Determination of Formaldehyde Levels in Fish Samples Collected from different Wet Markets of Birbhum, West Bengal, India

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Abstract- The increasing use of chemical preservatives in food products, particularly in perishable items like fish, has raised significant concerns regarding public health and safety. The presence of formaldehyde in food, particularly in fish, is a growing public health concern due to its toxic, irritant, and carcinogenic properties. The present study was conducted to assess the level of formaldehyde in various fish species collected from multiple wet markets across four different markets in the Birbhum district of West Bengal, namely Dubrajpur, Chinpai, Kachujore, and Suri. Three fish species *Labeo rohita*, *Labeo catla*, and *Dendrobranchiates* were analyzed using UV-Vis spectrophotometry at 415 nm after extraction and derivatization with Nash reagent. The results revealed that the formaldehyde content ranged from 0.052 µg/g to 0.437 µg/g. The highest concentration was found in prawn from Kachujore bazar, while the lowest was observed in rohu from Chinpai bazar. This study serves as a small yet meaningful step toward highlighting the risks associated with unsafe food handling and the need for stricter monitoring and regulation. The study emphasizes the need for routine monitoring, better preservation practices, and consumer awareness to minimize exposure to potentially harmful substances in food.

Keywords: Formaldehyde, preservation, *Labeo rohita*, *Labeo catla, Dendrobranchiates.*

INTRODUCTION

The illegal use of Formaldehyde as a preservative in fish has become an emerging food safety issue in various parts of India. Formaldehyde, being a toxic and potentially carcinogenic compound, poses serious health risks when consumed through contaminated food. While several studies have been conducted to detect Formaldehyde in seafood products, these investigations are often concentrated in coastal or metropolitan areas such as Mumbai, Chennai, or Kochi. There is a noticeable lack of scientific research focusing on inland districts like Birbhum in West Bengal, where fish consumption is equally significant, and monitoring mechanisms are relatively weaker. Moreover, most of the existing studies utilize advanced analytical techniques such as Gas Chromatography–Mass Spectrometry (GC-MS) or High- Performance Liquid Chromatography (HPLC) for detection. Although these methods offer high precision, they require expensive instrumentation, skilled personnel, and complex sample preparation making them less practical for routine testing in resource-limited settings like rural West Bengal.

With the chemical formula for Formaldehyde, the most basic aldehyde is a compound made up of hydrogen, oxygen, and carbon. CH2O. Formaldehyde is widely used as a preservative in various industries, including food, cosmetics, and laboratory settings. It is effective in increasing shelf life and protecting against microbial spoilage (1). However, its use as a food preservative is legally prohibited in most countries due to its detrimental effects on human health (3). The detection of chemically added Formaldehyde may be hampered by the fact that

Formaldehyde is a naturally occurring byproduct of normal metabolism in many animal and plant species (1). According to Nowshad et al., the naturally occurring Formaldehyde level of various foods varies, with fruits and vegetables having up to 58.3 and 40.6 ppm, respectively. However, some research has discovered elevated amounts of Formaldehyde in imported fish samples, which raises questions over its illicit use as a preservation (2). While Formaldehyde remains a key fixative reagent in laboratory settings, particularly for preserving cadaveric specimens and tissues (4). There are growing concerns about its potential health risks. Alternative fixatives have been developed to replace Formalin, but studies show that Formalin still provides the highest histomorphology quality for tissue examination in surgical pathology (3). The use of Formaldehyde as a preservative requires careful consideration of its benefits and risks, with ongoing research focusing on safer alternatives and improved detection methods.

Formaldehyde contamination in fish samples is a significant concern for human health and food safety. Studies have shown that Formaldehyde is often used as a preservative by fishermen and merchants to prolong the shelf life of fish during transportation and sales (2). However, this practice poses serious health risks to consumers. In some fish species, Formaldehyde can also accumulate naturally during frozen storage due to enzymatic activity. The enzyme trimethylamine oxide aldolase (TMAOase) has been found to cause Formaldehyde accumulation in gadiform fish species during frozen storage (4). This natural process can lead to protein in solubilization and quality deterioration in frozen fish products. While Formaldehyde use as a preservative is problematic, it's important to note that some preservation methods may be necessary for scientific studies. For instance, Formalin-Ethanol preservation has been shown to have minimal effects on carbon and nitrogen isotopic signatures in fish muscle tissue, making it potentially suitable for certain ecological applications (2). However, alternative preservation methods, such as salt preservation, may be preferable as they cause even smaller isotopic shifts. Overall, the introduction of Formaldehyde in fish samples, whether through artificial preservation or natural processes, remains a complex issue with implications for both food safety and scientific research.

Formaldehyde's Chemical Characteristics

An extremely reactive and adaptable chemical compound, Formaldehyde (HCHO) has major industrial and environmental significance. It is an important industrial chemical that is utilized in many different products, such as those for the home, business, aviation, pharmaceutical, and automobile industries (5). HCHO is an essential step in the photochemical breakdown of methane and non-methane volatile organic compounds (NMVOCs) in the atmosphere because of its reactivity (6). Fascinatingly, Formaldehyde contributes to atmospheric chemistry in addition to being a prevalent indoor air contaminant. HCHO concentrations in isolated regions, such as Antarctica, exhibit seasonal and diurnal fluctuations, ranging from values below detection limits to 0.7 ppbv during the summer (7). This suggests more intricate atmospheric processes and deviates from previous predictions of the photochemical model. In forest environments, isoprene is a major precursor, contributing up to 82% of the calculated midday HCHO production rate (9).

