Incidence of Formalin in Fishes in Asian Countries: Some Solutions

Sunil Kumar Sahu, Naresh Kumar Mehta, Swapnarani Samantaray and R. K. Majumdar

Asia is the home of world aquaculture as it accounts for about 89 percent of world aquaculture production of fish for human consumption in the past two decades (FAO 2016). The major contributing factors in achieving this production are quality seed and feed availability, intensive husbandry practices, disease prophylaxis and cheap labor in Asian countries. But at the same time, development of post-harvest facilities for handling and processing this huge production has been outpaced by growth of aquaculture. From the production points, most of the fish is consumed within the countries where it is produced or exported to other countries.

Fish is a highly perishable food item and its quality deteriorates quickly. Hence, maintenance of the freshness and prime quality of fish remains one of the challenging tasks for fish producers, retailers, transporters, traders and processors worldwide. Formalin and sodium benzoate may be added to fresh fish to enhance its shelf-life considerably compared to existing short-term preservation methods such as icing and refrigeration. Formaldehyde, easily available and cheap, has antimicrobial properties and can extend the shelf life of fish and keep fish appearing fresh for longer time.

Fish is a highly perishable food item and its quality deteriorates quickly. Hence, maintenance of the freshness and prime quality of fish remains one of the challenging tasks for fish producers, retailers, transporters, traders and processors worldwide. Large production levels coupled with a deficit of post-harvest management infrastructure has led to the addition of chemicals like formalin and sodium benzoate to fresh fish to enhance its shelf-life considerably compared to existing short-term preservation methods such as icing and refrigeration. Fresh and prime-quality fish fetches high prices.

Formaldehyde, easily available and cheap, has antimicrobial properties and can extend the shelf life of fish and keep fish appearing fresh for longer time. Formalin is an aqueous solution of 37 percent formaldehyde. Formaldehyde is a very reactive chemical. The gaseous form is known as formaldehyde and liquid form as formalin. Formaldehyde is a colorless gas with a strong odor that is poisonous and flammable (WHO 2002).

A very small amount of formaldehyde exists naturally in fish, where it may form during ageing and deterioration. Many marine fish contain a considerable amount of trimethylamine N-oxide (TMAO) that degrades further into dimethylacetamide (DMA) and formaldehyde. Freshwater fish contain much less TMAO, so chances of formation of formaldehyde in freshwater fish is considerably less compared to marine fish. Beside natural

TABLE 1. Some incidences of formalin occurring in fish in Asian countries.

Lead author	*Year*	*Species*	*Formaldehyde content*	*Country*
Hossain	2008	Rohu	13.04 nmol/mg	Bangladesh
Yeasmin	2010	Rohu, catla	Qualitative about 0.5-1% of imported fish	Bangladesh
Uddin	2011	Rohu	Qualitative: about 70% of imported rohu	Bangladesh
Rahman	2012	Rohu, catla, shrimp	Qualitative: about 16.8% of imported fish	Bangladesh
Goon	2014	Rohu	Qualitative: 42-70% of imported rohu	Bangladesh
Hoque	2016	Rohu	Qualitative: about 25% of rohu	Bangladesh
Bhowmik	2017	Rohu	5.1–12.26 mg/kg	Bangladesh
Zailina	2013	Noodle fish	VNR	Hong Kong
Noordiana	2011	Finfish, shellfish	0.38 to 15.7 µg/g	Malaysia
Goon	2014	Cod, salmon, tuna	VNR	Malaysia
Goon	2014	Tuna, cod	VNR	Sri Lanka
Joshi	2015	Rohu, mrigal	0.393 to 2.328 µg/g	Nepal
Zhang	2015	Squid	15.1-146 mg/kg	China
Sanyal	2017	*Pangasius sp.*	VNR	India
Nayana	2018	Seer fish	0.704 mg % to 5.83 mg %	India

VNR=Value not reported.

TABLE 2. Various techniques available for formaldehyde detection.

