Importation of frozen poultry meat is currently banned in Nigeria however; reports have it that such products are readily available in the market due to the activities of smugglers who are alleged to illegally add formalin to the smuggled poultry meat as a preservative. Exposure to high levels of formalin has deleterious health consequences. Therefore, assessment of formaldehyde contents in imported frozen chicken and turkey on sale in five major markets located in Ibadan, South west Nigeria, were studied between October, 2012 and February, 2013; in three batches using spectrophotometry. Result reveals a range of 0.063 mg/kg to 7.47 mg/kg (mean±SD; 2.82±2.4 mg/kg) of formaldehyde content in the imported raw poultry meat which is significantly higher (P<0.01) than that of poultry meat obtained from a local farm (0.02 mg/kg).

**Keywords:** Carcinogen, formaldehyde, poultry, public health

**Introduction**

Reports of illegal use of formaldehyde as food preservative are becoming a global problem (Shahdat et al., 2008; Norlina et al., 2009; Emdadul and Mohsin 2009; Riaz et al., 2011). In 2012, the state news agency; Xinhua reported that vegetable sellers in China were caught spraying cabbages with formaldehyde solution to keep them fresh in transit, (BBC, 2012). In Bangladesh, a study indicated that 70% Rui fish (Labeo rohita) offered for sale was formalin contaminated and almost 50% of all fish samples screened contained formalin, (Riaz et al., 2011).

Formaldehyde (H-CHO) is the simplest member of aldehyde family. It is a very reactive chemical with the gaseous form known as formaldehyde and the liquid form as formalin (Noordiana et al., 2011). Formaldehyde, usually sold as a 37% (w/w) aqueous solution as embalming fluid and preservative in medical laboratories is also applied in consumer goods such as noodles, salted fish and tofu to protect them from spoilage by microbial contamination (Wang et al., 2007; Xiaojiang et al., 2009). It is found naturally at low levels in a wide range of foods such as fruit, vegetables, mushrooms, meat and seafood. (Bianchi et al., 2005), report indicated that Italian Ministry of Health in 1985, proposed formaldehyde values of 60 µg/g and 10 µg/g for Gadidae and crustaceans, respectively. Formaldehyde is a normal product of human metabolism with a range of its content between 0.38-15.75 mg/kg observed in fish and seafood from wet markets in Malaysia (Noordiana et al., 2011). Naturally, production of formaldehyde can occur by enzymatic activity of trimethylamine oxide aldolase (TMAOase) in meat preserved in frozen form for long periods and also during the ageing and deterioration of fish flesh. However, high
levels of formaldehyde do not accumulate in fish tissues due to its subsequent conversion to other chemical compounds (Norliana et al., 2009). Obviously, there is paucity of information on formaldehyde content of frozen poultry meat.

When consumed in little quantities, formaldehyde possesses no significant health risk to humans but at higher doses, this chemical is dangerous to health. According to Noordiana et al. (2011), United States Environmental Protection Agency (EPA), fixed maximum daily dose reference (RfD) for formaldehyde as 0.2 µg/g body weight. At exposures increasingly greater than the recommended RfD, the potential for adverse health effects increases (Wang et al., 2007).

Studies of professionals who are potentially exposed to formaldehyde in their work, such as anatomists and embalmers, have suggested that these individuals are at an increased risk of leukemia and brain cancer compared with the general population (NCI, 2013). Toxic levels of formaldehyde classified as a class 2a carcinogen, can induce a variety of illnesses ranging from localized skin/respiratory tract irritation, genotoxic effects to cancer (Bosetti et al., 2008, Speit et al., 2006, Shahdat et al., 2008, IARC, 2004).

Apart from its direct adverse health effects, formaldehyde reduces the nutritional value of meat by denaturing the proteins and causing muscle toughness, (Sotelo et al., 1995). A significant reduction in solubility and gel forming ability has been reported in formalin treated fish, resulting in poor eating quality and reduced digestibility from denaturation of fish muscle protein (Yeasmin et al., 2010).

Poultry meat though regarded as an important source of animal protein which is affordable by the rapidly growing human population in Nigeria especially the low income earners, seems adulterated with illegal use of formaldehyde (FAO, 2013, Foraminifera, 2012). Furthermore, records show that Nigeria spends ₦191.6 billion ($579 million) annually on poultry meat of which Southwest Nigeria accounted for 44% of this huge expenditure, (NBS, 2012).

The illegal use formalin as meat preservative on the increase with reports of Nigerian Customs Service seizing tons of poultry meat allegedly contaminated with formaldehyde along Nigerian boarders, (Leadership, 2012, Nigerian Tribune, 2012; The Punch, 2012). Some countries have initiated routine testing of frozen meat for formaldehyde contamination (Riaz et al., 2011). Unfortunately, no such structures exist in Nigeria. It is against this background that this market survey to determine the formaldehyde levels in imported frozen poultry meat in Ibadan, Southwest Nigeria, was carried out.

