

Control of Cadmium, Copper, Iron and Lead Residues in Chicken Meat and Their Offal

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Abstract

The cadmium (Cd), copper (Cu), iron (Fe) and lead (Pb) as heavy metal may reach chicken meat as a result of many of human activities causing severe health hazards to consumers by its accumulative effect. Therefore, A total of 100 chicken meat and their offal (50 of each) were randomly collected from chicken butchers at New Valley governorate, Egypt to evaluate the effect of grilling, marination and simmering on the metals residues. The mean concentration levels of Cd, Cu, Fe and Pb in chicken meat were; 0.04 ± 0.03 , 0.19 ± 0.090 , 7.130 ± 0.251 , $0.30 \pm 0.195 \mu\text{g/g}$ respectively. While in offal were; 0.056 ± 0.035 , 0.76 ± 0.420 , 87.16 ± 2.485 , $0.45 \pm 0.190 \mu\text{g/g}$ respectively. In concern to Egyptian standard and WHO/FAO all samples were within the permissible limit and fit for human consumption. Properly cooking of chicken has limited reducing the potency of heavy metals in food, depending on cooking (temperature, cooking medium and time). The most cooking method decline the concentration levels of Cd, Cu, Fe and Pb was simmering which reduce the concentration level in chicken meat to; 0.0 for Cd, 0.15 ± 0.00 , 5.97 ± 0.294 , $0.10 \pm 0.010 \mu\text{g/g}$ for Cu, Fe, Pb respectively in simmered chicken meat samples and were; 0.0 for Cd, 0.46 ± 0.240 , 73.18 ± 2.850 , $0.24 \pm 0.0135 \mu\text{g/g}$ for Cu, Fe, Pb respectively in simmered chicken offal samples. More studies still needed to control environmental pollution in chicken meat & offals.

Keywords: Heavy metals; Chicken; Simmering; Grilling; Marination; Cooking

Introduction

The overall chicken industry is the biggest supplier of acceptable animal protein with high meat yield, low shrinkage in cooking and great source of amino acids, vitamins and minerals for human utilization as chicken meat. Chicken meat may carry heavy metals which might be actually present in air, water, soil and chicken nourishment or can achieve it as a consequence of human activities^[1-3]. The most heavy metals poisonous due to their aggregation in living tissues and hazard; nervous systems, gastrointestinal and genital systems, hepatic toxicity, immune system and carcinogenesis^[4-6].

Cooking methods of chicken as; grilling, marination, simmering which uses to increase palatability, increase flavor, tenderness and aroma of food and decrease microbial load and break down some hazardous residues in food. Grilling is a method of cooking which involves the application of dry heat to the food. The food is usually place on a Grill, a wire grid with a heat source on the top or below the grid. Marination is soaking food items in a mixture of flavoring ingredients, containing spices, an acid and one oil, Simmering is a moist heat of food in hot water at a temperature slightly lower the boiling^[7].

Heavy metals is one of the most dangerous elements which may reach to consumers not only by polluted environment but also by ingestion of contaminated food by these serious elements which cannot be tasted, smelled or seen be hidden in meat and offals. Cadmium (Cd), and lead (Pb) considered the most heavy metals distributed in our environment and may cause a many side effects to human. However, Copper (Cu),

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Iron (Fe) are essential for human health, they are the main components of vitamins and enzymes but ingestion of over doses causes harmful effects on consumers^[8-14].

One of the most human health hazardous element is cadmium which accumulated in kidney about 10 years with accumulated effect which may resulted in adverse renal effects, moreover its adverse effect on the pain center of the brain, lungs, blood vessels and heart, its toxic dose leading to fatigue, scaly and dry skin, hair loss, anemia, immune suppression, hepatic dysfunction, joint pain, hypertension, renal stones and yellowish teeth^[15-17]. Pb is has neurotoxin which inactivate many cellular components and act with some essential body enzymes in addition to its adverse effect on cardiovascular and increasing the blood pressure of the adults and retardation of the children mental performance^[18,19].

There are almost no available studies performed to control heavy metals in chicken meat and offals thus, we performed this study to examine the effect of some cooking techniques on some heavy metals; cadmium, copper, iron and lead in (meat and offal) of chicken.

Material and Methods

Ethical approval

The Animal Rights and Ethical Use Committee of Assiut Universities have approved this study.

Study area: A cross-sectional study was in fresh chicken meat and offals marketed in New Valley, Egypt to determine the concentration levels of heavy metals deposits in chicken meat and consumable offal. The investigations done in the Animals Health Researches Laboratory Institute, El-Doky, Egypt.

