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Analytical Methods

Total and haem iron content lean meat cuts and the contribution to the diet

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ABSTRACT

This study provides data on the total and haem iron contents in raw lean beef, chicken, lamb and pork meat samples. Total iron, expressed as mg/100 g edible portion on fresh weight basis in raw lean beef (A-age), lamb, pork and chicken average 1.58, 1.64, 0.81 and 0.78, respectively. The haem iron content in beef (A-age), lamb, pork and chicken are 77%, 81%, 88% and 74% respectively of total iron. This has important dietary implications in calculating haem iron fractions of meat as this is higher than the common value used in the Monsen equation.

1. Introduction

Iron (Fe) deficiency is one of the most widely known nutritional disorders that affect an estimated two billion people worldwide. It occurs when there is a negative balance between iron requirements, absorption and losses. In developing countries iron deficiency is caused not only by an iron-deficient diet but also by low bioavailability of iron in the diet. Pregnant women, infants, young children and adolescents have higher iron requirements and are at greater risk of developing iron deficiency (Zimmermann & Hurrell, 2007). Despite the numerous initiatives implemented to control iron deficiency the problem persists along with substantial health and economic costs.

Food-based approaches as one of the more sustain ways to combat iron deficiency towards increasing iron intake, depends on reliable and relevant data about the iron composition (content, as well as availability) of a food. There are two primary forms of iron that are found in food, namely, haem and non-haem iron. Haem iron is derived mainly from haemoglobin and myoglobin in animal tissue, and according to the accepted Monsen model, makes up about 40% of total iron. Non-haem iron is found mostly in plant-based foods, and makes up the remaining 60% of iron in animal products. In most countries, no reference is made to the specific type of iron found in food sources (Monsen et al., 1978). Centre to this problem is that the single reference of total iron intake does not indicate the amount of iron that is absorbed by the body. The type of iron (haem or non-haem) differs in bio-availability. In general, the rate of non-haem iron absorption is related to its solubility in the upper part of the small intestine. The presence of soluble enhancers (ascorbic acid) and inhibitors (phytates, polyphenols and calcium) consumed during the same meal will have a significant effect on the amount of non-haem iron absorbed. Haem iron is much less affected by other dietary factors and contributes significantly to absorbable iron (Pettit, Rowley, & Brown, 2011; Zimmermann & Hurrell, 2007).

To date, haem intake is usually assessed by applying a fixed factor to the total iron content of all meat items – 40% of total iron from meat (Monsen & Balintfy, 1982; Monsen et al., 1978) – regardless of the origin of the meat. However, it is apparent from the literature that not only the absolute total iron content differs substantially between meat from different origins, but also the percentage iron from haem. To determine iron intake more accurately by using a meat-specific factor, more specific data on meat from different species and different retail cuts is necessary. No data on the haem iron content of South African meat is currently available. If these values are known it will significantly contribute towards consumer education about the role of meat in the diet of all South Africans.

This study aims to determine the total and haem iron content in South African meat (beef, lamb, pork and chicken). The haem iron content of different South African meats can be added to the National Food Composition Database to provide a more accurate

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reference of the amount of absorbable iron in South African foodstuffs.

2. Materials and methods

2.1. Sampling procedure

Nine Bonsmara carcasses of the A age group (with no permanent incisors), AB age group (with 1 to 2 incisors), B age group (with 2 to 6 incisors) and six carcasses of the C age group (with more than 6 incisors) were directly obtained from an abattoir. The shoulder, prime-rib and rump were selected for analyses. These cuts were selected as they represent the composition of a typical South African beef carcass the best (Schönfeldt, 1998). Three samples from three similar cuts were pooled together as composite samples (see Fig. 1). All the meat samples were immediately refrigerated after purchase. Triplicate samples of raw commonly consumed meat cuts (lamb, pork and chicken) were obtained from four retail outlets (see Fig. 1).

2.2. Preparation of samples

Raw beef, lamb and pork meat samples were de-boned and dissected into muscle, intramuscular and subcutaneous fat and bone. Chicken samples were de-boned and excess skin and fat removed. Analyses were done on muscle only. All the meat were diced, minced and freeze-dried before analyses. The samples were analysed in duplicate at Nutrilab, University of Pretoria.

2.3. Gravimetric determination of moisture

Moisture was measured in the samples by determining the loss in weight of the sample after it had been dried in an oven at 105 ± 1 °C for 16 h. Weight loss is used to calculate dry matter content (AOAC, 2005).