Materials and Methods

Description of study location

This study was conducted in Ibadan, South West Nigeria. Ibadan is one of the most populous cities in Nigeria with a human population of 2,628,000 as in 2007 (Britannica, 2013). Five major markets in which frozen poultry meat was highly traded were selected for this study. The markets are located in the central region of Ibadan with highest population density.

Sample collection

A total of thirty (30) frozen poultry meat samples were used for this study. The samples comprise 15 chicken and 15 turkey meat. Thirty 500 g samples of imported frozen chicken and turkey meat were purchased in three batches from the biggest cold rooms in the five selected markets in Ibadan. The three sample batches were obtained between October, 2012 and February, 2013. The first batch (Batch 1) was obtained in October while the second (Batch 2) and third (Batch 3) batches were obtained in December, 2012 and February, 2013 respectively.

The markets from which the meat samples were obtained were Bodija (Market A), Challenge (Market B), Eleyele (Market C) Iwo road (Market D) and Mokola (Market E) markets. A chicken was purchased from a farm in Ibadan, slaughtered, dressed and frozen to serve as a control sample (Farm control). Immediately after purchase, the meat samples were packed in sterile polythene bags and transported to the laboratory in ice.
Sample preparation

On arrival at the laboratory, bones were separated from the flesh in all samples with a sterile scalpel. The bones were discarded while the flesh were kept frozen till tested. 5 ml of water was added to 30g of each sample which was then heated in a sterile boiling tube by insertion in boiling water bath for 10 minutes. Four 10g meat samples from the farm control were immersed in 10 ml of 4%, 2%, 1%, 0.5% and 0% aqueous formaldehyde solution. Duplicates from these graded samples were boiled in the same manner as the market obtained test samples after 1 hour of immersion in formalin.

Reagents

All reagents were of analytical grade. Working formaldehyde solutions were prepared from 0, 2, 4, 6, 8 and 10 mcg / 50 ml from a 40% stock solution immediately before being used for plotting the calibration graph.

Nash’s Reagent (Indicator): A solution containing 2 M ammonium acetate, 0.05 M acetic acid and 0.02 M acetyl acetone was prepared by dissolving 150 g ammonium acetate, 3 ml of acetic acid and 2 ml of acetyl acetone (redistilled at 140°C) in water and adjusting the volume to 1000 ml. Nash’s Reagent is light sensitive and is kept in dark-glass reagent bottle.

Trichloroacetic acid, TCA: 6% w/w solution
Potassium hydroxide, KOH: 30% w/w solution.
Hydrochloric acid, HCl: 1% solution.

Procedure (Nash, 1953)

The samples were thawed and cut into small pieces and 5 g samples were placed in 50 ml beakers and 20 ml of 6% trichloroacetic acid was added. The mixture was homogenised for 2 min. The homogenate was then filtered using Whatman paper No. 1. The extraction was repeated by homogenising the residue with 10 ml of 6% trichloroacetic acid, followed by filtering. The filtrate was combined and neutralised to pH 6.0–6.5 using 30% KOH. The final volume was made up to 50 ml using distilled water. For blank determination, only 5 ml of the standard working solution (TCA) was mixed. Sample extracts with 2 ml Nash’s Reagent and was heated in water bath at 60°C for 30 min. The absorption at 415 nm was measured immediately by UV/Visible spectrophotometer (Thermo Fisher Scientific, Waltham, MA). Formaldehyde content was calculated and expressed as mg/kg of sample.

Statistical analysis

All experiments were done in duplicate and the mean values recorded. Based on the data generated, a descriptive statistical analysis was carried out to study the average content of formaldehyde in poultry meat. One-way ANOVA was used to compare mean formaldehyde content in poultry meat based on market surveyed and the sample batches while single sample Student-t test was used to compare mean formaldehyde content in poultry meat between the species (chicken/turkey) and heat treatment (raw/boiled). The data were analyzed using the statistical computer software ‘IBM®SPSS®statistics 20 (USA),’ and the statistical significance was determined at P<0.05.

Results

The distribution of formaldehyde levels of raw meat samples was the same across imported chicken and turkey meat samples; and across the five markets surveyed (P>0.05) (Table 1).

The formaldehyde content of imported raw poultry meat ranged from 0.063 mg/kg to 7.47 mg/kg (mean±SD; 2.82±2.4 mg/kg). These were significantly higher (P<0.05) than the mean formaldehyde content of home slaughtered raw poultry meat (0.02 mg/kg) (Fig. 1). The formaldehyde content of boiled poultry meat obtained from the markets ranged from 0.02 mg/kg to 3.54 mg/kg (mean±SD; 1.104±1.0 mg/kg) (Table 2).

