ORIGINAL ARTICLE

# Iron and heme iron concentrations in three different pork cuts compared with chicken filet

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Iron has several vital functions in the body. Meat is an important source of iron and especially heme iron, which is generally more efficiently absorbed than non-heme iron. However, there is a lack of data on the heme iron content in different meat cuts, since most databases contain data on the total iron content. Furthermore, the ratio between total iron and heme iron in meat is often based on an approximate value, which varies greatly in the literature. The aim of this study was to provide values for the content of total iron and heme iron in three different pork cuts compared with chicken filet. Total iron content was found to be 0.30 mg/100 g [loin], 0.44 mg/100 g [topside] and 0.84 mg/100 g [shoulder]. Chicken filet had a total iron content of 0.32 mg/100 g. The percentage of heme iron [of total iron] was 57% [loin], 55% [topside], 64% [shoulder] and 35% [chicken filet]. There was no significant difference between the total iron contents in pork loin and chicken filet. However, the heme iron contents in the pork cuts were significantly higher than the heme iron content in the chicken filet.

**Key Words:** *Chicken, Heme iron, Pork, Total iron*

Iron is a mineral of great importance to human nutrition (1,2). Iron is found in various foods, including sesame seed, oatmeal, pork, beef, and leguminous plants, just to mention a few. In meat, iron is present in two chemical forms: heme iron and non-heme iron (3). It is well established that human uptake of heme iron is generally more efficient than human uptake of non-heme iron (1).

Meat from different species is, often grouped and referred to as "red meat" and "white meat". However, there is no conclusive definition of this grouping, which may be the reason why it is debated on a regular basis. The term "red meat" is related to the colour of the meat, which is closely linked to the content of heme iron (3). On several official websites, red meat is defined as meat from mammals (4,5). However, some pork cuts, such as filet, are visually whiter than red compared with, for example, beef or veal cuts. The National Pork Board, among others, promotes pork as "the other white meat" (6).

Nevertheless, the literature presenting heme iron data is limited, and the available food databases contain data on total iron and not specifically on heme iron. Therefore, there is a need for more data on heme iron content in meat. The aim of this study therefore was to provide updated values for the content of total iron and heme iron in Danish pig meat. The study included the shoulder muscle, loin and topside from the fore end, the middle part and the ham of the pig, respectively. These three cuts provided variation in muscle types. In parallel, the iron content and heme iron content in chicken filet were determined for comparison, since chicken is classified as white meat.

## MATERIALS AND METHODS

### Collection and selection of meat

In order to ensure robustness of the results, it was important to include as much natural variation in the generated iron data set as possible. Therefore, at each of two commercial abattoirs, 15 shoulder muscles [m. triceps brachii caput longum], filets [m. longissimus dorsi] and topside [m. semimembranosus] were randomly collected from the production line the day after slaughter and transported to DMRI. Based on the weight and pH measured just before packaging, 25 of each of the three cuts were selected for analysis, with the high end and low end value cuts being discarded. The slaughter pigs were the common Danish crossbreed of Duroc, Landrace and Yorkshire [DLY].

In parallel, 12-13 chicken filets [pectoralis major] were collected immediately after deboning at two commercial abattoirs, giving a total of 25 filets. No further selection was made before analysis. The chickens were of the standard commercial race ROSS 308.

All of the meat cuts were individually vacuum-packed and kept at -18°C until analysis.

### Sample preparation

Homogenization of the samples was performed in accordance with DS/EN13804 (7). The meat cuts were thawed overnight at +5°C. The thawed samples were cut with a titanium knife and then homogenized in a blender [Retsch, Grindomix]. The blender had previously been tested for iron rub-off. The homogenized samples were stored in plastic tubes at -18°C.

### Chemical analysis

The samples for iron determination were pressure-digested with diluted nitric acid in a microwave oven [Anton Paar] in accordance with DS/EN13805 (8). The diluted samples were analyzed by ICP-OES [inductively coupled plasma optical emission spectrometry, Perking Elmer] using a method based on EN16943 (9).

The heme iron analysis was performed by a spectrophotometric method based on Hornsey (10). The heme pigments were extracted with an acetone-hydrochloric acid solution and the content of hemine was determined at 640 nm [Perkin Elmer, Lamda 25, and UV/VIS]. For both methods, each sample was analyzed in duplicate.

### Statistical analysis

The two sets of chemical results, total iron and heme iron, from four types of meat sample [pork shoulder, pork loin, pork topside, and chicken filet] can be assumed to be normally distributed with slightly uneven variances. Even though the precondition, the variance homogeneity, for an ordinary analysis of variance is not fully met, the robustness of the analysis is considered high and the variance inhomogeneity is ignored. Consequently, in order to analyze whether the average concentration of iron [total iron and heme iron] was at the same level in the four types of meat, a simple one-way analysis of variance is used:

$Y_{ij}=\alpha_i+\varepsilon_{ij}$, where Yij, i=1,2,3,4 j=1,...,25 designate the measurements of, for instance, total iron in the four types of muscle, each represented by 25 independent samples, $\alpha_i$ designates the average level of total iron in the muscle type i, and finally $\varepsilon_{ij}$ designates the independent normally distributed $N[0,\sigma 2]$ random error.

For analysis validation, an analysis using non-parametric one-way analysis was applied. This resulted in the same conclusion, indicating that the assumed robustness is acceptable.

