RELATIVE BIOAVAILABILITY OF IRON OF SOUTH AFRICAN LEAN MEAT (BEEF, LAMB, PORK AND CHICKEN)

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Abstract – This study provides data on the total and heme iron contents in raw lean beef, chicken, lamb and pork meat samples. Total iron, expressed as mg/100g in raw lean beef, lamb, pork and chicken average 2.46, 2.29, 0.76 and 0.75 respectively. The heme iron content in beef, lamb and pork are 81%, 82% and 84% respectively of total iron. Heme iron in chicken is lower at 76% of total iron. This has important dietary implications in calculating heme iron fractions of meat as this is higher than the common value used in the Monsen equation.

Key Words – heme iron, non-heme iron, total iron content.

I. INTRODUCTION

Worldwide, iron deficiency is the most prevalent nutritional deficiency, affecting over 2 billion people. Infants, women of childbearing age and preschool-aged children are particularly affected since iron requirements increase during growth, pregnancy and lactation [1]. In 1996 the South African Vitamin A Consultative Group (SAVACG) Survey found a prevalence of 21.4% of anaemia, 10% of iron deficiency (poor iron status) and 5% of iron deficiency anaemia in the country. Anaemia and poor iron status were more prevalent in urban areas [2]. The reasons might be due to infections like parasites and malaria, but also due to a deficient dietary intake. Mandatory fortification of maize meal and wheat flour with six vitamins, iron and zinc was subsequently implemented in 2003 to combat amongst others iron deficiency. However the Food Fortification Baseline Study (SANFCS-FB-1) done two years later suggests that the iron status of South Africans did not improve after the implementation of the National Fortification Programme [3], highlighting the need to determine the iron content of South African foods.

In South Africa, as in most countries, no reference is made to the specific type of iron found in food sources. 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 (heme or non-heme) differs in bio-availability. In general, the rate of non-heme iron absorption is related to its solubility in the upper part of the small intestine. Thus the presence of soluble enhancers and inhibitors consumed during the same meal will have a significant effect on the amount of non-heme iron absorbed. Heme iron is much less affected by other dietary factors and contributes significantly to absorbable iron [4].

According to the 1999 National Food Consumption Survey, the five most often consumed foods are maize porridge, brown bread, black tea, sugar and a small amount of full cream milk [5]. The fibres, phytates, oxalates and tannins in these most consumed foods may interfere with absorption. Animal foods are considered to be good sources of the more bio-available heme iron with less interference from absorption inhibitors [4]. No data on the heme 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 heme iron content in South African meat (beef, lamb, pork and chicken). Ample evidence suggests that although it is generally accepted that 40-60% of iron in all animal products is heme iron, significant differences exist in heme content of meats from different species and even between cuts within the same species. The heme iron content of different South African meats should be determined and added to the National Food Composition Database to provide a more accurate reference of the amount of absorbable iron in South African foodstuffs.

II. MATERIALS AND METHODS

Sampling Procedure

Triplicate samples of raw commonly consumed meat cuts (lamb, pork and chicken) were obtained from four retail outlets (see Figure 1). Nine Bonsmara carcasses within each of the AB age group (with 1 to 2 incisors) and B age group (with 2 to 6 incisors) and six carcasses within the C age group (with more than 6 incisors) were directly from an abattoir. The shoulder, prime-rib and rump were selected for analyses. These cuts were selected as they represent the composition of the carcass the best [6]. Three samples from three similar cuts were grouped together as composite samples (see Figure 2).

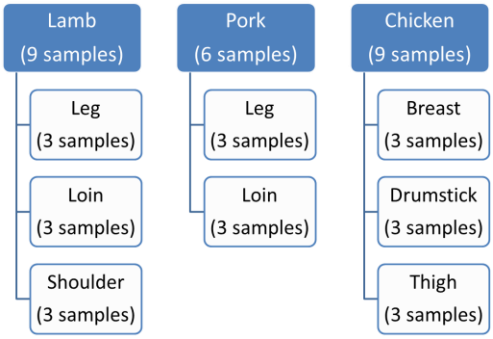

Figure 1: Sampling design for lamb, pork and chicken samples.

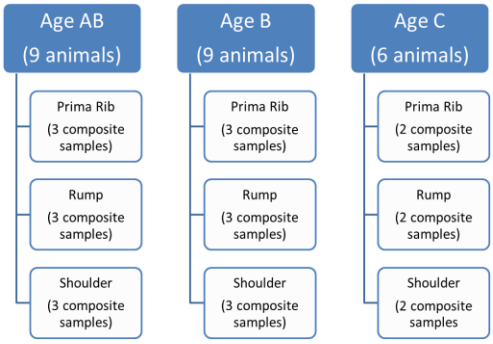

Figure 2: Sampling design for beef samples from three age groups.

The meat samples were immediately refrigerated after purchase. Sample preparation commenced within two days after purchase.

Preparation of Samples

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

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 hours. Weight loss is used to calculate dry matter content (AOAC, 2005) [7].

Total Iron Content Analysis

The concentration of total iron in the freeze-dried meat samples was measured using the procedure described by Giron, et al. (1973) [8], which utilizes nitric acid and perchloric acid digestion followed by quantitation with an atomic absorption spectrophotometer.

Heme Iron Content Analysis

A method adapted from the Hornsey method [8] was developed in order to determine the heme iron content in the different animal products. Non-heme iron content was calculated as the difference between total iron (TFe) and heme iron (HFe).

