



Chemical Compositions and Heavy Metal Contents of Local Fresh and Imported Frozen Beef Cattle Meat Available in Ranya Markets

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ABSTRACT

Background: The consumption of frozen meat from beef cattle has increased largely in Middle Eastern nations, especially in many Iraqi cities since it is a major source of protein which is necessary for the growth and maintenance of good health. In view of the fact that there are no available original data on the nutritional value and content of metals in the meat of beef cattle sold in Ranya city (northern Iraq), a study was undertaken in order to determine these levels in imported frozen and local fresh beef cattle meat, with emphasis on toxicological aspects.

Methods: A total of 10 samples of different types of beef cattle meat were collected from different markets in Ranya city and classified into two groups: fresh boneless meat of local beef (Iraqi cattle) and imported frozen boneless beef meat of Brazilian origin.

Result: The results clearly reveal no differences in the concentration of studied heavy metals between fresh and imported frozen beef cattle meat. Nevertheless, iron concentrations in imported frozen meat samples were higher than the recommended tolerable levels by Food and Agriculture Organization. No proximate analyses, except fat and ash content, differed between meat samples. Fat and ash concentration were significantly higher ($p < 0.05$) in fresh beef cattle meat compared to frozen beef cattle meat. The study concludes that while comparing local fresh and imported frozen beef cattle meat, only fat and ash content showed significant differences whereas other nutritional properties showed minor differences ($p > 0.05$).

Key words: Beef cattle meat, Chemical composition, Contamination, Heavy metals, Storage.

INTRODUCTION

Actually, the consumption of meat from beef cattle has increased largely everywhere in the world, especially in many Middle Eastern nations due to its distinct nutritional attributes with low content of fat, cholesterol and saturated fatty acids when compared to other red meats including mutton (Troy *et al.*, 2016). In spite of its low in lipid content when compared to meat from other ruminant, beef cattle meat has a high proportion of unsaturated fatty acids in addition to being a source of conjugated linoleic acid, which have such beneficial effects on human health as anti-inflammatory, anti-thrombotic and atherosclerotic preventatives (Sokoł-Wysoczańska *et al.*, 2018). Beef cattle meat has also protein of high biological value with all essential amino acids covering human requirement. According to a study made by Cabrera and Saadoun (2014) beef meat has higher levels of iron (2.9 mg) when compared to a similar serving size of lamb (1.4 mg). However, nutritional value of beef cattle meat is influenced by environmental and genetic factors. Among the environmental factors that influence meat nutritional qualities are events that take place post mortem especially under pro-oxidative conditions such as storage and ante mortem events that induced the presence of toxic substances.

Meat can be contaminated just like other foods when exposed to toxic substances. Toxic substances in meat tissues can be caused by a variety of sources including animal drugs, pesticides, feed and other agricultural or

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industrial chemicals substances (Nkansah and Ansah, 2014). Materials contain toxic substances such as heavy metals that can be contaminated the meat tissues and render them unfit for human consumption (Khalafalla *et al.*, 2011). Contaminated animal feed and rearing of livestock in proximity to polluted environment were reportedly responsible for heavy metal contamination in meat. Additionally, heavy metal pollutants can contaminate meat during processing (through the raw material, water and packaging), transportation and unhealthy way of selling

meat. Since the pollution with heavy metals causes toxicity, biomagnification and bioaccumulation in the food chain, it is a serious hazard (Pandey and Madhuri, 2014). In addition, meat contamination with heavy metals is a concern for both human health and food safety since these metals at relatively low concentrations are natural toxins.

In Ranya (northern Iraq), people commonly consume meat of beef cattle since it is a major source of protein which is necessary for growth and maintenance of good health. In view of the fact that there are no available original data on nutritional value and content of metals in meat of beef cattle in Ranya city, study was undertaken in order to determine these levels in imported frozen and local fresh beef cattle meat, with emphasis on toxicological aspects.

MATERIALS AND METHODS

Sample collection and preparation

A total of 10 samples of different types of cattle meats (beef) were collected from different markets in Rania city, Kurdistan region, Iraq during the last quarter of 2018. These samples classified into two groups: (a) fresh boneless meat of local beef (Iraqi cattle) and (b) imported frozen boneless beef meat of Brazilian origin. Each sample collected from different markets weighed between the ranges of 250 - 300 g. The collected samples were put into clean polythene bags, transported to the laboratory, gently washed with distilled water to remove contaminated particles and chopped into small pieces using a clean ceramic knife in order to determine the nutritional value.

