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Quantitative risk assessment for formalin treatment in fish preservation: food safety concern in local market of Bangladesh

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Abstract

In Bangladesh, fishes are adulterated by hazardous chemicals at different steps from farm to consumers. Formalin (FA) is reported to be frequently added as preservative either by dipping or spraying to the fresh fishes by the fish traders while transporting to domestic marketing chain to prevent spoilage and extend shelf life. Thus, the objective of the present study was toconduct quantitative risk assessment (QRA) for formalin treated fish in Bangladesh. The probabilistic QRA of formalin treated fish was performed based on available secondary data.Availabledata on concentration of formalin in fish, daily fish consumption by the consumer and their body weight were used to estimate the risk of residual formalin to the consumers. Based on the data, three different scenarios (average consumption, two and four times of average consumption considered as scenarios 1, 2 and 3, respectively) were used for exposure analysis using @Risk program version 6.0.FA concentration in consumedfresh and cooked (boiling) fish was 5.34×10^{-02} and 2.340×10^{-02} (mg/kg bw/day), respectively and national average fish consumption was 200 g/day. QRA reveals that FA intake under scenario1 and 2 was lower than acceptable daily intake (ADI 0.2 mg/kg bw/day set by the United States Environmental Protection Agency) thus lower risk observed for both fresh and cooked fish. However, scenario 3 revealed that 0.01 % population was at risk (FA intake 0.21 mg/kg bw/day higher than ADI) upon the fresh fish consumption, where cooked fish (FA 9.38×10^{-02} mg/kg bw/day) consumer remains safe at the same scenario. The result confirmed that cooking has significant effect to reduction of formalin. Therefore, probabilistic quantitative risk assessment of formalin treated fish could provide important risk information to the risk manager (government), whether the population is at risk or not? The result could be applied to establish effective risk management strategy in Bangladesh.

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1. Introduction

Fisheries is an important sector of Bangladesh in terms of creating job opportunities (16.5 million), gross domestic growth (4.39%), nutrient supply and earning of foreign exchange (470 million US dollar in 2011-2012)[1] which is contributing to the food security of the country either directly or indirectly. Fish and other seafood are the vital contributors to meet the nutritional requirement in the daily diet. About 60% of the total animal protein intake are coming from fish.

In Bangladesh, different food items are reported to be adulterated by unsafe chemicals at different marketing steps from farms to consumers. The fresh fish are sprayed with or dipped into formalin by the fish traders while transporting through domestic market chain[2]. Formalin is carcinogenic, allergenic and induce genotoxicity. Formalin recently classified by the International Agency for Research on Cancer (IARC) in the Group 1 ‘‘as carcinogenic to humans’’[3]. Chemical reaction of added formalin with fish composition could produce toxic product (adduct) and have residual harmful effects to the consumer. However, as consumers behavior in Bangladesh are habituated to eat well cooked fish and fishery products which could reduce the FA content up to a level. Several study reported that different household handling steps (freezing, thawing, washing, and cooking) could help to deduct the added FA from fish[4].

Recent trends in global food production, processing, distribution and storage are creating an increasing demand for food safety research in order to ensure a safer global food supply. Methods of risk analysis, potential risks of susceptible populations and combined low-level exposure to several chemicals are taking into account. However, there is limited information was observed on quantitative risk assessment of formalin contamination in fish of Bangladesh. Therefore, objective of the present study was to quantitative risk assessment of formalin treatment in fish chain of Bangladesh and established effective risk management strategy to obtain the status of safe fish in Bangladesh.

2. Risk assessment methodology

2.1. Exposure assessment

For concentration data, available secondary data containing minimum of 10 samples were considered per fish categories (fresh fish and cooked fish) for formaldehyde content[4]. On the other hand, consumption data were obtained from the report of National Fish Week Compendium (In Bengali) published by Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh.