Formaldehyde detection method	*Substances*	*Reference*
Spectrophotometric	Fish	Nash 1953, Castell and Smith 1973
Electrochemical biosensor	Fish	Herschkovitz et al. 2000, Aini *et al.* 2016
Biosensor	Cell-based sensor	Korpan *et al.* 2000
Conductometric enzyme biosensor	Aqueous solution	Dzadevych *et al.* 2001
SPMEGC- MS	Fish products	Bianchi *et al.* 2007
Chromatography (HPLC)	Squid products	Li *et al.* 2007
Colorimetry	-	Indang *et al.* 2009
Electronic nose technology	Seafood	Zhang *et al.* 2009
HPLC method	Food, feed, fish	Wahed *et al.* 2016, Bhowmik *et al.* 2017

formation of formaldehyde in fish by enzymatic reaction, other biochemical reactions such as oxidation of lipids may also lead to formaldehyde formation, although the amount of formaldehyde produced by those reactions does not cause any harm.

Toxic Effects in Humans

Formaldehyde is a metabolic product that forms in all cells during the metabolism of amino acids such as serine, glycine, methionine and choline. However, formaldehyde is a highly toxic substance, with human carcinogenicity. Chronic inhalation can result in respiratory symptoms and irritation of eyes, nose and throat (Zhang *et al*. 2009a).

Increased exposure of this chemical can increase the risk of cancers of the pharynx, nasopharynx and brain, as well as dermatitis and allergic reactions. In a study of industrial workers in the USA exposed to formaldehyde, a statistically significant excess of deaths from nasopharyngeal cancer was observed in comparison with the US national population, with statistically significant exposure-response relationships for peak exposure and cumulative exposure (Hauptmann *et al*. 2004). Ingestion of 30 mL of formalin can cause death in an adult human. Ingestion may cause corrosive injury to the gastrointestinal mucosa with nausea, vomiting, pain, bleeding and perforation. These injuries are most pronounced in the pharyngeal mucosa, epiglottis and esophagus. Systemic effects include metabolic acidosis, central nervous system depression and coma, respiratory distress, renal failure and associated cancer and tumor development (Wooster *et al*. 2005). Recently, an International Agency for Research on Cancer has classified formaldehyde as a Group 1 carcinogen for humans (IARC 2012). The US Environmental Protection Agency (EPA) proposed maximum daily dose reference (RfD) level of formaldehyde of 0.2 μg/g body weight (Wang *et al*. 2007). The Italian Ministry of Health proposed maximum formaldehyde level in the cod family of 60 μg/g and in crustaceans of 10 μg/g (Bianchi *et al*. 2007).

Pressure to maintain the utmost freshness puts pressure on producers, processors and marketers to take short-cuts. Reports of formalin detection in fish and shellfish indicate that incidence of formalin in fish is mainly observed in Asian countries. Of these, probably Bangladesh suffered most seriously. The Bangladesh Council of Scientific and Industrial Research has developed a formalin detection kit for fish for field use and quick detection of formalin contamination in fish. In the meantime, Bangladesh has enforced many policies and laws to control formalin contamination in fish and other food items but news of formalin contamination of fish continues to surface.

Reports of Formalin Presence in Fish

Pressure to maintain the utmost freshness puts pressure on producers, processors and marketers to take short-cuts. Reports of formalin detection in fish and shellfish are given in Table 1. Reports summarized in Table 1 indicate that incidence of formalin in fish is mainly observed in Asian countries. Of these, probably Bangladesh suffered most seriously. The Bangladesh Council of Scientific and Industrial Research (BCSIR) has developed a formalin detection kit for fish for field use and quick detection of formalin contamination in fish. In the meantime, Bangladesh has enforced many policies and laws to control formalin contamination in fish and other food items but news of formalin contamination of fish continues to surface. Now, reports of formalin in fish from north-east Indian states bordering Bangladesh such as Tripura, Manipur and Nagaland are also widespread as fish are imported to these areas from Bangladesh legally and illegally. Very recently, the Central Institute of Fisheries Technology (CIFT) located in Cochin, India also developed a formalin detection kit that will be available this year.

Different methods are available for detection and quantification of formaldehyde in fish and other foods (Table 2). The spectrophotometric method is the classic detection method and one that continues to be used in many laboratories for research and analysis purposes. The HPLC method is very sensitive and accurate but, to protect consumers, it is out of reach or too expensive. The availability of cheap and rapid detection methods in kit form would be a great help for common use.