The statistical analysis was performed using SAS ver. 9.4 [SAS Institute, Cary, USA].

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## RESULTS AND DISCUSSION

The measured iron values, total iron [mg/100 g], heme iron [mg/100 g], and the proportion of heme iron in total iron [%] in the three pork cuts and in the chicken filet are presented in Table 1.

Mean values [n=25] of total iron [mg/100 g], heme iron [mg/100 g] and the proportion of heme iron in total iron [%] in four meat cuts. Standard deviations between the samples are shown in brackets [%, relative]. Different capital letters refer to significant differences between the meat cuts based on Duncan's Multiple Range Test.

From Table 1, it can be seen that the shoulder muscle contains the highest concentration of total iron [significant] compared with the two other pork cuts and chicken filet. The contents of total iron in pork loin and in chicken filet are comparable and not significantly different, while the contents of heme iron differ between the four meat cuts. This is reflected in the proportion of heme iron in total iron, with the highest content in pork shoulder and the lowest in chicken filet, while the contents in pork topside and loin are comparable.

Table 2 summarizes the iron contents available in food databases and recent scientific publications.

When comparing the concentrations of total iron content (Tables 1 and 2), it can be seen that the concentrations determined in the present study fall within the range of variation in the previous findings or are lower. In the study by Goran et al. pork loins were found to have a higher level of iron than beef rib eye (11). This is not in accordance with the common understanding of meat biochemistry, in which beef is redder than pork due to its higher content of myoglobin (3). Furthermore, the iron value for beef given by Goran et al. is markedly lower than all database-reported values (11) (Table 2). Zhao et al. investigated the effect of organic and conventional rearing on the mineral content in pig meat (12). In pork loins, the total iron content was 22.6 mg/kg in organic pigs and 18.9 mg/kg in conventionally reared pigs. These values are a factor of ten higher than the findings in the present study. Furthermore, it is important to note that differences in the given iron contents may vary due to a number of factors, e.g. the method of analysis and the raw meat quality [including the age of the meat, genetics of the animal, etc].

Heme iron is the iron molecule of greatest interest due to its link to cancer development (2). Furthermore, heme iron is known for its higher bioavailability than non-heme iron and its importance for human nutrition (1,2). In the very recent review by Czerwonka et al. it is stated that heme iron represents a significant part of the total iron content (13). It is further stated that the literature is inconclusive and that the heme iron percentages vary between 40% and 90%, with 70% being the most common value. In the Nordic Nutrition Recommendation, it is stated that heme iron accounts for 50% of total iron in meat (1). In the present study, heme iron accounts for between 55% and 64% of total iron content in pork cuts and 35% in the chicken filet. Based on these findings, it is clear that no common percentage can be used for the estimation of heme iron from a given content of total iron, since the heme iron content varies significantly between cuts and between species (14).

Lombardi-Boccia et al. measured the heme iron content in meat from various species and found it to be 2.11 mg/100 g in raw beef filet, 0.20 mg/100 g in raw pork loin and 0.12 mg/100 g in raw chicken breast (15). These findings are in accordance with the present study.

**TABLE 1**

**The measured iron values, total iron (mg/100 g), heme iron (mg/100 g), and the proportion of heme iron in total iron (%) in the three pork cuts and in the chicken filet**

| Meat cut | Total iron | Heme iron | Heme iron |
|---|---|---|---|
| | mg/100 g | mg/100 g | % of total iron |
| Pork shoulder | 0.84 (9.2) A | 0.54 (10.9) A | 64 (5.3) A |
| Pork topside | 0.44 (17.1) B | 0.24 (18.0) B | 55 (10.6) B |
| Pork loin | 0.30 (11.8) C | 0.17 (14.6) C | 57 (6.9) B |
| Chicken filet | 0.32 (12.3) C | 0.11 (20.0) D | 35 (19.9) C |

**TABLE 2**

**The content of total iron in raw meat samples found in databases and the literature**

| Species | Meat cut | Iron content, mg/100 g |
|---|---|---|
| **Pig** | Topside | 0.46 (0.42-0.51) |
| | Ham | 1.01 |
| | Filet | 0.71 (0.64-0.79) |
| | Loin | 0.84 |
| | Meat unspecified, lean | 0.89 (0.64-1.15) |
| | Shoulder | 1.2 |
| | Meat w/bones | 1.48 |
| | Loin | 0.42 |
| **Chicken** | Meat unspecified | 0.58 (0.42-1.06) |
| | Breast meat, lean | 0.37 |
| | Meat w/skin | 1.2 |
| **Cattle** | Filet | 2.47 (1.5-4.5) |
| | Sirloin | 2.23 |
| | Loin/filet | 2.39 |
| | Minced, 10% fat | 2.04 |
| | Rib eye steak | 0.3 |

## CONCLUSION

Few values for the concentration of total iron and especially heme iron in different pork cuts can be found in the literature and food databases. In the present study, we found that the total iron concentration was 0.30 mg/100 g [loin], 0.44 mg/100 g [topside] and 0.84 mg/100 g [shoulder]. Chicken filet had a total iron content of 0.32 mg/100 g. The percentage of heme iron was 57% [loin], 55% [topside], 64% [shoulder] and 35% [chicken filet]. There was no significant difference between the total iron contents in pork loin and chicken filet. However, the heme iron contents in the pork cuts were significantly higher than the content in the chicken filet.

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