Effects of microwave power on the biochemical quality of dark and white muscle of tuna during microwave vacuum heating

Viji P.[1], Deepika K.[1,2], Sireesha S.[1,2], Jesmi Debbarma[1], and Madhusudana Rao B.[1]*

[1]Visakhapatnam Research Centre of ICAR-CIFT, Visakhapatnam - 03
[2]Andhra University, Visakhapatnam - 03
* pankyammaviji@gmail.com

Microwave processing has been receiving great attention by the food processors and researchers worldwide in the recent years due to its higher heat transfer efficiency. Microwave heating is superior to conventional heating methods due to higher energy efficiency, shorter processing time and retention of nutritional components. Microwave vacuum heating is a hybrid technology, making use of high heat transfer property of microwave and controlled temperature rise aided by vacuum. Microwave vacuum drying has been successfully demonstrated for drying of various food products including seafood. Superior product quality can be achieved by microwave vacuum drying in terms of sensory attributes and rehydration properties (Viji et al., 2019). Like any other thermal processing method, drying induces many physicochemical changes in the fish during dehydration and it is necessary to evaluate and standardize the process conditions to minimize those changes. Eastern little tuna (*Euthynnus affinis*) is an abundantly caught tuna species in Indian coast. It has good demand in the Indian market and is mostly consumed locally as fresh, dried or pickled products. Fishes belonging to the group tuna are characterized by high content of dark muscle. The present research was aimed to evaluate the physico- chemical changes to dark and white meat of Eastern little tuna during microwave vacuum heating.

Fresh Eastern little tuna (average weight 1 kg) procured from Visakhapatnam fishing harbour was brought to the laboratory in iced condition. After washing the tuna thoroughly, skinless fillets were prepared and the fillet was cut into uniform chunks manually. The chunks were dehydrated using a laboratory model microwave vacuum oven (RagaTech, Pune, India) at different power (600 W -T1, 700 W -T2 and 800 W -T3) for 2 h. Proximate composition of tuna chunks dehydrated at different microwave power was analysed by AOAC method (AOAC 2000). The dark muscle and white meat of dehydrated tuna chunks were separated manually from each sample and packed in polythene pouch for further analysis. Solubility of dark and white muscle proteins was estimated by measuring salt soluble (SSN) and water soluble nitrogen (WSN) content (Winton and Winton, 1958; Ironside and Love, 1958). Lipid oxidation was measured by determining thiobarbituric acid reactive substances (TBARS) (Tarladgis, Watts and Youthan 1960) and the result was expressed as mg malonaldehyde/kg sample. The color of dark and white muscle was evaluated by measuring $L*$, $a*$ and $b*$ values of the

ground muscle using Hunter's colorimeter (ColorFlex EZ, Hunter Lab, USA).

Microwave power had a significant influence on the proximate parameters of tuna muscle. Moisture content of fresh fish muscle was (76.85)%, which was reduced to 60.76, 53.67 and (47.32)%, in tuna chunks dried at 600 W, 700 W and 800 W, respectively. Consequently, protein content increased from (19.63)% in fresh tuna to 33.02, 39.51, and (45.02)%, respectively in T1, T2 and T3 samples. The results indicate that increasing microwave power had significantly reduced the moisture content while increasing the percentage of protein and fat. Nearly 30% reduction in moisture was achieved by vacuum-microwave heating for 2 h at 800 W. Since, the fresh fish had a negligible level of ash, the processing parameters didn't pose an influence on ash content. Moisture removal during microwave drying is primarily dependent on the power of microwave applied. Many reports suggest that moisture removal increases with microwave power (Chahbani et al., 2018; Pankyamma et al., 2021).

Extractability of water soluble and salt soluble nitrogen fractions of dark and white muscle significantly decreased with increase in microwave power. White muscle registered higher loss of WSN and SSN compared to dark muscle. The observed loss in WSN and SSN could be attributed to the protein denaturation that occurred during microwave heating. Mostly, sarcoplasmic proteins contribute to water soluble fractions in fish. It has been proven that microwave treatments accelerate protein degradation by altering the tertiary structure (Dong et al., 2021).

Table1. Proximate composition of Tuna chunks

Sample/parameter	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
Fresh tuna	76.85±1.60^{d}	19.63±1.05^{a}	1.85±0.17^{a}	1.15±0.26^{a}
T1-600 W	60.76±1.11^{c}	33.02±1.12^{b}	2.89±0.19^{b}	1.86±0.59^{a}
T2-700 W	53.67±1.39^{b}	39.51±0.53^{b}	3.43±0.47^{c}	2.12±0.85^{b}
T3-800 W	47.32±1.28^{a}	45.02±0.44^{c}	3.88±0.34^{c}	2.46±0.78^{b}