Solutions to Prevent or Reduce Formalin Contamination of Fish

The following solutions may be effective to prevent or reduce formalin contamination in fish:

(CONTINUED ON PAGE 68)

Different methods are available for detection and quantification of formaldehyde in fish and other foods. The spectrophotometric method is the classic detection method and one that continues to be used in many laboratories for research and analysis purposes. The HPLC method is very sensitive and accurate but, to protect consumers, it is out of reach or too expensive. The availability of cheap and rapid detection methods in kit form would be a great help for common use.

Monitoring programs. Continuous monitoring by regulatory bodies in wet fish market to prevent such malpractices and contaminants. Responsibilities of regulatory bodies to create awareness among fish consumer, buyer and seller about formalin and its harmful effect on human health, therefore protect health of consumer as well as fish retailer and fish producer. For example, in Hong Kong, the government advised the public to choose fish that are fresh and avoid those with unusual smell and also avoid buying noodle fish that are stiff as addition of formaldehyde could stiffen flesh of fish (Zailina *et al*., 2013).

Food policies. Make new food policies to prevent such adulteration in fish, therefore protect food and nutritional losses. For example, Malaysian Food Regulation 1985 (in exercise of the powers conferred by section 34 of the Food Act 1985, 2006) establishes a maximum limit for formaldehyde in fish and fish products of 5 mg/kg. Very recently the Food Safety and Standards Authority of India (FSSAI) has proposed stringent punishment of fine of ~US$ 14,500 and imprisonment up to life for those adulterating foodstuffs. The regulator has also suggested creating a 'Food Safety and Nutrition Fund' to support promotional and outreach activities among food businesses and consumers.

Washing. Washing vegetables, fish and meat is common practice in households around the world before cooking food. If there is doubt of formalin in fish, wash with tap water or warm water for few minutes, because formaldehyde is volatile in nature and will readily dissolve in water. Warm water is much more effective than cool water at removing formalin (Bhowmik *et al*. 2016). However, complete removal not possible but the residue level will be reduced.

Storage of fish on ice. It is most advisable method for short-term preservation practice in fish processing industries where fresh fish is kept in ice storage before further processing. Formaldehyde is volatile in nature and it readily dissolves in ice meltwater. When melted water is replaced with new ice, some formalin is also removed from fish with melted water.

Cooking. During cooking temperature exceeds 100 C and the boiling point of formaldehyde is 101 C therefore a substantial quantity of formaldehyde is evaporated during cooking (Bechmann *et al*. 1998). The USEPA's Exposure Factors Handbook (USEPA 1997) has reported cooking the fish will result in weight (moisture and fat) loss which subsequently decreases the formaldehyde concentration in cooked fish.

Frying. Frying of food (vegetable, meat and fish) is also commonly practiced among households in the world. When fish is fried in oil, added formalin is evaporated and reduced to an acceptable limit due to its volatile nature at frying temperature (160-180 C) (Zailina *et al*. 2013; Bhowmik *et al*. 2016). Therefore, frying may be used to eliminate added formalin from fish for safe consumption.

Conclusion

Stringent policies for formalin mixing in fish should be in place so that consumer safety is considered. Awareness among the consumers should be disseminated widely by modern communication media at national and international levels. Quick and cheap detection techniques and harsh punishment for formalin adulteration should be implemented by national and international regulators.

Notes

Sunil Kumar Sahu, College of Fisheries, Central Agricultural University (Imphal), Tripura – 799210, India. smartsahu96@gmail.com

Naresh Kumar Mehta, Assistant Professor, Dept. of Fish Processing Technology & Engg., College of fisheries, Central Agricultural University (Imphal), Tripura – 799210, India. nareshfishco@gmail.com

Swapnarani Samantaray, College of Fisheries, Central Agricultural University (Imphal), Tripura – 799210, India. swapna73703@gmail.com

Ranendra Kumar Mjumdar, Head & Professor, Dept. of Fish Processing Technology & Eng., College of Fisheries, Central Agricultural University (Imphal), Tripura – 799210, India. drrkmcof@gmail.com

References

Aini, B., S. Siddiquee and K. Ampon. 2016. Development of formaldehyde biosensor for determination of formalin in fish samples; malabar red snapper (*Lutjanus malabaricus*) and longtail tuna (*Thunnus tonggol*). Biosensors 6:32.