Formaldehyde's chemical characteristics make it both a valuable industrial compound and a significant environmental concern. Its presence in various environments, from indoor spaces to remote Antarctic regions, highlights the need for effective detection and mitigation strategies. The development of advanced sensors (5) and novel detection methods (6). demonstrates ongoing efforts to address these challenges and better understand Formaldehyde's role in atmospheric chemistry and human health.

Formaldehyde as a Preservative and Natural Occurrence in Fish

Formaldehyde in fish is an escalating concern due to its misuse as a preservative and its natural occurrence during storage and degradation. In certain regions, Formaldehyde is illegally used to extend the shelf life of fish, posing significant health risks to consumers (7). This practice is particularly alarming because Formaldehyde is a known carcinogen, and its presence in food products is strictly regulated in many countries. However, fish may naturally contain Formaldehyde due to microbial and enzymatic activity during storage and breakdown (10). Because it becomes difficult to distinguish between endogenously produced Formaldehyde and that which is purposefully added, this natural development makes it more difficult to detect and regulate Formaldehyde in fish. Even naturally occurring forms of Formaldehyde can raise overall exposure levels; therefore, their presence does not eliminate the health hazards. The issue is further compounded by the fact that some fish vendors are fined for the presence of Formaldehyde in their products, even when it occurs naturally. This situation highlights the need for more accurate and reliable methods for detecting and quantifying Formaldehyde in fish, as well as greater awareness among both vendors and consumers about the sources and risks of Formaldehyde contamination. Enforcement of regulations becomes difficult when natural processes contribute to the presence of the chemical, necessitating a nuanced approach that considers both intentional and unintentional contamination. Clear guidelines and educational initiatives are essential to ensure fair treatment of vendors and protection of public health.

The detection of Formaldehyde, whether natural or artificial, requires sophisticated analytical techniques such as spectrophotometry and High-Performance Liquid Chromatography (HPLC). These methods can accurately measure the concentration of Formaldehyde in fish tissues, allowing for a more precise assessment of potential health risks. Research into the factors that influence natural Formaldehyde formation, such as storage temperature, fish species, and handling practices, is crucial for developing strategies to minimize its occurrence. By understanding the complex interplay of these factors, stakeholders can implement more effective measures to safeguard the quality and safety of fish products.

Ill Effects of Various Level of Formaldehyde in Human Body

Exposure to Formaldehyde has been linked to a number of detrimental health impacts in people, from severe irritation to possible cancer. Studies have shown that Formaldehyde can disrupt hematopoietic function and produce leukemia-related chromosome changes in exposed workers. In a study of 94 workers in China, those exposed to Formaldehyde exhibited significantly lowered peripheral blood cell counts and elevated leukemia-specific chromosome changes in myeloid blood progenitor cells, suggesting Formaldehyde's potential to induce leukemia (8). Exposure to Formaldehyde concentrations higher than 66 $\mu g/m^3$ has been linked to increased levels of malondialdehyde-deoxyguanosine adducts (M1-dG), a biomarker of oxidative stress and lipid peroxidation, particularly in nonsmokers (9).

This suggests that exposure to Formaldehyde may cause oxidative damage within cells. Formaldehyde concentrations in indoor environments have been observed in a variety of situations, including residences and workplaces, and range from 5.86 to 47.7 $\mu g/m^3$. These levels have been associated with non-carcinogenic risks above the threshold limit (HQ > 1) and unacceptable carcinogenic risks (>10−4) (10). Genotoxic effects have been observed in workers exposed to Formaldehyde, even at levels below the recommended exposure limits. A study of 80 workers in Portugal found significantly higher frequencies of micronuclei in peripheral blood lymphocytes and epithelial cells in exposed groups compared to controls, with a moderate positive correlation between duration of exposure and micronucleus frequency (11). Formaldehyde exposure, even at relatively low levels, can have significant adverse effects on human health, including genotoxicity, oxidative stress, and potential carcinogenicity. The evidence suggests that current exposure limits may not be sufficiently protective, highlighting the need for more stringent regulations and improved risk assessment processes.