III. RESULTS AND DISCUSSION

Average of total and heme iron contents in beef, lamb, pork and chicken meat samples are presented in Table 1. Beef and lamb meat have the highest total iron and heme iron content with chicken and pork meat having the lowest values.

Table 1: Moisture, Total Iron (TFe), Heme Iron (HFe), Non-heme Iron (NHFe) and Percentage Heme Iron (%HFe), in raw lean meat from different species

	% Moisture	TFe (mg/100g)	HFe (mg/100g)	%HFe
[a]Lamb	72.26	2.29	1.89	82
[b]Pork	72.13	0.76	0.64	84
[a]Chicken	75.47	0.75	0.57	76
[c]Beef	73.87	2.46	1.97	81

[a]Each value is a mean of nine samples analysed in duplicate
[b]Each value is a mean of six samples analysed in duplicate
[c]Each value is a mean of 24 samples analysed in duplicate

Table 2: Moisture, Total Iron (TFe), Heme Iron (HFe), Nonheme Iron (NHFe) and Percentage Heme Iron (%HFe), in different retail cuts of raw lean lamb, pork, chicken and beef meat

	% Moisture	TFe (mg/100g)	HFe (mg/100g)	%HFe
[a]*Lamb*				
Loin	73.80	1.75	1.54	88
Leg	72.63	1.69	1.42	85
Shoulder	73.64	1.51	0.81	53
[a]*Pork*				
Rump	72.66	0.82	0.69	85
Loin	71.59	0.70	0.58	84
[a]*Chicken*				
Drumsticks	76.68	0.75	0.65	88
Thighs	74.46	0.86	0.64	75
Breasts	75.25	0.65	0.43	66
[b]*Beef*				
Prima Rib	72.26	2.29	1.89	82
Rump	74.27	2.93	2.19	77
Shoulder	75.07	2.17	1.82	84

[a]Each value is a mean of three samples analysed in duplicate
[b]Each value is a mean of eight samples analysed in duplicate

Table 3: Moisture, Total Iron (TFe), Heme Iron (HFe), Non-heme Iron (NHFe) and Percentage Heme Iron (%HFe), in raw lean beef from three different age categories

	% Moisture	TFe (mg/100g)	HFe (mg/100g)	%HFe
Age AB	74.44	2.74	2.02	77
Age B	73.89	2.36	2.00	85
Age C	73.27	2.29	1.87	82

Age AB (with 1 to 2 incisors) and Age B (with 2 to 6 incisors) - Each value is a mean of nine samples analysed in duplicate
Age C (with more than 6 incisors) - Each value is a mean of six samples analysed in duplicate

Table 2 presented and table 3 presented data on TFe and HFe content of beef meat from three different age groups.

The total iron content in lamb, beef, pork and chicken meat was in the range generally reported for these meats (Table 4). In this study the percentage heme iron (%HFe) content for beef and lamb meat was also in the generally reported range, but the % HFe for chicken and pork was higher than reported.

Table 4: Moisture, Total Iron (TFe) and Percentage Heme Iron (%HFe) in different meat samples as reported by various authors

	Mean		
	% Moisture	TFe (mg/100g)	% HFe
Lamb, Raw			
Pretorius, *et al.*	73.36	1.65	75
Schricker, *et al*. [10]		1.64	57
Lombardi-Boccia, *et al.* [11]		2.23	75
Carpenter & Clark [12]		1.6	88
Beef, Raw			
Pretorius, *et al.*	73.87	2.46	81
Schricker, *et al*. [10]		2.61	62
Leonhardt & Wenk [13]		7.7	61
Lombardi-Boccia, *et al.* [11]		2.09	87
Carpenter & Clark [12]		2.27	93
Kalpalathika, *et al.* [14].	60.4	3.34	62
Purchas, *et al.* [15]		1.75	88
Pork, Raw			
Pretorius, *et al.*	72.13	0.76	84
Schricker, *et al*. [10]		1	49
Leonhardt & Wenk [13]		1.90	58
Lombardi-Boccia, *et al.* [11]		0.42	62
Carpenter & Clark [12]		0.96	75
Chicken, Raw			
Pretorius, *et al.*	75.47	0.75	76
Leonhardt & Wenk [13]		2.20	61
Lombardi-Boccia, *et al.* [11]		0.59	38
Carpenter & Clark [12]		6.40	54

IV. CONCLUSION

Reliable data are needed concerning the total and heme iron fractions of meat to facilitate the development of a sustainable food-based approach to combat iron deficiency. In this study the TFe and HFe contents of meat from four different species were determined. This has important dietary implications since heme iron is the more bioavailable form of iron in the human diet. Education on the role of meat as part of a balanced diet can thus be better informed by more relevant data.

Because of the variability, the use of mean total and heme iron values for meat from different species for evaluating and predicting iron availability may be of limited value. The Monsen model [18] uses the value of 40% for the percentage heme iron to total iron in meat, fish and poultry. In determining the EAR's for iron, the iron bioavailability was estimated as 18% for

adults. This was based on a mixed diet including all food groups. It does not consider iron from meat as an independent food group. The meats in this study contain higher percentage of heme iron. This indicated that the heme iron value used in the Monsen equation, as well as other equations, should not be a constant value, but should be different for each particular meat type consumed in the diet.

Species, cut, as well as cooking method, are all factors that will have an influence on the %HFe [11, 12, 15]. As meats are normally consumed cooked, further research needs to be done to determine the heme iron fractions in cooked meat.

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