Bechmann, I.E. 1998. Comparison of the Formaldehyde Content Found in Boiled and Raw Mince of Frozen Saithe using Different Analytical Methods. Lebensmittel-Wissenschaft und-Technologies 31:449-453.

Bhowmik, S., M. Begum and A.N. Alam. 2016. Seasonal variations of formaldehyde and risk assessment of marketed fish contaminated with formaldehyde: fish and food safety issue. Proceedings of 3rd AFSA Conference on Food Safety and Food Security. September 15 – 17, 2016. Bhubaneswar, India. Pages 1-5.

Bhowmik, S., M. Begum, M.A. Hossain, M. Rahman and A.N. Alam. 2017. Determination of formaldehyde in wet marketed fish by HPLC analysis: A negligible concern for fish and food safety in Bangladesh. The Egyptian Journal of Aquatic Research 43:245-248.

Bianchi, F., M. Careri, M. Musci and A. Mangia. 2007. Fish and food safety: Determination of formaldehyde in 12 fish species by SPME extraction and GC–MS analysis. Food Chemistry 100:1049-1053.

Dzyadevych, S.V., V.N. Arkhypova, Y.I. Korpan, V. Anna, A.P. Soldatkin, N. Jaffrezic-Renault and C. Martelet. 2001.

Conductometric formaldehyde sensitive biosensor with specifically adapted analytical characteristics. Analytica Chimica Acta 445:47-55.
FAO (Food and Agriculture Organization of the United Nations). 2016. The State of World Fisheries and Aquaculture. Department of Fisheries and Aquaculture, Rome, Italy.
Goon, S., M. Bipasha, M.S. Islam and M.B. Hossain. 2014. Fish Marketing Status with Formalin Treatment in Bangladesh. International Journal of Public Health Science 3:95-100.
Hauptmann, M., J.H. Lubin, P.A. Stewart, R.B. Hayes and A. Blair. 2004. Mortality from solid cancers among workers in formaldehyde industries. American Journal of Epidemiology 159:1117-1130.
Herschkovitz, Y., I. Eshkenazi, C.E. Campbell and J. Rishpon. 2000. An electrochemical biosensor for formaldehyde. Journal of electroanalytical chemistry 491:182-187.
Hoque, M.Z., M.S. Islam, M.I. Khalil and M.R. Bari. 2016. Formalin treated fish marketing and its impact on public health. International Journal of Academic Research and Development 1:7-12.
Hossain M.S., M.A. Rahman, T.K. Sharkar and H.M. Shahjalal. 2008. Formaldehyde content in the Rui Fish (*Labeo rohita*) in Bangladesh and effect of formaldehyde on lipid peroxidation in rat liver and intestinal tissues. Journal of Medicinal Science 8:405-409.
IARC (International Agency for Research on Cancer). 2012. Chemical agents and related occupations. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, France.
Indang, M.N., A.S. Abdulamir, A.A. Bakar, A.B. Salleh, Y.H. Lee and Y.N. Azah. 2009. A review: Methods of determination of health-endangering formaldehyde in diet. Research Journal of Pharmacology 3:31-47.
Joshi, R., R. Bhatta, P.N. Paudel and B.K. Kafle. 2015. Formaldehyde content of selected fish from the wet markets of Kathmandu valley markets. International Food Research Journal 22:1434-1437.
Korpan, Y.I., M.V. Gonchar, A.A. Sibirny, C. Martelet, A.V. El'skaya, T.D. Gibson and A.P. Soldatkin. 2000. Development of highly selective and stable potentiometric sensors for formaldehyde determination. Biosensors and Bioelectronics 15:77-83.
Li, J.R., J.L. Zhu and L.F. Ye. 2007. Determination of formaldehyde in squid by high-performance liquid chromatography. Asia Pacific Journal of Clinical Nutrition 16:127-130.
