Some Heavy Metals Residues in Chicken Meat and their Edible Offal in New Valley

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Abstract

Metals present in food as a result of many of the human activities. The heavy metal of concern as it exert harmful effects on health such as Arsenic (Ar), cadmium (Ca), copper (Cu), iron (Fe), lead (Pb) and mercury (Hg) are toxic due to the their accumulation in the biological tissues. A total of 400 chicken meat breast, thigh, liver and gizzard samples (100 of each) were randomly collected from Elkharga chicken butchers, New Valley governorate, Egypt, to estimate their residual content. The mean values of arsenic in breast, thigh, liver and gizzard samples were 0.36 ± 0.02 µg/g, 0.49 ± 0.01 µg/g, 0.77 ± 0.06 µg/g and 0.85 ± 0.05 respectively. While the mean values of cadmium were; 0.03 ± 0.01 µg/g, 0.04 ± 0.02 µg/g, 0.05 ± 0.03 µg/g and 0.02 ± 0.01 µg/g. The mean values of copper residues were; 0.15 ± 0.012 µg/g, 0.26 ± 0.008 µg/g, 1.16 ± 0.008 µg/g and 0.35 ± 0.003 µg/g respectively. The mean values of iron were 6.77 ± 0.24 µg/g, 7.49 ± 0.18 µg/g, 9.36 ± 2.96 µg/g and 5.85 ± 1.85 µg/g respectively. The mean values of lead were 0.25 ± 0.008 µg/g, 0.26 ± 0.016 µg/g, 0.31 ± 0.017 µg/g and 0.30 ± 0.017 µg/g respectively and the mean values of mercury residues were; 0.19 ± 0.008 µg/g, 0.20 ± 0.016 µg/g, 0.34 ± 0.017 µg/g and 0.28 ± 0.017 µg/g respectively. All examined samples were laid within the permissible limits set by the Egyptian Organization for Standardization and Quality Control, to avoid the accumulation effect of the heavy metals more governmental efforts are needed to control the environmental pollution and improve the environment quality of New Valley Zoon.

Introduction

The world-wide commercial poultry industry is well-developed and is the largest supplier of animal protein and good source of essential amino acids, vitamins and minerals for human consumption in the form of meat and eggs. Its significance is even greater in developing countries where chicken are relatively cheap and can be kept in a small area, usually providing an excellent source of high quality and most palatable animal protein due to its high meat yield, low shrinkage during cooking and low cost. The chicken meat has a good advantage in comparison with beef meat, but sometime poultry may carry heavy metals and other elements which may be naturally present in air, water, soil and poultry food or can reach it as a result of human activities such as industrial and agricultural processes (Järup, 2003; Islam et. al., 2007 and Faten et. al., 2014).

The metals of particular concern in relation to harmful effects on health are mercury, lead, cadmium, tin and arsenic, which are often referred to as “heavy metals”. The toxicity of these metals is in part due to the fact that they accumulate in biological tissues, a process known as bioaccumulation. This process of bioaccumulation of metals occurs in all living organisms as a result of exposure to metals in food and the environment, including food animals such as poultry, poultry and fish as well as humans The toxic effect of these metals including the central and peripheral nervous systems, gastrointestinal and genital systems, damage of tubular cells in gizzards, hepatic toxicity, immune system and carcinogenesis (Pikkemaat, 2009).

In view of the fact that there are very little or no available original data on content of metals in tissues of domestic animals and poultry in New Valley Governorate. Therefore we performed this study in order to determine the
concentration level of some of the most health hazardous heavy metals; arsenic, cadmium, copper, iron, lead and mercury in (meat, liver and gizzard) of poultry from New Valley Governorate, Egypt.

Material and Methods

Study area: A cross-sectional study was conducted in New Valley poultry butchers and markets to determine the concentration levels of heavy metals residues in meat and edible offal of poultry. Samples have been randomly collected from the poultry butchers and markets. The chemical analyses were carried out in the Animals Health Researches Laboratory Institute, El-Doky, Egypt.

Sampling: A total of 400 random samples of chicken meat (breast and thigh), liver and gizzard samples (100 of each) from 100 carcasses randomly collected from New Valley chicken butchers and markets. Each samples was rapped in plastic bag then identified and transferred in an ice-box to the laboratory for evaluation.