Sampling: A total of 100 irregular specimens of chicken meat, and offal tests (50 of each) gathered from chicken butchers and markets in New Valley governorate, Egypt, each sample was wrapped in plastic pack then identified and moved in an ice-box to the research center for assessment.

Sample preparation: The samples were prepared and digested with 10 ml of nitric / sulfuric / perchloric acids (Oxoid) (8: 1: 1). Initial digestion was made for 4 hours at room temperature followed by warming 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 cadmium, copper, iron and lead by Atomic Absorption Spectrophotometer (Sens AA; GBC scientific equipment *Spectrophotometer*) at the adjusted conditions as follow:

Metal	Lamp Wave Length (nm)	Slit Width (nm)	Lamp Current (ma)	Fuel Flow Rate (l/min)	Burner Height (cm)	Detection Limit (ppm)
Cd	228.8	0.7	5	30	8	0.01
Cu	217.0	0.7	5	30	5	0.05
Fe	235.6	0.7	5	30	8	0.01
Pb	248.3	0.7	12	30	8	0.01

The calculation of residual levels ($\mu\text{g/g}$ wet weight) using the following equation:

$$\text{Element, (ppm, mg/kg)} = R \times D/W$$

Where:

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

D= Dilution of the prepared sample.

W= Weight of the sample.

Experimental Trials

Effect of grilling on heavy metals residues

Each positive meat sample for cadmium, copper, iron and lead residues was placed into grill for 30 minutes then cooling. Each sample putted in clean bottle, identified and sends to laboratory for quantitative evaluation of heavy metals.

Effect of marinating on heavy metals residues

Each positive sample was marinated using the following formula: about 1 g commercial Egyptian table salt iodine free, 5 g Egyptian red onion “Allium cepa”, 5 mL Lemon juice “Rutaceae Citrus” and 1g black pepper “PiperaceaeNigrum”). Meat, liver and kidney samples were kept in marinade for 4 hours at 4°C. Then of the samples for evaluation of the same heavy metals.

Effect of simmering on heavy metals residues

Each positive sample heavy metals (cadmium, copper, iron, and lead) residues (25g.) was placed into strainer contained 50 ml. di-ionized water then heated to 100 °C and cooked for 30 minutes then allow to cool. Each sample putted in clean bottle, identified and sends to laboratory for quantitative evaluation of antibiotics and heavy metals.

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 ($P < 0.05$).

Results and Discussion

Cadmium

The mean concentrations level for cadmium residues in chicken meat and offal samples presented in figure (1). The mean cadmium values in the meat samples in raw, grilling and marinating cases was; $0.04 \pm 0.03 \mu\text{g/g}$, $0.07 \pm 0.030 \mu\text{g/g}$, $0.02 \pm 0.011 \mu\text{g/g}$ respectively while, (Cd) not detected in simmered chicken meat samples, while were; $0.056 \pm 0.035 \mu\text{g/g}$, $0.66 \pm 0.035 \mu\text{g/g}$

$\mu\text{g/g}$, $0.03 \pm 0.025 \mu\text{g/g}$ in raw, grilled, marinated offal chicken samples respectively while, (Cd) not detected in simmered offal chicken samples. The cadmium concentration levels were; raw> grilling> marinating> simmering samples. It was cleared that the chicken samples had a significant effect ($P > 0.05$) on the cadmium levels in the examined samples. Other investigators obtained the same results from chicken samples^[20-22]. Cadmium is apparently non-essential element which is absent at birth but accumulate at gizzard and increasing by age called tissue specific bioaccumulation^[9,23,24].

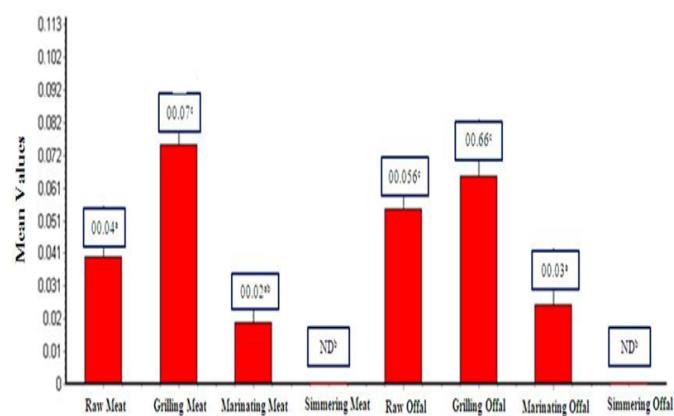


Figure 1: Cadmium concentrations in different meat and offal

Cadmium cause severe respiratory symptoms, nephrotoxicity, glucosuria, aminoaciduria, hypertension, hepatic injury and lung damage. Cadmium chloride at teratogenic dose induced significant alterations in the detoxification enzymes in the liver and cause osteoporosis, osteomalacia and that known as Itai-Itai disease^[8,25,26].