Formalin dietary exposure in two different categories of fish (fresh fish and cooked fish) included the formaldehyde concentrations and three different scenarios of consumptions (average consumption, 2 and 4 times of average consumption) data were analyzed. Risk assessment was done based on the available secondary data, where the current study would establish a complete modeling for the risk assessment. Available data of formaldehyde concentration in fish (*mg/kg*) and average fish consumption (*g/day/person*) was used for exposure analysis. Fish consumption (*g/day/person*) was further converted to *g/kg body weight/day* (Annex 1). In case of body weight, based on assumption three age group subpopulation namely child, adult and older was referred as minimum, most likely and maximum body weight for the distribution. Exposure was calculated as per following equation:

$$\text{Exposure} = \frac{\text{Concentration of contaminant (mg/kg)} \times \text{Consumption(kg/day)}}{\text{Body weight (kg)}}$$

Where, distribution of concentration and consumption used; Exposure expressed as *mg/kg body weight/day*

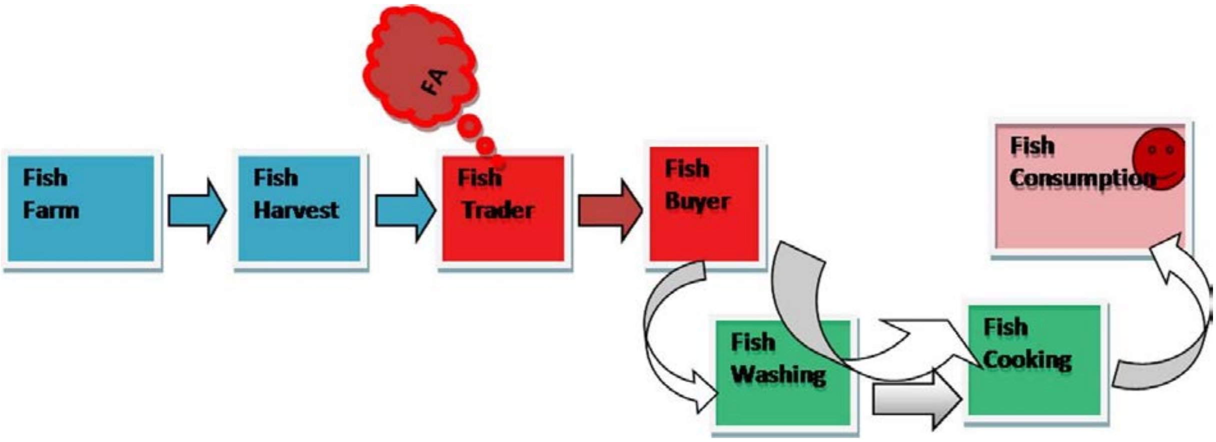

Fig. 1. Scenario of formalin inclusion in fish chain of Bangladesh

In Bangladesh, a typical short chain of farmed fish from farm to consumption is shaped in Figure 1. Middle men invented formaldehyde treatment in both domestic produced and imported (mainly from Myanmar) Carp fishes are widely known as risk for the consumer of Bangladesh. It is considered that before consumption different handling steps (freezing, thawing, washing, and cooking) could altered downward of formaldehyde content[4].

2.2. Risk assessment simulations/Probabilistic analysis

Risk assessment was done based on the available secondary data. Initially available data were then fit into a distribution at @Risk program in Microsoft Excel format. Best fit distributions were applied to formaldehyde contents in the two different fish categories (fresh and cooked fish) (Annex 3 and 4). Based on assumption, the average body weight of three different age groups referred as minimum, most likely and maximum body weight was fit into pert distribution. Three scenarios based on national fish consumption (average consumption, 2 and 4 times of average consumption) were analyzed. First order Monte Carlo simulations were performed considering 50000 iterations. Estimated formaldehyde intake (minimum, mean, maximum and SD) was determined per fish category and different scenarios separately. Calculations were performed using the software package @Risk program version 6.0 (Palisade Corporation, US). Table 1 shows the general summary of the data used in @Risk.

Table 1: Summary of datasheet used for risk assessment

Data set	Data source	Distribution Used	Remark
FA conc. in fish	Primary Data[4]	Best fit (Chi-Squared statistics)	Used to calculate exposure
Consumption	National data	-	,,
Body weight	Expert opinion/Assumption	Pert	,,

3. Results and discussion

3.1. Risk characterization

For the purpose of risk characterization and risk assessment of formaldehyde treated fish was required available concentration and consumption data from Bangladesh, which was limited. Wherever the data lapses were found to be undermining the risk assessment, similar data on formaldehyde from the literature were presumptively applied for risk assessment models. As an example, lack of local data for formaldehyde concentration in fishes and removal of formaldehyde in washing and cooking process from fish led necessary to use data from related literature.