Proximate composition

Proximate composition of the beef cattle samples was determined in triplicates per sample following the procedures of AOAC (2000).

Moisture determination in meat

The meat samples were individually weighed (approximately 20 g) and recorded as initial weight (W1). The weighed samples were dried in an oven at 75°C for 48 h. After a constant weight obtained, the samples were immediately weighed and recorded as W2. The percentage of moisture was calculated as the difference between sample initial weight and sample weight after 48h drying divided by sample initial weight.

$$\text{Moisture (\%)} = [(W1 - W2) \div W1] \times 100$$

Protein determination in meat

The samples used for moisture determination were collected, prepared and used for determining the concentration of protein. Crude protein was determined by the Kjeldahl method. The method was conveniently divided into three steps which are digestion, neutralization and titration. Briefly, the organic component in meat sample (1 g) was digested at 420°C for 2 h with strong sulfuric acid in the presence of tow catalyst tablets VST (code A00000277; 3.5 g K₂SO₄, 0.0035 g Se) in order to convert total nitrogen to ammonia

sulphate (digestion stage). In the neutralization or distillation stage, the nitrogen in digested solution was converted to ammonia hydroxide by ammonium hydroxide then being distilled with a boric acid solution and converted to ammonia borate which was titrated with strong hydrochloride acid (titration stage). Because the Kjeldahl method does not measure the protein content directly, the following equation was used to determine the nitrogen (N) concentration of meat sample that weighs m grams using xM HCl acid solution for the titration:

$$\% N = \frac{x \text{ moles} \times (V_s - V_b) \text{ cm}^3 \times 14g}{\text{cm}^3 \times \text{mg}} \times 100$$

Where

V_s and V_b are the titration volumes of the sample and blank and 14g is the molecular weight of nitrogen N. Once the nitrogen content was determined, it was converted to a protein content using the following equation:

Protein (%) = N × 6.25 (equivalent to 0.16 g nitrogen per gram of protein)

Fat determination in meat

Fat content of dried meat samples was determined by Soxhlet extraction method using hexane. The dried meat sample was individually weighed (approximately 1 g) and recorded as initial weight (W1) and placed into a dried and pre-weighed filter paper (W2). The sample was then put in a distillation path or extraction tube. The cleaned distillation flask was filled up to ¾ with hexane then tidily attached with other parts of the Soxhlet device and put the device on a head source after the water passing through the condenser was opened. After hexane started to evaporate in the condenser then dropped into the meat sample which was placed in the distillation path, the fat extracted from the sample and the hexane filled with fat went back to the distillation flask reaching the end of the side tube of the distillation path (siphon). The process of siphon is repeated at a rate of 5 to 10 siphon per hour and continued for 3 hours. After extraction, the meat sample was dried to take the hexane, cooled and then re-weighed (W3). The percentage of fat concentration is calculated using the following equation:

$$\text{Fat (\%)} = [(W2 - W3) \div W1] \times 100$$

Ash determination in meat

For ash determination, the samples of both fresh and frozen meat were individually weighed and recorded as initial weight (W1) and placed into a dried and pre-weighed porcelain crucible (W2). The samples were then burned in a muffle furnace at a temperature of 550°C for 48 h. The burned samples were removed from the muffle furnace, equilibrated to room temperature in a desiccator and reweighed (W3). The ash percentages were calculated using the following equation:

$$\text{Ash (\%)} = [(W3 - W2) \div W1] \times 100$$

Mineral elements analysis

In order to obtain the dry weight of the samples about 50g

of meat was homogenized and dried at 75°C for 48 h in an oven. The dried samples were crushed using a ceramic mortar. About 2g of fine powder was used to analyze the elements. Iron (Fe), Zinc (Zn), Cobalt (Co), Selenium (Se), Nickel (Ni), Mercury (Hg), Lead (Pb) and Arsenic (As) in meat samples from both fresh and frozen beef cattle were determined directly on each sample using X-ray fluorescence spectrometer (Genius 9000 XRF, USA) following the procedures described by Yakup *et al.* (2018).