These values were significantly lower than that of corresponding raw meat samples (P<0.05). Boiling for ten minutes reduced the formaldehyde content of the raw meat samples by 60%. There was significant correlation (r= 0.7) between pre-heating and post-heating formaldehyde content of the meat samples (P<0.05). However, the reduction in the formaldehyde content of samples from market E deviated from the trend obtained from Market A through Market D. we regard this unexpected trend
Table 1. Formaldehyde levels of raw meat samples

<table>
<thead>
<tr>
<th>Markets Species</th>
<th>Market A</th>
<th>Market B</th>
<th>Market C</th>
<th>Market D</th>
<th>Market E</th>
<th>Farm (control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td>Chicken</td>
<td>Turkey</td>
<td>Chicken</td>
<td>Turkey</td>
<td>Chicken</td>
<td>Turkey</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch 1</td>
<td>0.56±0.00</td>
<td>0.48±0.00</td>
<td>0.78±0.01</td>
<td>0.48±0.00</td>
<td>0.37±0.00</td>
<td>0.55±0.01</td>
</tr>
<tr>
<td>levels of poultry</td>
<td>6.29±0.05</td>
<td>6.71±0.03</td>
<td>4.96±0.02</td>
<td>6.33±0.00</td>
<td>4.18±0.03</td>
<td>7.47±0.04</td>
</tr>
<tr>
<td>meat (mg/kg)</td>
<td>2.06±0.07</td>
<td>3.11±0.05</td>
<td>1.32±0.09</td>
<td>2.49±0.08</td>
<td>2.96±0.04</td>
<td>4.17±0.18</td>
</tr>
</tbody>
</table>

*Significant (P<0.005)

Table 2. Formaldehyde levels of boiled meat samples

<table>
<thead>
<tr>
<th>Markets Species</th>
<th>Market A</th>
<th>Market B</th>
<th>Market C</th>
<th>Market D</th>
<th>Market E</th>
<th>Farm (control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td>Chicken</td>
<td>Turkey</td>
<td>Chicken</td>
<td>Turkey</td>
<td>Chicken</td>
<td>Turkey</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch 1</td>
<td>0.18±0.00</td>
<td>0.23±0.00</td>
<td>0.20±0.00</td>
<td>0.15±0.00</td>
<td>0.84±0.00</td>
<td>0.07±0.00</td>
</tr>
<tr>
<td>levels of poultry</td>
<td>1.78±0.02</td>
<td>0.22±0.01</td>
<td>1.33±0.01</td>
<td>1.61±0.02</td>
<td>2.51±0.03</td>
<td>2.78±0.01</td>
</tr>
<tr>
<td>meat (mg/kg)</td>
<td>0.95±0.01</td>
<td>1.73±0.02</td>
<td>0.31±0.02</td>
<td>0.53±0.02</td>
<td>1.26±0.06</td>
<td>1.73±0.02</td>
</tr>
</tbody>
</table>

*Boiled for ten minutes, **Significant(P<0.005)

Discussion

The health risk of exposure to formaldehyde has been extensively studied with the main concern being its genotoxic and carcinogenic potentials. (Spert, 2006, Norlina, 2009, WHO 2002). The significantly higher formaldehyde content of imported poultry meat compared to the locally produced poultry in Ibadan, Nigeria, implies a higher formaldehyde exposure level in people who consume such smuggled imported poultry products which are relatively cheaper.

The obtained values in this study were slightly above the 2.5-5.7 mg/k range of naturally occurring levels of formalin in poultry as proposed by Otuh et al. (2001). The slight increase in the post-heating formaldehyde levels of the control Farm (control) samples may be attributed to the high formaldehyde content of the batch, higher than the other two batches. Batch 2 had significantly higher formaldehyde content of raw meat (mg/kg) to which 4%, 2%, 1%, 0.5%, and 0% aqueous formaldehyde solution had been added after boiling for ten minutes.
Fig. 1. Formaldehyde content of raw and boiled meat samples

Fig. 2. Formaldehyde content of meat samples from different batches
As seen from Table (2), this study shows that boiling significantly reduces the formaldehyde levels in poultry meat which implies reduced consumer exposure to the contaminant. A similar reduction in formaldehyde levels in Shiitake mushrooms after 6 minutes of boiling has been reported by Food Standards Agency (FSA, 2013).

The relatively high formaldehyde levels of batch 2 samples (4.16-7.47 mg/kg) may not be unconnected to either deterioration due to post mortem formaldehyde production in meat samples as a result of prolonged storage or most likely illegal addition of formalin as preservative by the smugglers. These activities of the smugglers are usually due to sale pressure accompanied by increased demand for poultry products by consumers during festivities. There are few or no social or religious stigmas attached to the use of poultry meat in human diet (Foraminifera, 2012). This demand for poultry meat, which is increased during festive periods, is not met by local poultry production and leaves a gap which is unfortunately filled with smuggled products.

Efforts should be geared towards increased local production of poultry meat to fill supply gap. In addition, government should ensure enforcement of strict measures against smuggling and provide adequate mechanism for continuous assessment of poultry meat before sales. It is imperative that wholesome meat be always made available for the health safety of consumers. Furthermore, we advocate that consumers of frozen poultry meat in should patronize local poultry producers. Consumers when in doubt of the source, cook purchased meat thoroughly since boiling significantly reduced the formaldehyde content of the poultry meat samples.

References