The data source of this study, formaldehyde (FA) content was tested in fresh and cooked fish (boiled)[4]. In the fresh and cooked fish sample, FA content was found ranged from 5.80 to 21.80 mg/kg and 0.98 to 5.93 mg/kg, respectively. Not statistically significant but generally lower FA content was observed in cooked fish than fresh fish. Since in Bangladesh consumer behavior to eat well cooked food where, fish and fishery products are generally eaten after cooking. This is why data from this study was highly relevant to Bangladesh. The evaluation of possible decreasing behavior of FA content was not surprising. The fish cooked in open pots allowing the evaporation of the analytes during the cooking process. Due to the chemical characteristics of FA is volatile, soluble in water and highly reactive. The last properties of the contaminant could lead to residual effect and chemical reacted toxic product (adduct) formation in food materials. However, different household handling steps (freezing, thawing, washing, and cooking) could reduce the FA in fish. FA content could be also varied in fish dimension and some other time-temperature factor[4]. The effect of household processing steps was highly focused as different scenarios study during probabilistic risk assessment.

Table 2: Probabilistic analysis of estimated formaldehyde intake (minimum, maximum, mean, and percentiles, mg/ kg body weight/day) from fish by Bangladeshi population

Scenario	Formaldehyde intake (mg/ kg body weight/day)							
	Min.	Max.	Mean	SD	95%	97.5%	99.9%	exposed≤ADI
Fresh Fish-1	$2.97x10^{-03}$	$5.34x10^{-02}$	$7.73x10^{-03}$	$3.81x10^{-03}$	$1.50x10^{-02}$	$1.80x10^{-02}$	$3.30x10^{-02}$	100%
Fresh Fish-2	$5.94\ x10^{-03}$	0.11	1.5410^{-02}	$7.61x10^{-03}$	$3.01x10^{-02}$	$3.58x10^{-02}$	$6.61x10^{-02}$	100%
Fresh Fish-4	$1.19x10^{-02}$	0.21	$3.09x10^{-02}$	$1.52x10^{-02}$	$6.02x10^{-02}$	$7.16x10^{-02}$	0.13	99.998%
Cooked Fish-1	$4.28x10^{-04}$	$2.34x10^{-02}$	$2.10x10^{-03}$	$1.59x10^{-03}$	$5.15x10^{-03}$	$6.36x10^{-03}$	$1.28x10^{-02}$	100%
Cooked Fish-2	$8.43\ x10^{-04}$	$4.69x10^{-02}$	$4.20x10^{-03}$	$3.18x10^{-03}$	$1.03x10^{-02}$	$1.27x10^{-02}$	$2.56x10^{-02}$	100%
Cooked Fish-4	$1.67x10^{-03}$	$9.38x10^{-02}$	$8.39x10^{-03}$	$6.36x10^{-03}$	$2.06x10^{-02}$	$2.54x10^{-02}$	0.051	100%

In regard to probabilistic analysis, exposure was observed in cumulative distributions where percent probability of FA intake/exposure was plotted against population. Table 2 showed the probabilistic estimates of formaldehyde intake/exposure (mg/kg bw/day) from fish by Bangladeshi population considering 3 different scenarios. In case of scenario 1 for fresh fish and cooked fish, the estimated formaldehyde mean was $7.73x10^{-03}$ and $2.10x10^{-03}$ (mg/kg bw/day), and 99.9% intakes were $3.30x10^{-02}$ and $1.28x10^{-02}$ (mg/kg bw/day), respectively. These values are below than ADI value (0.2 mg/kg bw/day)[4]and consequently could indicate that based on average fish consumption formaldehyde concentrations found in both fresh and cooked fish pose a low risk to the Bangladeshi population. Similar observation was found in scenario 2 (2 times of average fish consumptions) where value for mean formaldehyde intake and 99.9% intakes were lower than ADI values thus in low risk as well. The result from scenarios 1 and 2 indicates that 100% of the population has the probability getting expose to ≤ 0.2 mg/kg (ADI value), accordingly in lower risk. However, scenario 3 (4 times of average fish consumptions) showed the different result for fresh and cooked fish. For fresh fish and cooked fish-4, the estimated formaldehyde mean was $3.09x10^{-02}$ and $8.39x10^{-03}$ (mg/kg bw/day), and 99.9% intakes were 0.13and 0.051(mg/kg bw/day), respectively. In fresh fish-4, the result revealed that 99.998% population is exposed to ≤ 0.2 mg/kg (ADI value) and remaining 0.01% exposed to ≥ 0.2 (Annex 2), hence might be at risk. On the other hand, 100% population is exposed to ≤ 0.2 mg/kg and referred them safe side when population consumed same amount of cooked fish. Therefore, the different household handling step has significant effect in reduction of formaldehyde risk.