Malaysian Food Regulations. 1985. *In*: Food Act 1983 & Regulations. International Law Book Services. Malaysia.
Nash, T. 1953. The colorimetric estimation of formaldehyde by means of the Hantzsch Reaction. Biochemical Journal 55:416-421.
Nayana A. and S. Sabu. 2018. Incidence of formaldehyde residues in fresh seer fish (*Scomberomorus guttatus*) collected from Ernakulum fish market. Indian Journal of Scientific Research 19:56-61.
Noordiana, N., A.B. Fatimah and Y.C.B. Farhana. 2011. Formaldehyde content and quality characteristics of selected fish and seafood from wet markets. International Food Research Journal 18:125-136.
Rahman, M.M., S. Ahmed, M.M. Hosen and A.K. Talukder. 2012. Detection of formalin and quality characteristics of selected fish from wet markets at Sylhet city in Bangladesh. Bangladesh Research Publications Journal 7:161-169.
Sanyal, S., K. Sinha, S. Saha and S. Banerjee. 2017. Formalin in fish trading: an inefficient practice for sustaining fish quality. Archives of Polish Fisheries 25:43-50.
Uddin, R., M.I. Wahid, T. Jasmeen, N.H. Huda and K.B. Sutradhar. 2011. Detection of formalin in fish samples collected from Dhaka City, Bangladesh. Stamford Journal of Pharmaceutical Sciences 4:49-52.
USEPA (United State Environmental Protection Agency). 1997. Exposure Factors Handbook. National Center for Environmental Assessment Office of Research and Development. USA.
Wahed, P., M.A. Razzaq, S. Dharmapuri and M. Corrales. 2016. Determination of formaldehyde in food and feed by an in-house validated HPLC method. Food Chemistry 202:476-83.
Wang, S., X. Cui and G. Fang. 2007. Rapid determination of formaldehyde and sulphur dioxide in food products and Chinese herbals. Food Chemistry 103:1487-1493.
Wooster, G.A., C.M. Martinez, P.R. Bowser and D.S. O'Hara. 2005. Human health risks associated with formalin treatments used in aquaculture: initial study. North American Journal of Aquaculture 67:111-113.
WHO (World Health Organization). 2002. Formaldehyde. Concise International Chemical Assessment, Document 40, Geneva, Switzerland.
Yeasmin, T., M.S. Reza, M.N.A. Khan, F.H. Shikha and M. Kamal. 2010. Present status of marketing of formalin treated fishes in domestic markets at Mymensingh district in Bangladesh. International Journal of Biological Research 1:21-24.
Zailina, H. and A.B. Fatimah. 2013. Health risk assessment of adults consuming commercial fish contaminated with formaldehyde. Food and Public Health 3:52-58.
Zhang, L., C. Steinmaus, D.A. Eastmond, X.K. Xin and M.T. Smith. 2009a. Formaldehyde exposure and leukemia: a new meta-analysis and potential mechanisms. Mutation Research/ Reviews in Mutation Research 681:150-168.
Zhang, S., C. Xe, Z. Bai, M. Hub, H. Li and D. Zeng. 2009. Spoiling and formaldehyde-containing detections in octopus with an E-nose. Food Chemistry 113:1346-1350.
Zhang, X., X.S. Shen, Y.H. Hui, C. Kong, Y. Wang, B. Feng and D. Mei. 2015. Studies on the Determination of Formaldehyde in Squid and Bummalo. Journal of Advanced Engineering Research 46:20-22.

STRINGENT POLICIES FOR FORMALIN MIXING IN FISH SHOULD BE IN PLACE SO THAT CONSUMER SAFETY IS CONSIDERED. AWARENESS AMONG THE CONSUMERS SHOULD BE DISSEMINATED WIDELY BY MODERN COMMUNICATION MEDIA AT NATIONAL AND INTERNATIONAL LEVELS. QUICK AND CHEAP DETECTION TECHNIQUES AND HARSH PUNISHMENT FOR FORMALIN ADULTERATION SHOULD BE IMPLEMENTED BY NATIONAL AND INTERNATIONAL REGULATORS.