Sample preparation: The samples were prepared and digested with 10 ml of nitric / sulfuric / perchloric acids (8: 1: 1). Initial digestion was made for 4 hours at room temperature followed by heating at 40-45°C for one hour in water bath then temperature was raised to 75°C until the end of digestion. After cooling at room temperature the cold digest was diluted to 20 ml with deionized water and filtered through 0.45 µl Whitman filter paper. The clear filtrate of each sample was kept in refrigerator to avoid evaporation.

Determination of Heavy Metals Residues:
The standard solutions were analyzed for Arsenic, cadmium, copper, iron, lead and mercury by Atomic Absorption Spectrophotometer (Sens AA; GBC scientific EQUIPMENT Spectrophotometer) at the adjusted conditions as follow:

<table>
<thead>
<tr>
<th>Metal</th>
<th>Lamp Wave Length (nm)</th>
<th>Slit Width (nm)</th>
<th>Lamp Current (ma)</th>
<th>Fuel Flow Rate (l/min)</th>
<th>Burner Height (cm)</th>
<th>Detection Limit (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ar</td>
<td>193.7</td>
<td>0.7</td>
<td>5</td>
<td>30</td>
<td>8</td>
<td>0.02</td>
</tr>
<tr>
<td>Ca</td>
<td>228.8</td>
<td>0.7</td>
<td>5</td>
<td>30</td>
<td>8</td>
<td>0.01</td>
</tr>
<tr>
<td>Cu</td>
<td>217.0</td>
<td>0.7</td>
<td>5</td>
<td>30</td>
<td>5</td>
<td>0.05</td>
</tr>
<tr>
<td>Fe</td>
<td>235.6</td>
<td>0.7</td>
<td>5</td>
<td>30</td>
<td>8</td>
<td>0.01</td>
</tr>
<tr>
<td>Pb</td>
<td>248.3</td>
<td>0.7</td>
<td>12</td>
<td>30</td>
<td>8</td>
<td>0.01</td>
</tr>
<tr>
<td>Hg</td>
<td>243.5</td>
<td>0.7</td>
<td>5</td>
<td>30</td>
<td>7</td>
<td>0.01</td>
</tr>
</tbody>
</table>

The calculation of residual levels (µg/g wet weight) using the following equation:

Element, (ppm, mg/kg) = R × D/W

Where:

R= Reading of element concentration, ppm from the digital scale of AAS.

D= Dilution of the prepared sample.

W= Weight of the sample.

Statistical Analysis (GraphPad Instant, 2009): The statistical program, GraphPad Instant version 3 for window, was used for determination of means, the analysis of variance between the different data and treatment in this study were determined using standard error and analysis of variance (P<0.05). Figures were used to display the significance difference at the 5% level between the obtained results.

Discussion

Arsenic

The mean concentrations of arsenic in (breast, thigh) poultry meat samples, liver and gizzard were presented in table (1). The mean arsenic values in the (breast, thigh) poultry meat samples, liver and gizzard samples of 0.36±0.02 µg/g, 0.49±0.01 µg/g, 0.77±0.06 µg/g and 0.85±0.05 µg/g respectively. The arsenic concentration levels were: gizzard> liver> breast meat > thigh meat.

It was cleared that the poultry samples had a significant effect (P>0.05) on the arsenic levels in the examined samples. Similar results were recorded in poultry samples by ANZFA, (2001) other investigators obtained a lower arsenic concentration than this study (Mariam, et. al., 2004; Akan et. al., 2010 and Mohammed et. al., (2013)).

The Egyptian Organization for Standardization and Quality Control (EOS. No. 7136, 2010) dose not set a permissible limit for arsenic
residues in poultry meat and offal. Arsenic accumulation in meat is very low and the principal tissues involved in accumulation were the gizzards and liver. Inorganic arsenic initially shows as cutaneous vasodilatation than later as hyperpigmentation and hyperkeratosis then skin cancers (Miranda et al., 2003 and Hafez, 2009).