4. Conclusions and recommendations

The quantitative risk assessment for formaldehyde in fish from Bangladesh result confirmed that cooking has significant effect to reduction of formaldehyde. Concentration and consumption data from local studies are highly recommended to be carried out and support the quantitative risk assessment in Bangladesh to reflect the actual scenarios of the country.

Implementation of international food safety standards along the fish supply chain, institutional assistance to capacity building, training, traceability, up gradation of food safety regulation and strategy of Bangladesh are the demand of time to obtain effective FSMS. Therefore, probabilistic quantitative risk assessment could characterize and provide important risk information to the risk manager which can be applied to establish risk management strategy efficiently and effectively.

5. Acknowledgement

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Appendix A. Formaldehyde concentration (mg/kg) in fresh and frozen fish

Formaldehyde concentration (mg/kg)	
Fresh fish	Cooked fish
10.38	0.98
6.45	0.95
8.50	1.34
21.8	5.93
6.38	2.85
10.50	4.25
6.62	2.74
8.35	3.51
5.80	1.31
7.40	1.85

Appendix B. Details statistics output from @ Risk program

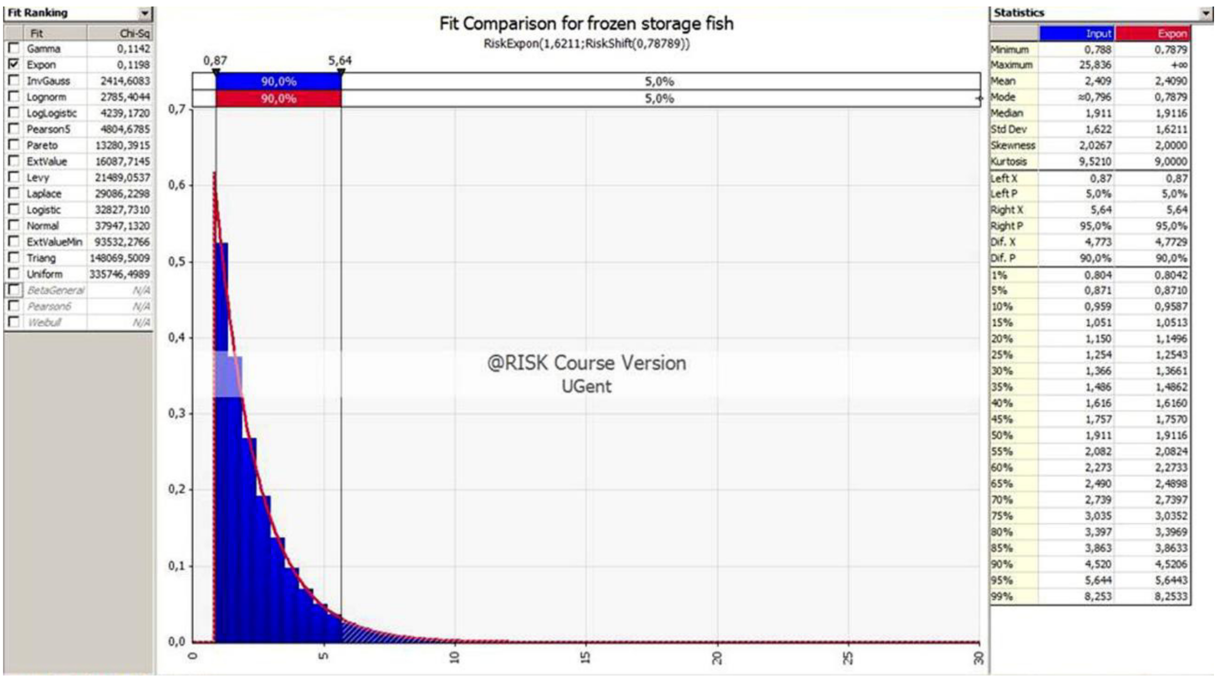
@RISK Detailed Statistics

Performed By:UGent