According to WHO (2010)^[15] the provisional tolerable monthly intake for cadmium of $2 \mu\text{g/kg}$ body weight. The Egyptian Organization for Standardization and Quality Control (EOS., 2010)^[27] is set a permissible limit for cadmium residues in chicken meat and offal which must be not exceed than $0.05 \mu\text{g/g}$ for meat and $1.0 \mu\text{g/g}$ for chicken 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 chicken meat and offal's samples presented in figure (2) observed the relatively similar effect of different cooking methods in reducing the copper residues in chicken meat and offal respectively. The mean copper values in raw, grilled, marinated and simmered in chicken meat samples were; 0.19 ± 0.090 , 0.18 ± 0.080 , 0.13 ± 0.055 and $0.15 \pm 0.00 \mu\text{g/g}$ respectively. While it was, 0.76 ± 0.420 , 0.73 ± 0.420 , 0.78 ± 0.400 and $0.46 \pm 0.240 \mu\text{g/g}$ in chicken offal samples respectively. The highest concentration levels for copper recorded in chicken offal samples. The copper concentration levels were; raw> grilling> marinating> simmering samples. The investigated animals had a significant effect ($P > 0.05$) on the copper levels in the chicken examined samples. Other investigators obtained the same results from chicken samples by (Perelló *et. al.*, 2008)^[20]. Aditya, *et. al.*, (2014)^[28] found that simmering decreased level of iron due to change iron to

ferrous iron which may decrease iron about 89%, cooking digested meat proteins producing iron-binding peptides. On the other hand, (Gharaibeh, 1993 and Farag, 2002)^[29,30] reported that marination used to prepare meat and offal before cooking may resulted in decreased copper values in meat and kidney samples while the values of copper in liver samples arisen up.

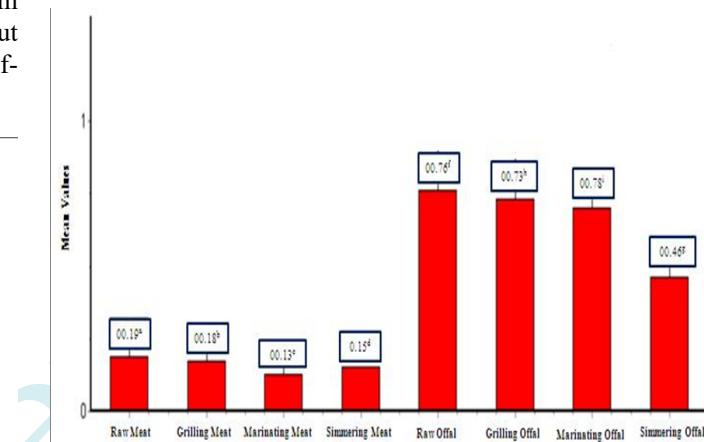


Figure 2: Copper concentrations in different meat and offal

According to WHO (2010)^[15] the provisional tolerable daily intake for copper of $2 \mu\text{g/kg}$ body weight. The Egyptian Organization for Standardization and Quality Control^[27] (EOS., 2010) is set a permissible limit for copper residues in meat and edible offal which must be not exceed than $15.0 \mu\text{g/g}$ 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; it accumulates in muscle and liver acting as essential element, may cause chronic toxicity 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^[26,31-33].

Iron

The mean concentrations level for iron residues in (breast, thigh) chicken meat, liver and gizzard samples were presented in figure (3). The mean iron values in (raw, grilled, marinated and simmered) chicken meat samples were; 7.130 ± 0.251 , 6.857 ± 0.256 , 6.400 ± 1.100 and $5.97 \pm 0.294 \mu\text{g/g}$ respectively, it were; 87.16 ± 2.485 , 86.48 ± 2.589 , 81.04 ± 5.695 and $73.18 \pm 2.850 \mu\text{g/g}$ in (raw, grilled, marinated and simmered) chicken offal respectively. The iron concentration levels were; raw> grilling> marinating> simmering samples. It was cleared that the chicken samples had a significant effect ($P > 0.05$) on the iron levels in the examined samples. Other investigators obtained the same results from chicken samples^[20,21,34]. Bæch, *et. al.*, (2002)^[35] observed that the cooking at high temperature ($90 - 120^\circ\text{C}$) diminished the meat heme iron content about 50%.