**Cadmium**

The mean concentrations level for cadmium residues in (breast, thigh) poultry meat, liver and gizzard samples were presented in table (2). The mean cadmium values in the meat, liver and gizzard samples of 00.03± 0.01 µg/g, 0.04± 0.02 µg/g, 0.05± 0.03 µg/g and 0.02± 0.01 µg/g. The cadmium concentration levels were; liver> thigh meat> breast meat> gizzard. It was cleared that the poultry samples had a significant effect (P>0.05) on the cadmium levels in the examined samples.

Other investigators obtained the same results from poultry samples (Iwegbue et al., 2008; Reem et al., 2012; Hamasalim & Mohammed 2013 and Faten et. al., 2014). The obtained results were higher than those obtained by (Ghimpeteanau et al., 2012 and Mohammed et. al., 2013). Cadmium is apparently non-essential element which is absent at birth but accumulate at gizzard and that occur with increasing of age called tissue specific bioaccumulation (Nasef & Hamouda, 2008; Atiah, 2011 and Khalafalla et. al., 2011). Cadmium cause sever respiratory symptoms, gizzard dysfunction such as; nephrotoxicity, glucosuria, aminoaciduria and decrease the glomerular filtration rate, cadmium may lead to hypertension, hepatic injury and lung damage. Cadmium chloride at teratogenic dose induced significant alterations in the detoxification enzymes in the liver and the gizzard. They added that cadmium cause osteoporosis and osteomalacia and that known as Itai-Itai disease (Akesson et. al., 2009; Akan et. al., 2010 and Faten et. al., 2014).

The Egyptian Organization for Standardization and Quality Control (EOS. No. 7136, 2010) is set a permissible limit for cadmium residues in poultry meat and offal which must be not exceed than 0.05 µg/g for meat and 1.0 µg/g for poultry offal. According to this limits, all examined samples (100%) were within the permissible limits and considered safe for human consumption.

**Copper**

The mean concentrations level for copper residues in meat, liver and gizzard samples were presented in table (3). The mean copper values in (breast, thigh) poultry meat, liver and gizzard of poultry samples were; 0.15± 0.012 µg/g, 0.26± 0.008 µg/g, 1.16± 0.008 µg/g and 0.35± 0.003 µg/g respectively. The highest concentration levels for copper were recorded in liver samples. The lowest concentration levels for copper were recorded in liver samples. The copper concentration levels were; liver> gizzard > thigh meat > breast meat.

The same observation was reported in meat and edible offal of slaughtered poultry by (Mariam et al., 2004; Aiad et. al., 2007; Iwegbue et. al., 2008 and Hamasalim & Mohammed 2013). On the contrary, some authors had reported higher copper concentration in gizzard than liver samples (El-Sakkary, 2007; Ghimpeteanau et. al., 2012 and Faten et. al., 2014). The investigated animals had a significant effect (P>0.05) on the copper levels in the poultry meat examined samples and non significant effect in liver and gizzard examined samples.

The Egyptian Organization for Standardization and Quality Control (EOS. No. 7136, 2010) is set a permissible limit for copper residues in meat and offal which must be not exceed than 15.0 µg/g for meat and edible offal. According to this limits, all examined samples (100%) were within the permissible limits and considered safe for human consumption.

Copper is an important constituent in a number of different enzymes in man and animals; it accumulates mostly in muscle and liver acting as essential element, but it may cause chronic toxicity for both animals and humans when its concentrations crosses the safe limits. Copper
toxicity including jaundice, nausea, severe colic, diarrhea, while chronic disease was epitomized by wilson’s disease which characterized by excessive copper deposition in most organs as liver, gizzard, brain and eyes, so consumption of such meat from polluted environment may pose human health hazards (Brito et. al., 2005; Nnaji et. al., 2007; Morshdy, 2010 and Faten et. al., 2014).

Iron

The mean concentrations level for iron residues in (breast, thigh) poultry meat, liver and gizzard samples were presented in table (4). The mean iron values in the meat, liver and gizzard samples of 6.77± 0.24 µg/g, 7.49± 0.18 µg/g, 9.36± 2.96 µg/g and 5.85± 1.85 µg/g. The iron concentration levels were; liver> thigh meat> breast meat > gizzard. It was cleared that the poultry samples had a significant effect (P>0.05) on the iron levels in the examined samples.