Date:zondag 15 december 2013
17:51:09

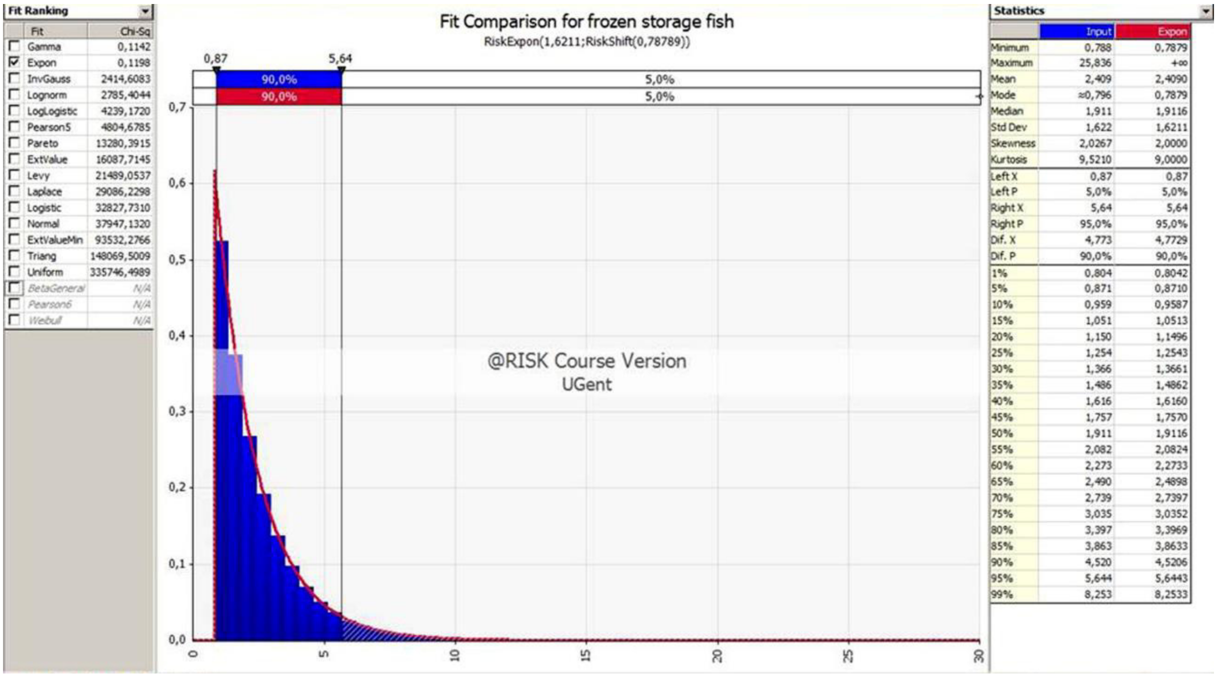
Name	exposure-fresh fish	exposure-cooked fish	exposure-fresh fish 2	exposure-cooked fish 2	exposure-fresh fish 4	exposure – cooked fish 4
Description	Output	Output	Output	Output	Output	Output
Cell	Sheet1!B18	Sheet1!E18	Sheet1!B19	Sheet1!E19	Sheet1!B20	Sheet1!E20
Minimum	0,002973816	0,000421701	0,005947633	0,000843403	0,01189527	0,001686805
Maximum	0,0534969	0,0234444	0,1069938	0,04688879	0,2139876	0,09377758
Mean	0,007729905	0,002098154	0,01545981	0,004196308	0,03091962	0,008392616
Std. Deviation	0,003807371	0,001591128	0,007614742	0,003182256	0,01522948	0,006364513
Variance	1,44961E-05	2,53169E-06	5,79843E-05	1,01268E-05	0,000231937	4,0507E-05
Skewness	2,255327	2,520874	2,255327	2,520874	2,255327	2,520874
Kurtosis	11,75728	13,79368	11,75728	13,79368	11,75728	13,79368
Errors	0	0	0	0	0	0
Mode	0,005536982	0,000812325	0,01107396	0,001624651	0,02214793	0,003249301
5% Perc	0,003912213	0,000653841	0,007824427	0,001307683	0,01564885	0,002615366
10% Perc	0,004279741	0,000763713	0,008559481	0,001527427	0,01711896	0,003054854
15% Perc	0,004595079	0,000857405	0,009190159	0,001714809	0,01838032	0,003429618
20% Perc	0,004884169	0,000947356	0,009768337	0,001894712	0,01953667	0,003789424
25% Perc	0,005163744	0,001039775	0,01032749	0,00207955	0,02065498	0,0041591