Toxic Effects of Consuming Formaldehyde-Contaminated Fish on the Human Brain and Blood

Formaldehyde exposure through contaminated fish consumption can have significant toxic effects on the human brain and blood. Studies have shown that Formaldehyde is a known air toxic associated with cancer and lung disease (25). direct research on Formaldehyde- contaminated fish is limited; insights can be drawn from related studies on mercury and other contaminants in fish. Formaldehyde exposure has been found to alter microRNA expression profiles in human lung cells, potentially disrupting signaling pathways associated with cancer, inflammatory response, and endocrine system regulation **(**15). This suggests that Formaldehyde could have wide- ranging effects on various biological processes. In the context of fish consumption, it's important to note that fish can accumulate various contaminants, including heavy metals like mercury, which has known neurotoxic effects (13). The blood-brain barrier and growing central nervous system is especially susceptible to environmental pollutants (17). Studies on methylmercury (MeHg) contamination in fish have demonstrated that exposure can cause neurological development impairment in babies and children as well as damage to the adult nervous system, albeit these findings are not exclusive to Formaldehyde (18). Fetal growth and infant development during the first two years of life may be impacted by low-level MeHg exposure (19). These results draw attention to the possible dangers of eating tainted seafood, particularly for groups that are already at risk. Although there aren't many direct investigations on Formaldehyde-contaminated fish, what is known indicates that eating them may have neurotoxic consequences and interfere with other biological functions. Further research is needed to fully understand the specific mechanisms and long-term consequences of Formaldehyde exposure through fish consumption on human brain and blood health.

Neurotoxic Effects of Formaldehyde from Fish Consumption

Formaldehyde exposure through fish consumption is not directly addressed in the provided papers. However, the papers do discuss related topics of neurotoxicity from Environmental pollutants, including methylmercury found in fish. Methylmercury (MeHg), a neurotoxic compound, can accumulate in fish and seafood, posing risks to human health through consumption. MeHg readily crosses the placenta and blood-brain barrier, potentially causing severe impacts on fetal neurobehavioral development even at low maternal blood levels (14). However, the evidence for adverse neurodevelopmental outcomes from lower-level exposures through maternal fish consumption is inconsistent (15). While Formaldehyde is not directly linked to fish consumption in these papers, it is discussed as a common environmental pollutant with neurotoxic effects.

Formaldehyde exposure can occur through various sources, including polluted air, domestic materials, and industrial settings (16). Studies have demonstrated Formaldehyde's neurotoxic effects on neuronal morphology, behavior, and biochemical parameters in rats (16). Additionally, occupational exposure to Formaldehyde has been associated with increased acetylcholinesterase (AChE) activity, suggesting potential neurotoxic effects in humans (17). while the papers do not specifically address Formaldehyde neurotoxicity from fish consumption, they highlight the potential neurotoxic risks associated with environmental pollutants like methylmercury in fish and Formaldehyde from various sources. Further research may be needed to investigate any potential link between Formaldehyde and fish consumption.

Reason for Level of Formaldehyde in Fishes

Formaldehyde levels in fish can vary due to several factors: Formaldehyde can occur naturally in some fish species as a result of enzymatic processes. However, it is also sometimes illegally added as a preservative to extend shelf life and maintain freshness of seafood products (18). The presence of Formaldehyde in fish is concerning because of its potential health risks. Interestingly, some fish species contain high levels of trimethylamine N-oxide (TMAO), which protects them against pressure and cold. During bacterial spoilage, TMAO can be converted to trimethylamine (TMA), a precursor to Formaldehyde (4). This suggests that Formaldehyde levels may increase in fish as they spoil, even without intentional addition. Formaldehyde in fish can come from both natural metabolic processes and illegal use as a preservative. Levels may increase during spoilage in some species. Proper handling and storage of fish, as well as monitoring for illegal preservative use, are important to minimize Formaldehyde content. Further research on species-specific variations and impacts of storage conditions could help better understand and control Formaldehyde levels in fish products.

Regulatory Limits and Standard of Formaldehyde in Fish

Regulatory limits and standards for Formaldehyde in fish samples vary across different regions and organizations: The European Union has established permissible limits for Formaldehyde in fish, though specific values are not mentioned in the provided papers (2). In India, there are currently no regulatory limits for Formaldehyde in fish, highlighting the need for establishing such standards to safeguard public health (2). The World Health Organization (WHO) has set short-term exposure limits for Formaldehyde, which are used as a reference in some studies (25).

Formaldehyde is a known carcinogen and its use in food preservation is problematic, some studies have found that exposure levels in certain settings may be below established limits. For instance, in dermatology clinics where Formaldehyde is used to prepare skin biopsy specimens, concentrations remained below short-term exposure limits set by WHO, OSHA, and NIOSH (19). However, in other environments like beauty salons, Formaldehyde levels often exceeded WHO's permissible limit of 100 $\mu g/m^3$ for an eight-hour working period (20). The lack of consistent global standards for Formaldehyde in fish samples is evident. While some regions have established limits, others like India lack specific regulations. This variability underscores the need for more comprehensive and standardized regulatory approaches to protect consumer health and ensure food safety across different countries and industries. Based on the provided context, there is limited specific information about regulatory limits and standards for Formaldehyde in fish according to FDA, EU, or Codex Alimentarius.