Other investigators obtained the same results from poultry samples (Reem et. al., 2012). The obtained results were higher than those obtained by (Hamasalim & Mohammed 2013; Mohammed et. al., 2013). While the obtained results were lower than those obtained by (Iwegbue et. al., 2008 and Al-Ashmawy, 2013). Iron is an essential dietary element for humans and animals as it is an essential component of hemoglobin. Iron facilitates the oxidation of carbohydrate, proteins and fats to control body weight. Low iron concentration level increases suitability to gastrointestinal infections, nose bleeding, and myocardial infarctions. Iron occurs as a natural constituent of all foods of plant and animal origin and may also be present in drinking water. The effects of toxic doses of iron in animals include depression, coma, convulsions respiratory failure and cardiac arrest. Post-examination of intoxicated animals revealed adverse effects on the gastrointestinal tract (Al-Ashmawy, 2013).

The Egyptian Organization for Standardization and Quality Control (EOS. No. 7136, 2010) is set a permissible limit for cadmium residues in poultry meat and offal which must be not exceed than 15.0 µg/g for meat and 20.0 µg/g for poultry offal. According to this limits, all examined samples (100%) were within the permissible limits and considered safe for human consumption.

Lead

The mean concentrations level for lead residues in meat, liver and gizzard samples were presented in table (5). The mean lead values in the meat, liver and gizzard samples were; 0.25±0.008 µg/g, 0.26±0.016 µg/g, 0.31±0.017 µg/g and 0.30±0.017 µg/g. The lead concentration levels were; liver> gizzard > thigh meat > breast meat. It was cleared that the poultry samples had a significant effect (P>0.05) on the iron levels in the examined samples.

Other investigators obtained the same results recorded from meat samples (Mariam et. al., 2004; Iwegbue et. al., 2008; Oforka et. al., 2012 and Okeke et. al., 2015). The concentration of lead in samples is low compare to that of (Reem et. al., 2012 and Hamasalim & Mohammed 2013).

Lead has attendance to bio-accumulate in human tissues and organs mainly in the liver, gizzards and bones leading to several diseases. Absorbed lead in human body has biologic half-life in bone about 27 years (Hanaa et. al., 2004 and Food Standards 2005). Lead encephalopathy in children due to lead toxicity characterized by irritability, ataxia, convulsion and altered state of consciousness, whereas lead toxicity in adults lead to neuropathy result in wrist and food drop (European Commission, 2001; Nishijo et. al., 2002; Adekunle et. al., 2003; Jarup, 2003 and Lidsky & Schneider, 2003). Other diseases as haemolytic anemia, atherosclerosis, liver apoptosis, renal toxicity and atrophy of the ovary may be occur (D’Mello, 2004; Johansen et. al., 2004; Kocak et. al., 2005; Regina et. al., 2007; Miranda et. al., 2009; Itodo and Itodo, 2010 and Khalafalla et. al., 2011).

The Egyptian Organization for Standardization and Quality Control (EOS. No. 7136, 2010) is set a permissible limit for lead residues in meat

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and offal which must be not exceed than 0.1 mg/kg for meat and 0.5 mg/kg for edible offal. According to this limits, all examined samples (100%) were within the permissible limits and considered safe for human consumption.

### Mercury

The mean concentrations level for iron residues in (breast, thigh) poultry meat, liver and gizzard samples were presented in table (6). The mean iron values in the meat, liver and gizzard samples of 0.19± 0.008 µg/g, 0.20± 0.016 µg/g, 0.34± 0.017 µg/g and 0.28± 0.017 µg/g. The mercury concentration levels were; liver> gizzard > thigh meat > breast meat. It was cleared that the poultry samples had a significant effect (P>0.05) on the iron levels in the examined samples.

It was cleared that the poultry samples had a significant effect (P>0.05) on the mercury levels in the examined samples. Other investigators obtained the same results from poultry samples (Ghimpeteanu et. al., 2012; Faten, et. al., 2014; Okeke et. al., 2015). The obtained results were higher than those obtained by (Aiad et. al., 2007).