Data analysis

The experiment followed a completely randomized design. Data obtained from proximate composition were analyzed using the GLM procedure of Statistical Analysis System (SAS) package version 9.2 software (SAS, 2007). T-test was used to test the significance of variance between the means of the studied parameters at significant level of $p < 0.05$. All values are reported as means $\pm$ standard errors.

RESULTS AND DISCUSSION

Proximate composition of different types of beef cattle meat

Beef meat (cattle) is an important part of a healthy diet because it is considered an excellent source of high value protein and essential nutrients. The mean of moisture, protein, fat and ash for fresh and imported frozen cattle meat

are presented in (Fig 1). The moisture percentage was found to be $68.27 \pm 1.58\%$ and $68.90 \pm 1.61\%$ in fresh and imported frozen beef cattle meat, respectively and values were not significantly different according to statistical findings. There are some factors which are directly responsible for water loss while freezing meat such as reduction in pH, the loss of adenosine triphosphate and the stearic effect for shrinkage. These results are in accordance with Inam *et al.* (2017) in lambs and Vieira *et al.* (2009) in beef cattle who reported no significant differences in total moisture content between fresh and frozen meat. The value of total protein content was recorded as $22.12 \pm 0.52\%$ and $21.82 \pm 0.82\%$ for fresh and imported frozen beef cattle meat, respectively and values were not significantly different. Despite this finding, the crude protein content in frozen meat is expected to be lower than in fresh meat because denaturation and loss in gelatin caused by extended frozen storage also due to proteolysis induced by enzymatic activities of psychotropic microbial growth. This finding is in tandem with those of Inam *et al.* (2017) who reported similar crude protein value for both fresh and frozen lamb meat samples. Fat content for fresh and imported frozen beef cattle meat were $7.71 \pm 0.65\%$ and $5.98 \pm 0.55\%$, respectively. The fat content is low for fresh and imported frozen cattle meat because the samples were free from subcutaneous and additional fat. In this experiment, samples from fresh beef cattle meat had significantly ($p < 0.05$) higher fat content than those from

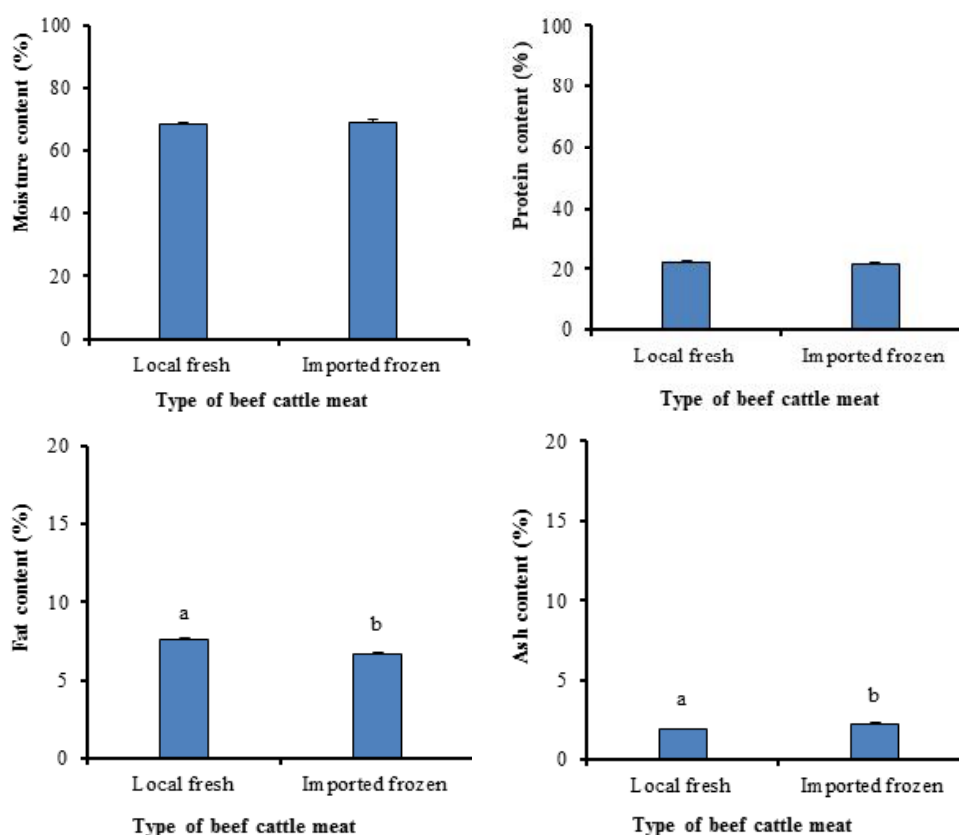


Fig 1: Chemical composition of different types of beef cattle meat available in Ranya markets.

