood Safety (Surendran, P.K., Mathew, P.T., Thampuran, N., Nambiar, V.N., Joseph, J., Boopendranath, M.R., Lakshmanan, P.T., Nair, P.G.V., Eds), pp 58-61, Society of Fisheries Technologists (India), Cochin

Yathavamoorthi, R., Mumthaz, V.R., Jinu, M., Bindu, J., Suseela, M. and Gopal, T.K.S. (2010) A comparative study on Lakshadweep masmin and improved masmin. In: Coastal Fishery Resources of India: Conservation and Sustainable Utilization (Meenakumari, B., Boopendranath, M.R., Edwin, L., Sankar, T.V., Gopal, N. and Ninan, G., Eds), pp 703-714, Society of Fisheries Technologists (India), Cochin