The use of Formaldehyde as a preservative in fish has become problematic and poses a threat to human health (2). While specific regulatory limits are not mentioned, the study conducted in Nagaon, Assam, India, found that imported fish species like *Labeo rohita, Catla catla, Ompok pabda, Pangasius pangasius, Hilsa ilisha, and Piaractus brachypomus* tested positive for Formaldehyde contamination (2). This suggests that there is a need for stricter regulations and better preservation methods to limit the use of hazardous chemical substances like Formaldehyde fish. The Codex Alimentarius Commission, which develops food standards and guidelines for protecting consumer health and ensuring fair trade practices globally, does not appear to have specific standards for Formaldehyde in fish mentioned in the provided context (27). The Codex Alimentarius is involved in setting standard for various food contaminants and additives. The provided context does not offer specific regulatory limits for Formaldehyde in fish from FDA, EU, or Codex Alimentarius, it highlights the need for stricter regulations and better preservation methods. The detection of Formaldehyde in imported fish species underscores the importance of implementing and enforcing standards to protect consumer health. Further research and regulatory action may be necessary to establish clear limits and standards for Formaldehyde in fish across different regulatory bodies.

Preservation Practices and Illegal Use of Formaldehyde in Fish

Preservatives, including Formaldehyde, are commonly used to extend the shelf life of fish products, but their use can be detrimental to human health (2). Formaldehyde, often in the form of formalin, is widely used in aquaculture as a disinfectant to eliminate infectious agents (21). However, its illegal use as a food preservative in aquatic products has become a significant concern (8). Formaldehyde is harmful when used directly on fish for preservation, it is naturally produced in small quantities during the decomposition process of marine foods (22). This makes it challenging to distinguish between naturally occurring and illegally added Formaldehyde. Moreover, the use of Formaldehyde can have negative effects on fish health, causing damage to gills and alterations in mucous cells (21).

The illegal use of Formaldehyde in fish preservation poses a serious threat to consumer health and safety. To address this issue, alternative preservation methods such as low-temperature storage, antioxidant additives, and novel packaging techniques should be explored (22). The development of rapid on-site detection methods, like the SERS technique (23), can help in identifying and preventing the illegal use of Formaldehyde in aquatic products. Strict regulations and improved preservation techniques are necessary to ensure the safety of fish products while maintaining their quality and shelf life.

Consumer Awareness and Food Safety of Formaldehyde Contaminated Fish

Consumer awareness and food safety concerns regarding Formaldehyde-contaminated fish have become increasingly important in recent years. Fish is widely recognized as a nutritious food source, but it is also highly susceptible to spoilage and contamination by microorganisms throughout the food chain (24). This vulnerability has led to the use of preservatives like Formaldehyde, which can pose significant health risks to consumers. In emerging markets, consumers are showing growing concern about food safety issues related to fish consumption. A study in Bangladesh revealed that consumers are particularly worried about preservatives in fish, with "claim of safety control (e.g., being formalin-free)" ranking as the second most influential attribute in fish choices (25). Consumers are willing to pay a price premium for information assuring that fish is formalin-free, indicating a strong desire for transparency and safety in seafood products. To address these concerns, the seafood industry and regulatory bodies must implement comprehensive traceability systems and safety measures. This includes rigorous inspection processes, sustainable sourcing practices, and clear labeling of production methods and safety controls (25,26) Additionally, educating consumers about proper handling techniques from purchase to preparation is crucial, as the final responsibility for food safety often lies with the consumer (27). By combining industry efforts with consumer awareness, it is possible to enhance the safety and quality of fish products while meeting the growing global demand for seafood.

UV Spectrophotometry, by contrast, is a relatively simple, cost-effective, and accessible technique that can be effectively used for detecting Formaldehyde concentrations with reasonable accuracy. Despite its advantages, limited studies have validated or applied UV spectrophotometric methods for Formaldehyde detection in fish samples at the district or community level. The absence of data on Formaldehyde contamination in fish sold in Birbhum, a non-coastal yet high-consumption district. The lack of region-specific monitoring of preservative misuse in rural and semi-urban fish markets. The underutilization of UV spectrophotometry as a practical method for routine Formaldehyde detection in local laboratories and field settings. Although this study found only minimal traces of Formaldehyde in fish samples collected from various areas of Birbhum district, its importance remains significant. The presence of even small quantities indicates a potential for misuse or accidental contamination, which must not be overlooked. This highlights the need for continuous monitoring and awareness, especially in regions like Birbhum where systematic testing and regulatory enforcement may be limited. Moreover, the use of UV spectrophotometry in this study demonstrates that effective and low- cost methods can be applied successfully to detect harmful substances at the local level. This is crucial for developing practical testing protocols that can be implemented by smaller laboratories or food safety authorities in rural districts.

The study is justified 1. Early Detection- identifying even small amounts of Formaldehyde helps in early intervention before the issue becomes widespread; 2. Preventive Action- low levels now do not guarantee safety in the future; regular testing is essential to prevent long-term health risks; 3. Public Reassurance and Policy Support- the findings support the need for continued surveillance and can help guide local health authorities and 4. Model for Rural Monitoring- it sets a precedent for affordable and accessible detection methods using UV spectrophotometry.

MATERIALS AND METHODS

The experiment was conducted in the laboratory of the Department of Pharmaceutical Microbiology and Pharmaceutical Biotechnology, Birbhum Pharmacy School, Bandhersole, Birbhum, WB 731124, India.