30% Perc	0,005453883	0,001135878	0,01090777	0,002271755	0,02181553	0,004543511
35% Perc	0,005744352	0,00124214	0,0114887	0,002484279	0,02297741	0,004968559
40% Perc	0,006049441	0,001355195	0,01209888	0,00271039	0,02419776	0,005420781
45% Perc	0,006360647	0,001479968	0,01272129	0,002959936	0,02544259	0,005919873
50% Perc	0,006715044	0,001608043	0,01343009	0,003216086	0,02686018	0,006432171
55% Perc	0,007089277	0,001755657	0,01417855	0,003511314	0,02835711	0,007022628
60% Perc	0,007498851	0,001925721	0,0149977	0,003851442	0,0299954	0,007702884
65% Perc	0,00794556	0,00211857	0,01589112	0,004237139	0,03178224	0,008474278
70% Perc	0,008469096	0,002350756	0,01693819	0,004701512	0,03387639	0,009403024
75% Perc	0,00911399	0,002620119	0,01822798	0,005240238	0,03645596	0,01048048
80% Perc	0,009890064	0,002948894	0,01978013	0,005897788	0,03956025	0,01179558
85% Perc	0,01089205	0,003395816	0,0217841	0,006791632	0,04356819	0,01358326
90% Perc	0,01236867	0,004045927	0,02473735	0,008091855	0,04947469	0,01618371
95% Perc	0,01501042	0,005152687	0,03002083	0,01030537	0,06004167	0,02061075
Filter Minimum						
Filter Maximum						
Filter Type						
# Values Filtered	0	0	0	0	0	0
Target #1 (Value)	0,2	0,2	0,2	0,2	0,2	0,2
Target #1 (Perc%)	1	1	1	1	0,99998	1
Target #2 (Value)	0,017902688	0,006365825	0,035805375	0,012731649	0,07161075	0,025463298
Target #2 (Perc%)	0,975	0,975	0,975	0,975	0,975	0,975
Target #3 (Value)	0,033056241	0,012803899	0,066112482	0,025607798	0,132224963	0,051215596
Target #3 (Perc%)	0,999	0,999	0,999	0,999	0,999	0,999

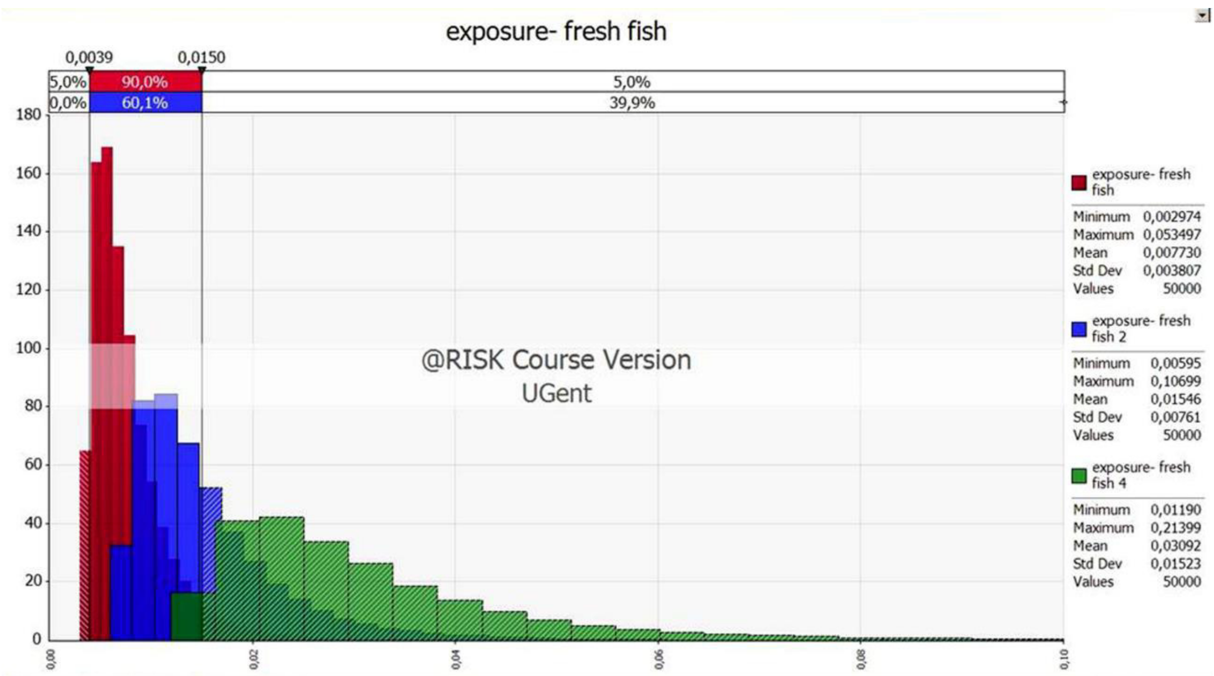
Appendix C. Best fitting distribution for concentration of FA fresh fish