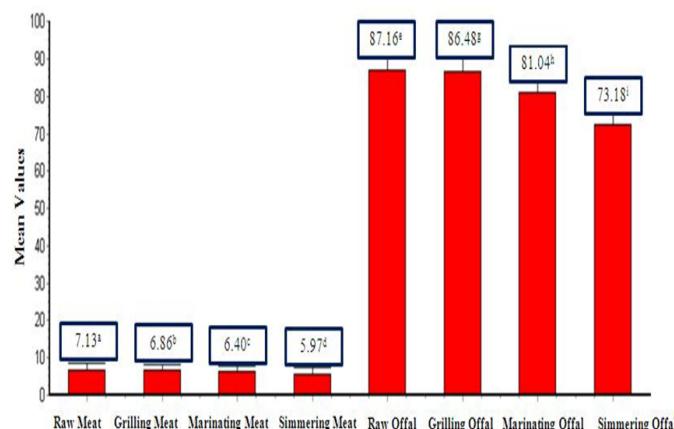


Figure 3: Iron concentrations in different meat and offal

However 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, exposure to high cooking temperature enhance thermal denaturation of non-heme iron structural changes of the meat the heme iron content of meat diminished by 50% at the highest cooking temperature. 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^[36,37].

According to WHO (2010)^[15] the provisional tolerable daily intake for iron of 15 µg/kg body weight. The Egyptian Organization for Standardization and Quality Control (EOS., 2010)^[27] is set a permissible limit for cadmium residues in chicken meat and offal which must be not exceed than 15.0 µg/g for meat and 20.0 µg/g for chicken 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 presented in figure (4). The mean lead values in (raw, grilled, marinated and simmered) chicken meat samples were; 0.30 ± 0.195 , 0.25 ± 0.0155 , 0.18 ± 0.013 and 0.10 ± 0.010 µg/g respectively and were; 0.45 ± 0.190 , 0.38 ± 0.0175 , 0.33 ± 0.0155 and 0.24 ± 0.0135 µg/g in (raw, grilled, marinated and simmered) offal samples respectively. The lead concentration levels were; raw > grilling > marinating > simmering samples. It was cleared that the chicken 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^[21,34]. However, Perelló, *et. al.*, (2008)^[20] noticed that (Pb) not detected after all method of cooking. On the other hand, Morgan, (1999)^[38] stated that toxic metal reach to the food from many environmental sources such as; handling, preparation and cooking techniques or cooking water, he added that ordinary proper cooking of food, cannot decrease or leach absolutely the heavy metals. 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^[39,40]. 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 foot drop^[41-45]. Other diseases as haemolytic anemia, atherosclerosis, liver apoptosis, renal toxicity and atrophy of the ovary may be occur^[9,19,46-49].

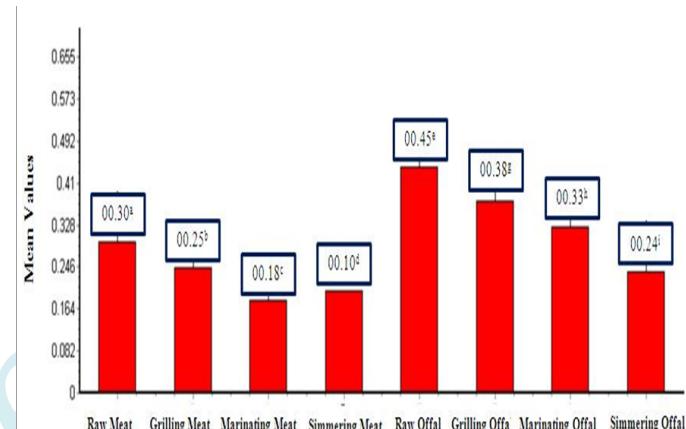


Figure 4: Lead concentrations in different meat and offal

According to WHO (2010)^[50] the provisional tolerable daily intake for lead of 114 µg/kg body weight. The Egyptian Organization for Standardization and Quality Control (EOS., 2010)^[27] is set a permissible limit for lead residues in meat 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.

This study concluded that the concentration of cadmium, copper, iron and lead residual recorded in chicken meat and edible offal, were below the permissible limits chicken samples while, were higher in offal, than chicken meat. Generally, properly cooking of chicken has limited reducing potency of heavy metals in food, depending on cooking (temperature, cooking medium and time). The best methods of cooking depending were; simmering, followed by marination while grilling has very mild or no effect on heavy metals. Purchase chicken from reputable sources, markets and grocers with a history of providing safe food to customers. More studies still needed to control environmental pollution in chicken meat & offal's.

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