Sample Collection

Fish samples were collected from different wet markets such as peri urban market- Dubrajpur bazar (23.7906232, 87.3745700), Chinpai bazaar (23.8220113, 87.4382037), Kachujor bazar (23.8408287, 87.4727791), Suri bazar (23.8408287, 87.4727791). Three types of fresh fish species namely Indian major carp, Rohu (*Labeo rohita*), Catla (*Labeo catla*) and Prawn (*Dendrobranchiates*) were collected from these markets. The collected fish was transported to the lab to measure the levels of formaldehyde while being maintained ice-cold in an insulated ice box.

Chemicals and Reagent

To extract the fish sample, 60 millilitres of 6% trichloroacetic acid (TCA) were utilized. Formaldehyde absorbance was measured using Nash's Reagent (Nash, 1953) as an indicator. In a 100 ml Erlenmeyer flask, 15 g of ammonium acetate was diluted with 0.3 ml of acetyl acetone and 0.2 ml of acetic acid. Because it is light-sensitive, Nash's Reagent was always stored in a dark glass reagent container. The distillate's pH was adjusted using 0.1(N) potassium hydroxide (KOH) and 0.1(N) hydrochloric acid (HCl) to be between 6.0 and 6.5 using a pH meter (25).

Standard Curve Establishment

The absorbance of known formaldehyde concentrations (i.e., 0.838, 1.68, 2.51, 3.35, and 5.03 ppm) was plotted against a stock solution of 6.2% formaldehyde to create the standard curve (Figure 1). Nash reagent was applied to several concentrations of formaldehyde solution to determine the corresponding

absorbance on a spectrophotometer (using 415 nm). The molar concentration of the Formaldehyde sample ranged "between" 0.26 × 10-4 to 1.56 × 10-4 using following formula: A = €Cl
Where, A = Absorbance; € = molar absorption co-efficient; C = Molar concentration; l = length of the cell; A= €l × C; A= Const. × C
The model used for the equation was, Y = mx equation, the straight line passing through the origin (25).

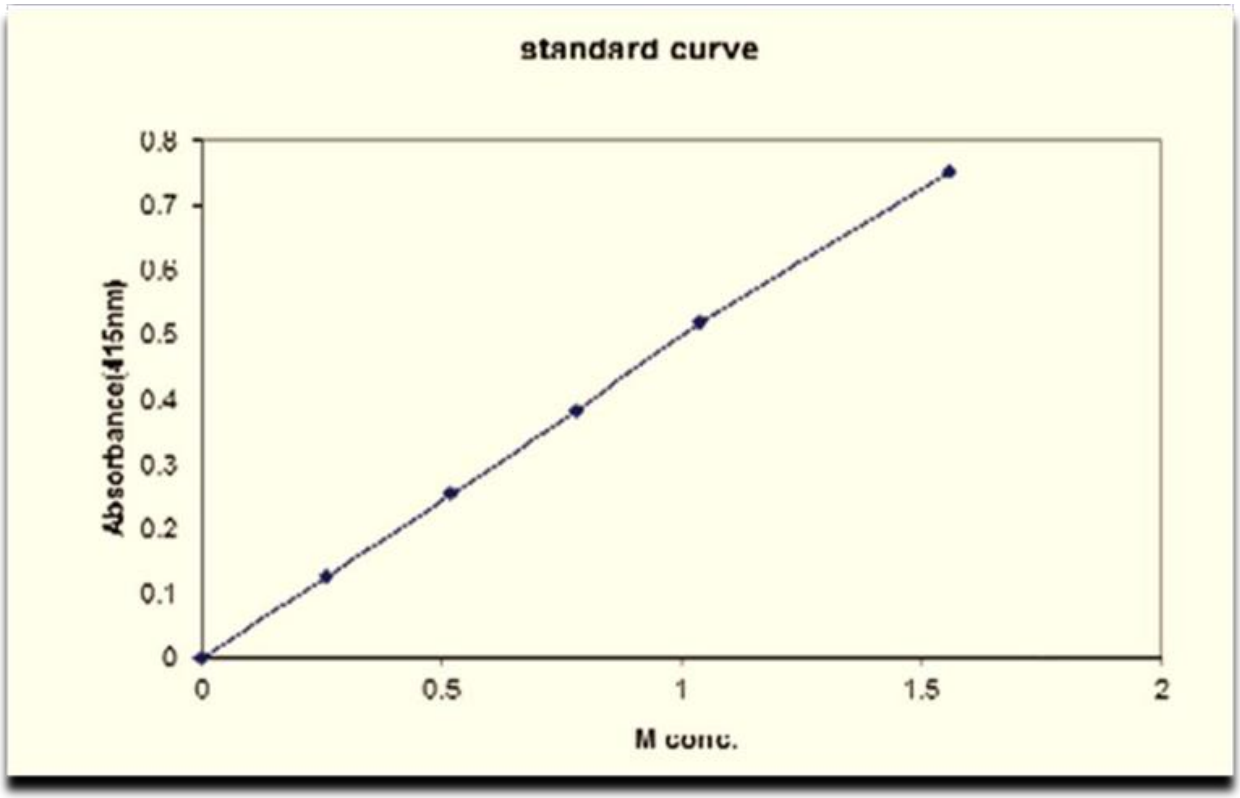


Figure 1: absorbance vs molar conc standard curve of formaldehyde concentration.