^{a,b}Means with different letters are significantly different at $p < 0.05$. Values are means $\pm$ standard error of $n=10$.

imported frozen beef cattle meat. The changes, observed on fat content in the analyzed meat, were in line with those previously reported (Hammad *et al.*, 2019; Inam *et al.*, 2017). It has been suggested that different factors may affect fat content in beef cattle meat such as breed, rearing system and nutritional supply, weight at slaughter, gender and for the same animal according to the piece recovered (*i.e.* according to the muscle (s) that constitute it) are influencing on fat content in beef cattle meat (Park *et al.*, 2018). Ash in beef muscle contains nutritionally important minerals. In the present study, the ash content was $1.69 \pm 0.08\%$ in the fresh meat samples while increased to $2.27 \pm 0.09\%$ in imported frozen meat. A significant difference was found between fresh and frozen meat ($p < 0.05$). The obtained values agree with those obtained by Ziani *et al.* (2018), showing an increase of ash content in beef cattle muscle after the frozen storage.

Essential minerals of different types of beef cattle meat

The concentration of essential minerals in the different cattle meat samples are presented in (Table 1). Iron (Fe) and zinc (Zn) presented the highest concentration in the two types of meat evaluated compared to the other essential elements. The value of Fe was recorded as 144.72 mg/kg meat and 136.72 mg/kg meat for fresh and imported frozen beef cattle meat, respectively and values were not significantly different. Greater value of iron in imported frozen meat could be due to the amount of blood retained in meat which is determined by the slaughter method. Blood contains a high amount of hemoglobin which contains four polypeptide chains with each chain containing one haem group: gathering: every haem group is composed of an iron atom inside the porphyrin ring (Sabow *et al.*, 2016). In current study, iron concentrations in imported frozen meat samples were higher than the recommended tolerable levels by FAO/WHO (2011). The poisonous quality of iron is represents by retention. The more you take in the more you are in danger. The iron is caught in the ferrous state by cell of the intestinal mucosa. Ferritin is one type of iron stockpiling protein containing 24 stockpiling protein. At the point when overabundance of dietary iron is assimilated, the body delivers more ferritin. Excess ferritin collected within the liver and heart can cause chronic free-radical induced injury. Over time, this tissue injury can lead to progressive heart and liver failure, eventually resulting in significant early mortality (Aljaff *et al.*, 2014). No significant differences were observed in the concentration of zinc (Zn) between local fresh and imported

frozen beef cattle meat. The values of zinc in both investigated samples were lower than the maximum zinc level allowed by FAO/WHO (2011) for red meat (50 mg/kg). Zinc element plays a vital role in human diet. Taking excessively zinc is destructive to human wellbeing. According to Badis *et al.* (2014) ordinary groupings of zinc in meat samples was 35 - 45 mg/day, so it gives the idea that most researched tests in the present examination contained elevated amounts of zinc. Nonetheless, our outcome for zinc was like those recorded by Miranda *et al.* (2006). These authors stated that muscles of cattle are the tissues where zinc is most likely to accumulate. There was no significant difference in the cobalt concentration between local fresh and imported frozen beef cattle meat. The values of cobalt (Co) in meat samples were lower than the maximum cobalt level (1 mg/kg) allowed by FAO/WHO (2011). Cobalt is an essential trace mineral for human body because it is an essential component of vitamin B12. This vitamin is important for making red blood cells (Akan *et al.*, 2010). Moreover, cobalt helps maintaining healthy bones, blood vessels, nerves and immune function as well as it contributes to iron absorption (Lee and Stuebing, 1990). The selenium concentrations (Se) in examined samples of meat ranged from 0.31 to 0.32 mg/kg for the two studied samples and none of them exceeded the recommended limit of 0.5 mg/kg (FAO/WHO, 2011). In humans, selenium is a fundamental supplement that assumes a part in shielding tissue from oxidative harm as a part of glutathione peroxidase. Although selenium is an essential nutrient, exposure to high levels via inhalation or ingestion may cause adverse health effects. Selenium appears to affect the ability of liver enzymes to activate some chemical mutagens (Aljaff *et al.*, 2014).