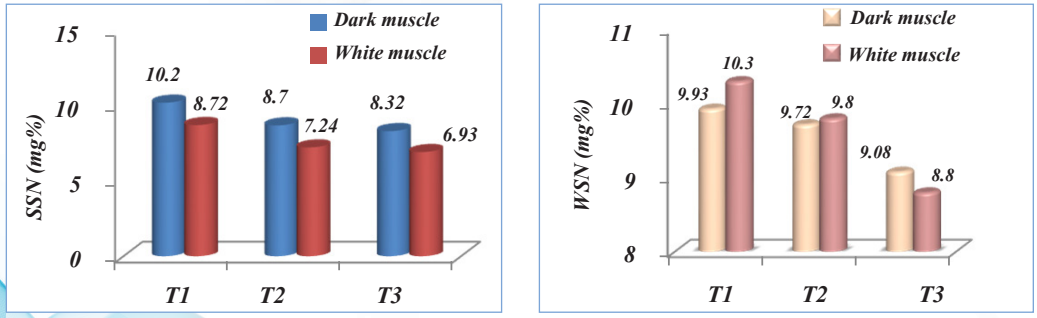

Fig. 1. Salt soluble and water soluble nitrogen content of the samples

Lightness of the muscles reduced with increase in power, but the redness value ($a*$) increased from 5.7 to 8.8 in dark muscle and 2.71 to 5.04 in white muscle on increasing microwave power level from 600-800 W. Rate of reduction in $L*$ value and the rate of increase in $a*$ value was higher with dark muscle compared to white muscle, which could be due to the presence of more myoglobin in dark muscle and its degradation during microwave heating. Lipid oxidation of both dark and white muscle increased significantly with increase in microwave power with higher values in dark muscle than white muscle. Researchers suggest that a high electromagnetic field separates fat cells from the muscle and hence, it becomes exposed to oxidation (Yarmand and Homayouni, 2009). So, with the increase of microwave power, more lipids get oxidized. Since the dark muscle of tuna is reported to have high lipid content than white muscle, the TBARS value of former (1.162-1.662 mg MDA/Kg sample) was significantly higher to that of later (0.771-0.889 mg MDA/Kg sample).

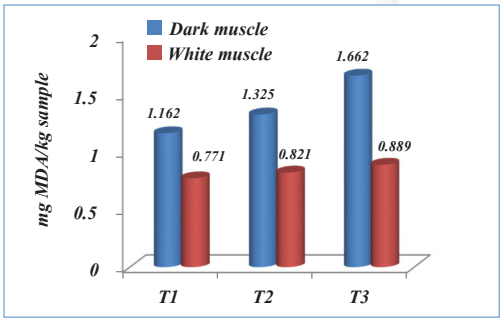

Fig. 2. TBARS values of dark and white muscles of Tuna after microwave heating

The study demonstrated that the dehydration rate increases with an increase in microwave power. Solubility of protein reduced when microwave power was increased from 600-800 W, and white muscle was more susceptible to protein denaturation during microwave heating compared to dark muscle. On the other hand, dark muscle lipids were more oxidized compared to those of white muscle with an increase in microwave power. The results of the study suggest that microwave heating can be employed for the rapid drying of seafood while the changes in protein and lipid qualities need to be addressed.

References

AOAC (2000). Official Methods of Analysis of the Association of Officials Analytical Chemists, (17th Ed). Association of Official Analytical Chemist, Washington D.C, U.S.A.

Chahbani, A., Fakhfakh, N., Balti, M.A., Mabrouk, M., El-Hatmi, H., Zouarib, N., and Kechaou, N. (2018). Microwave drying effects on drying kinetics, bioactive compounds and antioxidant activity of green peas (Pisum sativum L.). Food Bioscience, 25, 32–38.

Dong, X., Wang, J. and Raghavan, V. (2021). Impact of microwave processing on the secondary structure, in-vitro protein digestibility and allergenicity of shrimp (Litopenaeus vannamei) proteins. Food Chemistry, 337, Article e 127811.

Ironside, J.I.M. and Love, R.M. (1958). Studies on protein denaturation in frozen fish, biological

factors influencing the amount of soluble and insoluble protein present in the muscle of North Sea cod. Journal of the Science of Food and Agriculture, 9, 597–599.

Pankyamma, V., Rao, B.M., Debbarma, J. and Vijayakumar, P.P.N. (2021). Physicochemical, microstructural, and microbial qualities of dehydrated Tuna chunks: Effects of microwave power and drying methods. Journal of Fish Processing and Preservation, 45, Article e15426

Tarladgis, B.G., Watts, B.M. and Youthan, M.T. (1960). A distillation method for the quantitative determination of malonaldehyde in rancid foods. Journal of American Oil Chemists Society, 37, 44–52.

Viji, P., Shamuka Sai, K.S., Jesmi Debbarma, Dhiju Das P.H., Madhusudana Rao, B. and Ravishankar, C.N. (2019). Evaluation of physicochemical characteristics of microwave vacuum dried mackerel and inhibition of oxidation by essential oils. Journal of Food Science and Technology. 56, 1890-1898.

Winton, A.L. and Winton, K.B. (1958). The Analysis of Foods, London: John Wiley and Sons, PP 78-80.

Yarmand, M.S.,and Homayouni, A. (2009). Effect of microwave cooking on the microstructure and quality of meat in goat and lamb. Food Chemistry, 112, 782–785.