Sample Preparation for Determination of Formaldehyde Level
The fish samples that were being verified were sliced into tiny fragments. After that, the fish flesh was put in a blender and mixed for ten minutes to homogenize it. In order to remove formaldehyde from the fish flesh, 60 millilitres of 6% tri-chloroacetic acid were then added. A Whatman No. 1 filter paper was then used to filter the extracted solution. A pH meter was then used to measure the solution's pH. Although the addition of tri-chloroacetic acid decreased the sample's pH value, potassium hydroxide (KOH) and hydrochloric acid (HCl) were used to bring the pH back between the range of 6.00 and 7.00. A 50 ml volumetric flask was then filled with 5 ml of the sample solution.
After that, the material was frozen for one hour at -20°C. Two millilitres of previously made Nash's reagent were added as an indication after the sample was removed from the freezer for analysis. After that, the fish sample was cooked for 30 minutes at 60^0 C in a water bath. A UV spectrophotometer (double beam, model 1900i, Shimadzu, Kyoto, Japan) was used to test the sample's absorbance in a cuvette at 415 nm right away. Each sample's absorbance was measured in triplicate and documented for future computation. The sample reading was placed in the standard curve for the calculation of Formaldehyde content of the sample (25).

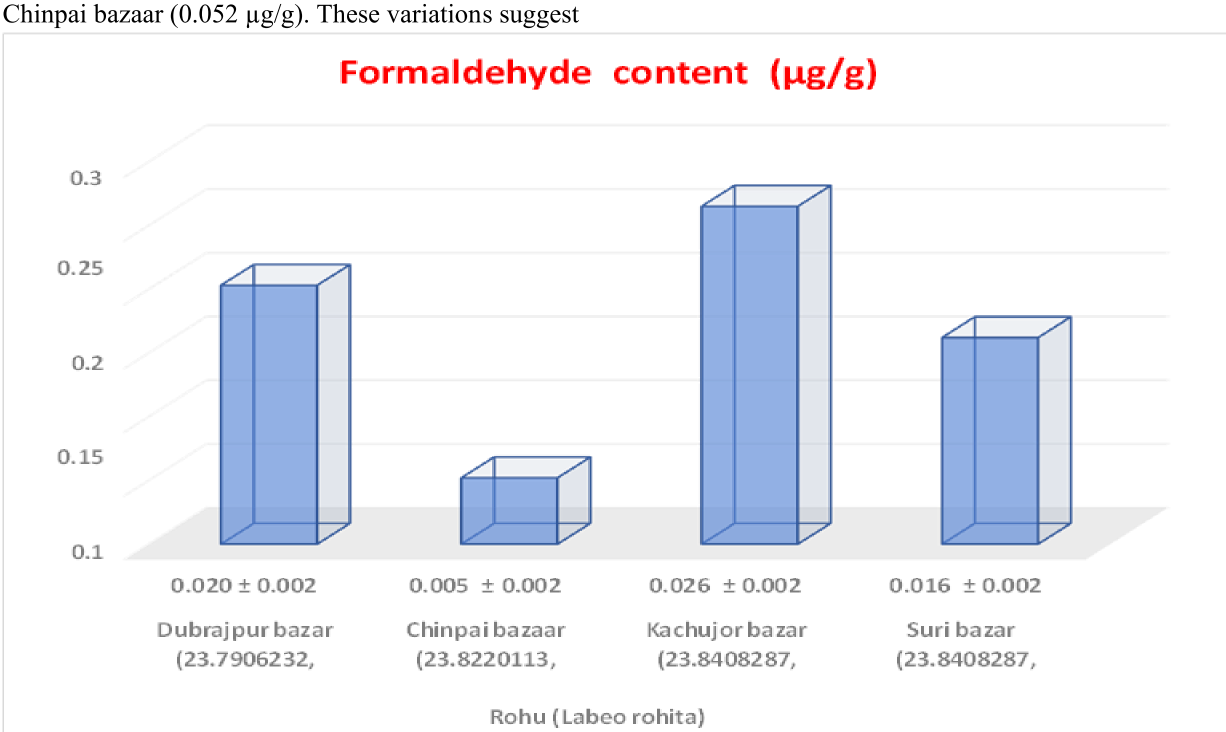
Determination of Formaldehyde Content
The absorbance and molar concentrations of the standard curve were used to assess the mean formaldehyde content of various fishes gathered from different markets. Table 1 shows the formaldehyde concentration of three distinct fish from various marketplaces.

Table 1: Formaldehyde Concentration (μg/g) in Fish Samples from Different Market of Birbhum, West Bengal Calculated as on the Basis of Absorbance (415nm) v/s Molar Conc.