2.4. Total iron content analysis

The concentration of total iron in the freeze-dried meat samples was measured using the procedure described by Giron (1973), which utilises nitric acid and perchloric acid digestion followed by quantitation with an atomic absorption spectrophotometer (Giron, 1973). Accuracy was confirmed with NIST Standard Reference Material 1546 (meat homogenate).

2.5. Haem iron content analysis

A method adapted from the Hornsey method (Hornsey, 1956; Turhan, Altunkaynak, & Yazici, 2004) was developed in order to determine the haem iron content in the different animal products. Approximately 0.6 g ground desiccated meat sample was weighed into 50-ml Erlenmeyer flasks. To this, 12 ml of acid–acetone mixture was added (40 ml of acetone, 9 ml of water, and 1 ml of concentrated hydrochloric acid). The mixtures were vortex-mixed for 15 s, then, an additional 12 ml of acid–acetone mixture was added, and the samples were vortex-mixed again for 15 s. Thereafter samples were allowed to stand in the dark for 60 min and swirled by hand occasionally. The samples were filtered through glass microfiber filters (Whatman GF/A) and the absorbance measured at 640 nm against a reagent blank. The absorbance was multiplied by 6800 and then divided by the sample weight to give the concentration of total pigments in the meat as μg haematin/g meat. The iron content in haematin was considered to be 0.0882 μg Fe/μg haematin.

2.6. Statistical analysis

Data was analysed by Linear mixed models, using the Residual Maximum Likelihood (REML) procedure of Genstat®. The analysis was used to test for the effect of species and age per cut. The residuals were normal distributed and heterogeneity was accounted for Payne, Welham and Harding (2013)). Fisher's Protected Least Significant Differences (FPLSD) test at the 5% level was used to separate means. The data was analysed with Genstat® Software™ (Payne, Murray, Harding, & Baird, 2013).

3. Results and discussion

In Table 1 total, haem and percentage haem iron content in retail cuts from beef, chicken, lamb and pork meat is reported. When comparing different cuts of beef, rump had a significantly higher ($p < 0.001$) total iron and haem iron content compared to shoulder and prime rib. However, the percentage haem iron (% HFe) between the cuts were not significantly different ($p = 0.937$). The difference in total iron concentration between lamb loin, leg and shoulder cuts were not significant, with lamb leg and loin having a significantly higher ($p < 0.001$) haem iron content. The % HFe in lamb shoulder is the lowest in the retail cuts from lamb. The difference between total, haem iron and percentage haem iron between pork loin and rump were not significant ($p > 0.05$). The total iron content of chicken breast and drumsticks were reported to be significantly lower ($p = 0.002$) than that

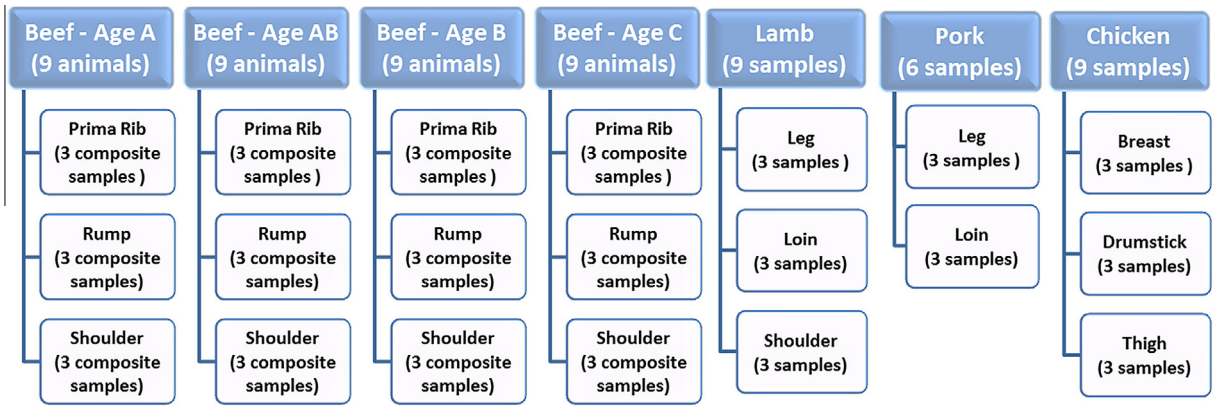

Fig. 1. Sampling design for beef (from three age groups), lamb, pork and chicken samples.