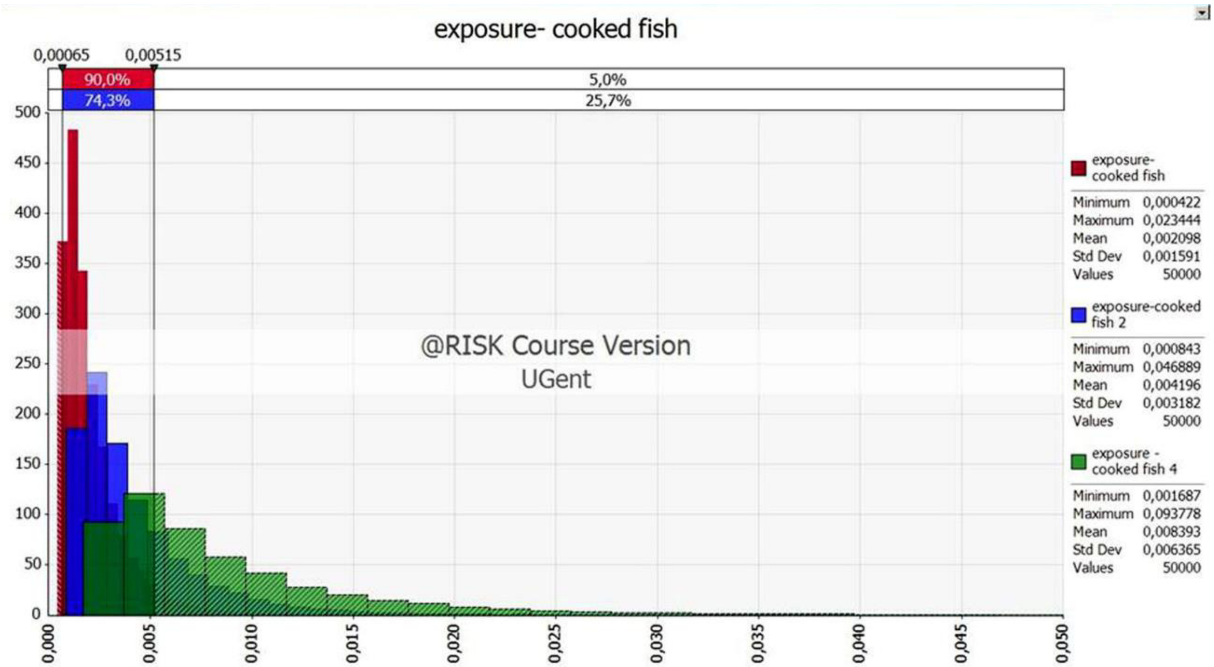
Appendix D: Best fitting distribution for concentration of FA in cooked fish



Appendix E. Density distribution of exposure for fresh fish



Appendix F. Density distribution of exposure for fresh fish



6. References

1. Syed, AA. *Fisheries sector of Bangladesh: Achievements and potentials*. National Fish Week Compendium (In Bengali), Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh; 2013.
2. Ali ANMA. Food safety and public health issues in Bangladesh: a regulatory. *European Food and Feed Law Review* 2013;8 (1):31-40.
3. IARC, Monograph Vol. 88, Formaldehyde. Available from: *http://monographs.iarc.fr/ENG/Monographs/vol88/volume88.pdf*.
4. Bianchi. F, Careri. M, Musci M, Mangia. A. Fish and food safety: Determination of formaldehyde in 12 fish species by SPME extraction and GC–MS analysis. *Food Chemistry* 2007;100(3):1049 -1053.