Fish species	Source	Absorbance	Molar conc.	Formaldehyde content (μg/g)
Rohu (*Labeo rohita*)	Dubrajpur bazar (23.7906232, 87.3745700)	0.020 ± 0.002	0.29	0.203
	Chinpai bazaar (23.8220113, 87.4382037)	0.005 ± 0.001		0.052
	Kachujor bazar (23.8408287, 87.4727791)	0.026 ± 0.002		0.265
	Suri bazar (23.8408287, 87.4727791)	0.016 ± 0.001		0.162
Catla (*Labeo catla*)	Dubrajpur bazar (23.7906232, 87.3745700)	0.017 ± 0.002	0.37	0.172
	Chinpai bazaar (23.8220113, 87.4382037)	0.016 ± 0.001		0.162
	Kachujor bazar (23.8408287, 87.4727791)	0.033 ± 0.002		0.335
	Suri bazar (23.8408287, 87.4727791)	0.021 ± 0.001		0.214
Prawn (*Dendrobranchiates*)	Dubrajpur bazar (23.7906232, 87.3745700)	0.015 ± 0.002	0.52	0.156
	Chinpai bazaar (23.8220113, 87.4382037)	0.016 ± 0.001		0.166
	Kachujor bazar (23.8408287, 87.4727791)	0.042 ± 0.001		0.437
	Suri bazar (23.8408287, 87.4727791)	0.036 ± 0.002		0.374

Evidence from the that the three species of market fishes viz. Rohu (*Labeo rohita*), Catla (*Labeo catla*) and Prawn (*Dendrobranchiates*) showed a range of 0.052 and 0.437 μg/g formaldehyde (Table 1).

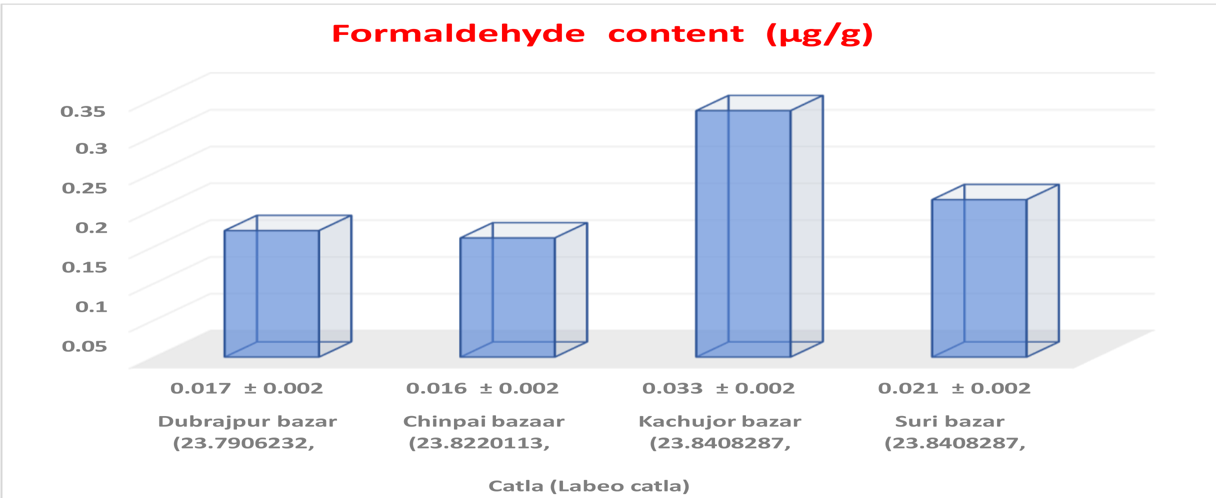
Formaldehyde content in Rohu (*Labeo rohita*)
From the standard curve, the result obtained that the Formaldehyde content in Rohu (*Labeo rohita*) varied between 0.052 μg/g to 0.265 μg/g across the four sampled markets (Graph 1). The highest concentration was detected in fish collected from Kachujore bazar (0.265 μg/g), whereas the lowest was observed in Chinpai bazaar (0.052 μg/g). These variations suggest that Rohu from certain markets may have slightly elevated formaldehyde levels, although all detected concentrations remain relatively low. Suri and Dubrajpur bazar samples showed moderate levels of 0.162 μg/g and 0.203 μg/g, respectively. These differences may arise due to varying post- harvest handling and storage conditions.



Graph 1: Formaldehyde Concentration (μg/g) in Rohu (Labeo rohita) Fish Sample collected from Different Markets of Birbhum, West Bengal.

Formaldehyde content in Catla (*Labeo catla*)