Mercury is widespread and persistent pollutant in the environment and is among the most highly bioconcentrated trace metals in the human food chain. Mercury is a constant component of municipal sewage, which may be used as soil conditioner and agricultural fertilizer, which creates a serious danger of introducing this heavy metal into food products and feeds for farm animals. The main source of heavy metals in chicken meat arises from contamination of poultry feed and drinking water. Other sources of contamination can be vehicle emission and dirty slaughter places (Clarkson, 2002; Zarski et. al., 2003; Tuzen et. al., 2009 and Ghimpeteanu et. al., 2012).

The Egyptian Organization for Standardization and Quality Control (EOS. No. 7136, 2010) is set a permissible limit for cadmium residues in poultry meat and offal which must be not exceed than 0.2 µg/g for meat and 0.5 µg/g for poultry offal. According to this limits, all examined samples (100%) were within the permissible limits and considered safe for human consumption.

### Conclusion

This study set out to elucidate the concentration of Arsenic, cadmium, copper, iron, lead and mercury residual recorded in poultry meat and edible offal, the concentration of all the heavy metals were found to be high level in liver, gizzard and meat respectively and below the permissible limits. In order to control these pollutants to gain access to chicken meat and offals, a good quality raw meat should be used. Purchase chicken from reputable sources, markets and grocers with a history of providing safe food to customers. Education and training of food handlers and consumers about harmful effects of chemical residues in foods is the key stone of effective quality control. Application of hazard analysis and critical control point (HACCP) system may be the appropriate solution to ensure quality and safety of such products particularly during preparation and serving. More governmental efforts still needed to control environmental pollution and improve the environment quality of New Valley Zone.

### Acknowledgments

I wish to express my deeply profound gratitude to my supervisor Prof. Dr. Ali Meawad Ahmed, Vice Dean Faculty of Veterinary Medicine, Suez Canal University, who helped me and supported me throughout my scientific life.

### References


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Okeke, O.; Ujah, I.; Okoye, P.; Ajiwe, V. and Eze, C. (2015): Assessment of the heavy metal levels in feeds and litters of chickens rose with in Awka Metropolis and its environs. IOSR journal of applied chemistry (IOSR-JAC), 8 (1) 60-63.


### Table (1)

<table>
<thead>
<tr>
<th>Poultry Samples</th>
<th>Minimum (µg/gm)</th>
<th>Maximum (µg/gm)</th>
<th>Mean (µg/gm)</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breast</strong></td>
<td>0.07</td>
<td>0.91</td>
<td>0.36^a</td>
<td>± 0.02</td>
</tr>
<tr>
<td><strong>Thigh</strong></td>
<td>0.19</td>
<td>0.65</td>
<td>0.49^b</td>
<td>± 0.01</td>
</tr>
<tr>
<td><strong>Liver</strong></td>
<td>0.21</td>
<td>0.51</td>
<td>0.77^c</td>
<td>± 0.06</td>
</tr>
<tr>
<td><strong>Gizzard</strong></td>
<td>0.55</td>
<td>0.98</td>
<td>0.85^d</td>
<td>± 0.05</td>
</tr>
</tbody>
</table>

Columns with the same letter were not significantly differences P<0.05

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Table (2)
Mean Concentrations Level of Cadmium Residues in (Breast, Thigh) Poultry Meat, Liver and Gizzard of Poultry Samples

<table>
<thead>
<tr>
<th>Poultry</th>
<th>Minimum (µg/gm)</th>
<th>Mean (µg/gm)</th>
<th>Maximum (µg/gm)</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast</td>
<td>0.01</td>
<td>0.03</td>
<td>0.05</td>
<td>± 0.01</td>
</tr>
<tr>
<td>Thigh</td>
<td>0.01</td>
<td>0.04</td>
<td>0.06</td>
<td>± 0.02</td>
</tr>
<tr>
<td>Liver</td>
<td>0.02</td>
<td>0.05</td>
<td>0.07</td>
<td>± 0.03</td>
</tr>
<tr>
<td>Gizzard</td>
<td>0.01</td>
<td>0.05</td>
<td>0.07</td>
<td>± 0.01</td>
</tr>
</tbody>
</table>