Non-essential minerals of different types of beef cattle meat

Concentrations of toxic metals in fresh and imported frozen beef cattle meat available in Ranya are shown in Table 2. The concentration of nickel (Ni) in the local fresh and imported frozen beef cattle meat was not different and ranged between 0.013 and 0.015 mg/kg meat. The values of Ni obtained from both beef cattle meat types in this study were lower than the permitted nickel limit of 0.2 mg/kg (FAO/WHO, 2011). The appropriate amount of nickel in human body is responsible for regulation of prolactin and stabilization of RNA and DNA structures, but at very high concentrations it can have negative effects on human health (Chowdhury *et al.*, 2011). Although there is no statistical

Table 1: Concentrations of essential minerals in different types of meat samples available in Ranya markets.

Mineral concentration (mg/kg dry weight)	Beef cattle meat		IPL (mg/kg)	P value
	Local fresh	Imported frozen		
Iron	136.72 ± 8.96	144.72 ± 0.43	140	0.402
Zinc	44.24 ± 4.63	46.36 ± 2.65	50	0.291
Cobalt	0.48 ± 0.01	0.49 ± 0.01	1.0	1.000
Selenium	0.32 ± 0.01	0.31 ± 0.02	0.5	0.632

IPL - International Permissible Limits (FAO/WHO, 2011). Values are means $\pm$ standard error of $n=10$.

Table 2: Concentrations of toxic minerals in various meat samples available in Ranya markets.

Mineral concentration (mg/kg dry weight)	Beef cattle meat		IPL (mg/kg)	P value
	Local fresh	Imported frozen		
Nickel	0.015 ± 0.000	0.013 ± 0.00	0.2	0.879
Mercury	0.119 ± 0.004	0.122 ± 0.006	1.0	0.766
Lead	0.212 ± 0.000	0.118 ± 0.00	0.5	0.967
Arsenic	1.247 ± 0.085	1.394 ± 0.023	2.0	0.149

IPL - International Permissible Limits (FAO/WHO, 2011). Values are means ± standard error of n=10.

difference, the high concentrations of nickel in frozen meat could be due to the increased use of nickel in industrial and agricultural activities in the areas that meat was imported from. Mercury was detected at concentrations ranging between 0.119 and 0.122 mg/kg meat for the two types of meat studied and none of them exceeded the recommended limit of 1.0 mg/kg (FAO/WHO, 2011). The level of lead in studied meat samples was in the range of 0.188 to 0.212 mg/kg and was below the permissible limit of 0.5 mg/kg set by FAO/WHO (2011). Lead is one of the major toxic heavy metals and can affect children's brain development resulting in reduced intelligence performance as well as increased blood pressure and cardiovascular disease in adults (Yakup *et al.*, 2018). The obtained results showed that the arsenic (As) contents of meat samples ranged between 1.247 and 1.394 mg/kg. The lowest arsenic value was recorded in local fresh beef cattle meat, while the highest concentrations were found in imported frozen beef cattle meat. However, the obtained results for arsenic were lower than the standard permissible levels, 2.0 mg/kg (FAO/WHO, 2011). The presence of arsenic in the feeding or drinking water leads to severe adverse effects on animals as it is non-biodegradable and therefore can easily be accumulated. Thus, human beings are potentially exposed to these contaminants through the food chain with the consumption of meat. The arsenic even at low concentrations results in various adverse health effects. The International Agency for Research on Cancer has classified arsenic and arsenic compounds as carcinogenic to humans (Nkansah and Ansah, 2014).

CONCLUSION

The present results indicated that essential and non-essential mineral elements of frozen beef cattle meat are comparable to that from local fresh beef cattle meat. However, the changes in the fat content under the effect of freezing were found. Thus, this study affirms that freezing does not affect negatively the nutritional composition of beef cattle meat.

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