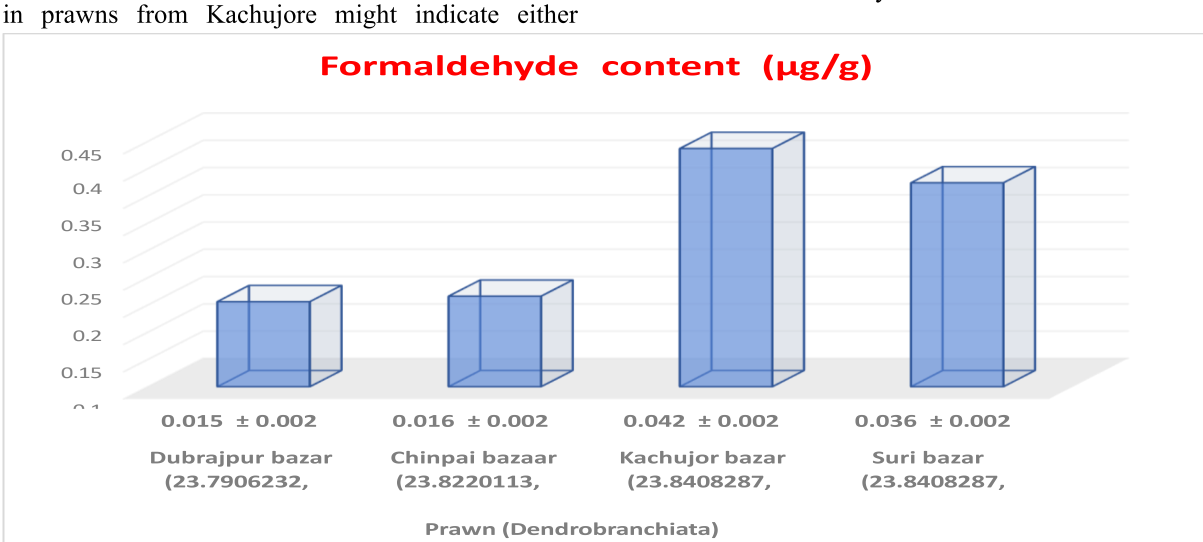
Catla (*Labeo catla*) samples showed a slightly broader range of formaldehyde concentration compared to Rohu. The values ranged from 0.162 µg/g in Chinpai to 0.335 µg/g in Kachujore, indicating possible variability in either natural generation or external contamination. The highest concentration (0.335 µg/g) observed in Kachujore market may suggest a higher exposure to temperature stress or post-mortem enzymatic activity (Graph 2). Suri and Dubrajpur markets yielded moderate levels (0.214 µg/g and 0.172 µg/g, respectively), aligning with general expectations of naturally occurring formaldehyde in freshwater fish species.



Graph 2: Formaldehyde Concentration (µg/g) in Catla (Labeo catla) Fish Sample collected from Different Markets of Birbhum, West Bengal.

Formaldehyde content in Prawn (*Dendrobranchiates*)

Prawn (*Dendrobranchiates*) samples exhibited slightly higher formaldehyde concentrations, ranging from 0.156 µg/g (Dubrajpur) to a peak of 0.437 µg/g in Kachujore (Graph 3). The relatively elevated value in prawns from Kachujore might indicate either enzymatic degradation of trimethylamine oxide (TMAO) or potential chemical adulteration. Nevertheless, even the highest value remains significantly below health risk thresholds and likely represents either naturally occurring or storage-induced formaldehyde formation.



Graph 3: Formaldehyde Concentration (µg/g) in Prawn (Dendrobranchiata) Fish Sample collected from Different Markets of Birbhum, West Bengal.

RESULTS

The formaldehyde concentration (µg/g) in fish samples collected from four major wet markets of Birbhum district—Dubrajpur, Chinpai, Kachujore, and Suri—was determined using UV-Visible spectrophotometry at 415 nm. The results varied depending on fish species and market location.

The formaldehyde concentration (µg/g) in Rohu (*Labeo rohita*) at Dubrajpur bazar, Chinpai bazaar, Kachujore bazar and Suri bazar has been found to be 0.203 µg/g, 0.052 µg/g, 0.265 µg/g and 0.162 µg/g respectively. In Catla (*Labeo catla*) at Dubrajpur bazar, Chinpai bazaar, Kachujore bazar and Suri bazar has been found to be 0.172 µg/g, 0.162 µg/g, 0.335 µg/g and 0.214 µg/g respectively. Lastly, in Prawn (Dendrobranchiates) at Dubrajpur bazar, Chinpai bazaar, Kachujore bazar and Suri bazar has been found to be 0.156 µg/g, 0.166 µg/g, 0.437 µg/g and 0.374 µg/g respectively.

Among all fish types analyzed, Prawn from Kachujore contained the highest formaldehyde level (0.437 µg/g), followed by Catla from the same market (0.335 µg/g). This suggests that the Kachujore market had the highest overall levels across all species. However, no sample exceeded commonly cited safe exposure limits, indicating no immediate public health risk. Still, variation among markets underscores the importance of improved cold chain management, monitoring, and public awareness to reduce spoilage and discourage any preservative misuse.

CONCLUSION

The present investigation revealed the presence of varying levels of formaldehyde in commonly consumed fish species—Rohu (*Labeo rohita*), Catla (*Labeo catla*), and Prawn (*Dendrobranchiates*)—collected from four different wet markets in the Birbhum district of West Bengal. Using the UV-Visible spectrophotometric method with Nash reagent, the formaldehyde concentration in all samples was found to be within a relatively low range, from 0.052 µg/g to 0.437 µg/g. The highest level was observed in prawn from Kachujore bazar (0.437 µg/g), while the lowest was in rohu from Chinpai bazar (0.052 µg/g). Despite these variations, all detected values remained well below the hazardous limit, suggesting no immediate health risk to consumers. However, the variability among samples and across markets indicates possible influences of post-harvest handling, temperature control, and natural biochemical degradation. The findings highlight the need for regular monitoring of fish markets to improved storage practices with cold chain management and public awareness regarding chemical usage in perishable foods. Continued surveillance and stricter enforcement of food safety regulations are essential to ensure the supply of fresh, uncontaminated fish to the consumer population.

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