Columns with the same letter were not significantly different P<0.05

Table (3)
Mean Concentrations Level of Copper Residues in (Breast, Thigh) Poultry Meat, Liver and Gizzard of Poultry Samples

<table>
<thead>
<tr>
<th>Poultry</th>
<th>Minimum (µg/gm)</th>
<th>Mean (µg/gm)</th>
<th>Maximum (µg/gm)</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast</td>
<td>0.10</td>
<td>0.19</td>
<td>0.20</td>
<td>± 0.012</td>
</tr>
<tr>
<td>Thigh</td>
<td>0.23</td>
<td>0.28</td>
<td>0.30</td>
<td>± 0.008</td>
</tr>
<tr>
<td>Liver</td>
<td>1.13</td>
<td>1.18</td>
<td>1.20</td>
<td>± 0.008</td>
</tr>
<tr>
<td>Gizzard</td>
<td>0.34</td>
<td>0.36</td>
<td>0.36</td>
<td>± 0.003</td>
</tr>
</tbody>
</table>

Columns with the same letter were not significantly different P<0.05

Table (4)
Mean Concentrations Level of Iron Residues in (Breast, Thigh) Poultry Meat, Liver and Gizzard of Poultry Samples

<table>
<thead>
<tr>
<th>Poultry</th>
<th>Minimum (µg/gm)</th>
<th>Mean (µg/gm)</th>
<th>Maximum (µg/gm)</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast</td>
<td>5.71</td>
<td>7.40</td>
<td>7.49</td>
<td>± 0.24</td>
</tr>
<tr>
<td>Thigh</td>
<td>6.95</td>
<td>8.02</td>
<td>8.49</td>
<td>± 0.18</td>
</tr>
<tr>
<td>Liver</td>
<td>78.32</td>
<td>96.08</td>
<td>93.65</td>
<td>± 2.96</td>
</tr>
<tr>
<td>Gizzard</td>
<td>6.79</td>
<td>17.89</td>
<td>5.85</td>
<td>± 1.85</td>
</tr>
</tbody>
</table>

Columns with the same letter were not significantly different P<0.05

Table (5)
Mean Concentrations Level of Lead Residues in (Breast, Thigh) Poultry Meat, Liver and Gizzard of Poultry Samples

<table>
<thead>
<tr>
<th>Poultry</th>
<th>Minimum (µg/gm)</th>
<th>Mean (µg/gm)</th>
<th>Maximum (µg/gm)</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast</td>
<td>0.10</td>
<td>0.49</td>
<td>0.25</td>
<td>± 0.008</td>
</tr>
<tr>
<td>Thigh</td>
<td>0.23</td>
<td>0.28</td>
<td>0.26</td>
<td>± 0.016</td>
</tr>
<tr>
<td>Liver</td>
<td>0.25</td>
<td>0.63</td>
<td>0.31</td>
<td>± 0.017</td>
</tr>
<tr>
<td>Gizzard</td>
<td>0.22</td>
<td>0.36</td>
<td>0.30</td>
<td>± 0.017</td>
</tr>
</tbody>
</table>

Columns with the same letter were not significantly different P<0.05

Table (6)
Mean Concentrations Level of Mercury Residues in (Breast, Thigh) Poultry Meat, Liver and Gizzard of Poultry Samples

<table>
<thead>
<tr>
<th>Poultry</th>
<th>Minimum (µg/gm)</th>
<th>Mean (µg/gm)</th>
<th>Maximum (µg/gm)</th>
<th>Error</th>
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<tbody>
<tr>
<td>Breast</td>
<td>0.10</td>
<td>0.29</td>
<td>0.19</td>
<td>± 0.008</td>
</tr>
<tr>
<td>Thigh</td>
<td>0.13</td>
<td>0.26</td>
<td>0.20</td>
<td>± 0.016</td>
</tr>
<tr>
<td>Liver</td>
<td>0.25</td>
<td>0.63</td>
<td>0.34</td>
<td>± 0.017</td>
</tr>
<tr>
<td>Gizzard</td>
<td>0.21</td>
<td>0.36</td>
<td>0.28</td>
<td>± 0.017</td>
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Columns with the same letter were not significantly different P<0.05

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