Relative Bioavailability of Iron of South African Lean Meat
(Beef, Lamb, Pork and Chicken)

Beulah Pretorius, Hettie C Schönfeldt and Nicolette Hall

Institute of Food, Nutrition and Well-being │ Department of Animal and Wildlife Science │ University of Pretoria │ Pretoria │ South Africa

Abstract – This study provides data on the total and heme iron contents in raw lean beef, chicken, lamb and pork meat samples. Total iron content, expressed as mg/100g in raw lean beef, lamb, pork and chicken, averaged 2.46, 2.29, 0.76 and 0.75 respectively. In beef 81%, in lamb 82% and in pork 84% of total iron was in the heme form. Heme iron in chicken was 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.

INTRODUCTION

Iron deficiency is the most prevalent nutritional deficiency in the world, affecting over 2 billion people. 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]. 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.

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. This study aims to determine the total and heme iron content in South African meat (beef, lamb, pork and chicken).

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 three age groups were obtained 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).
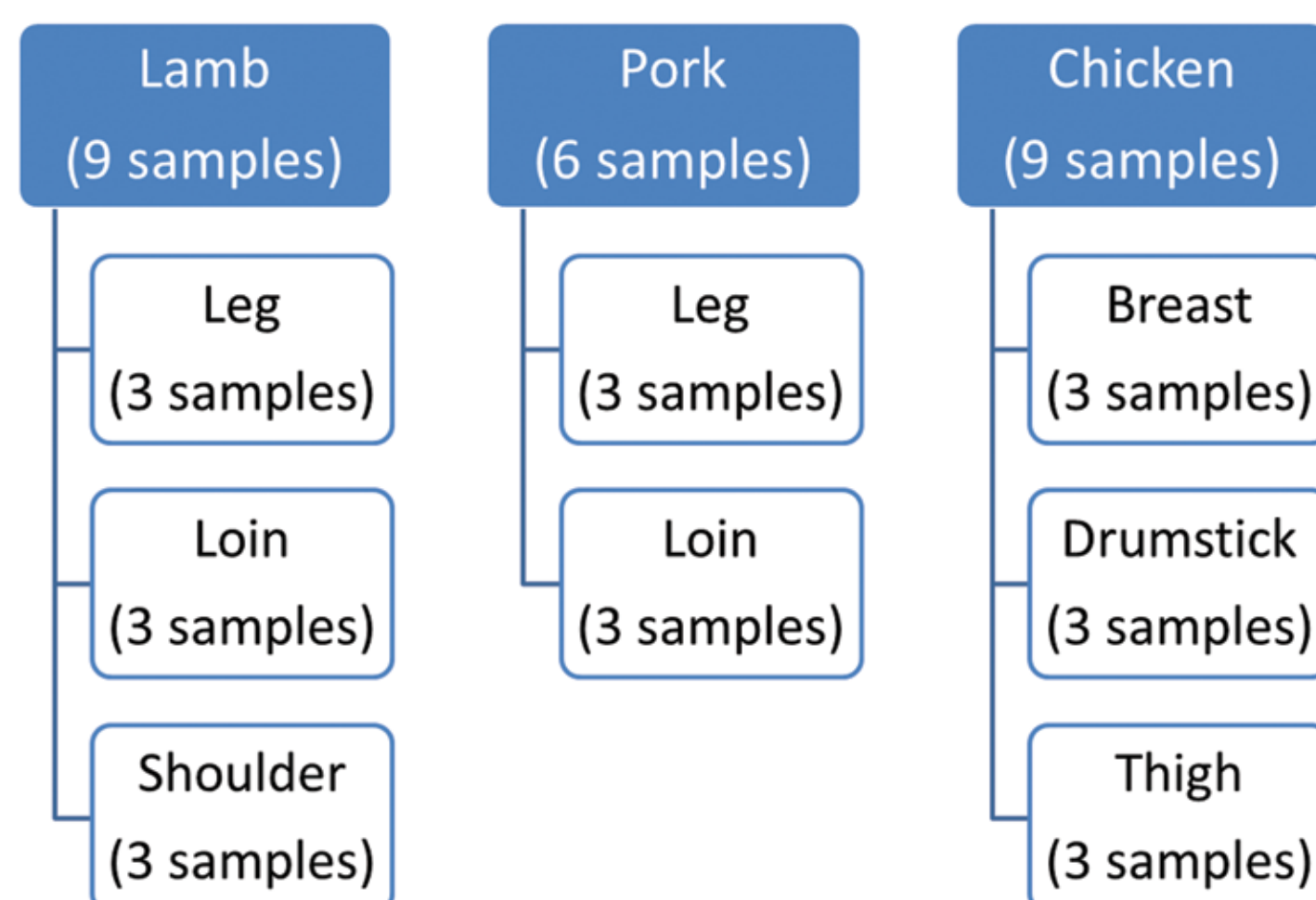

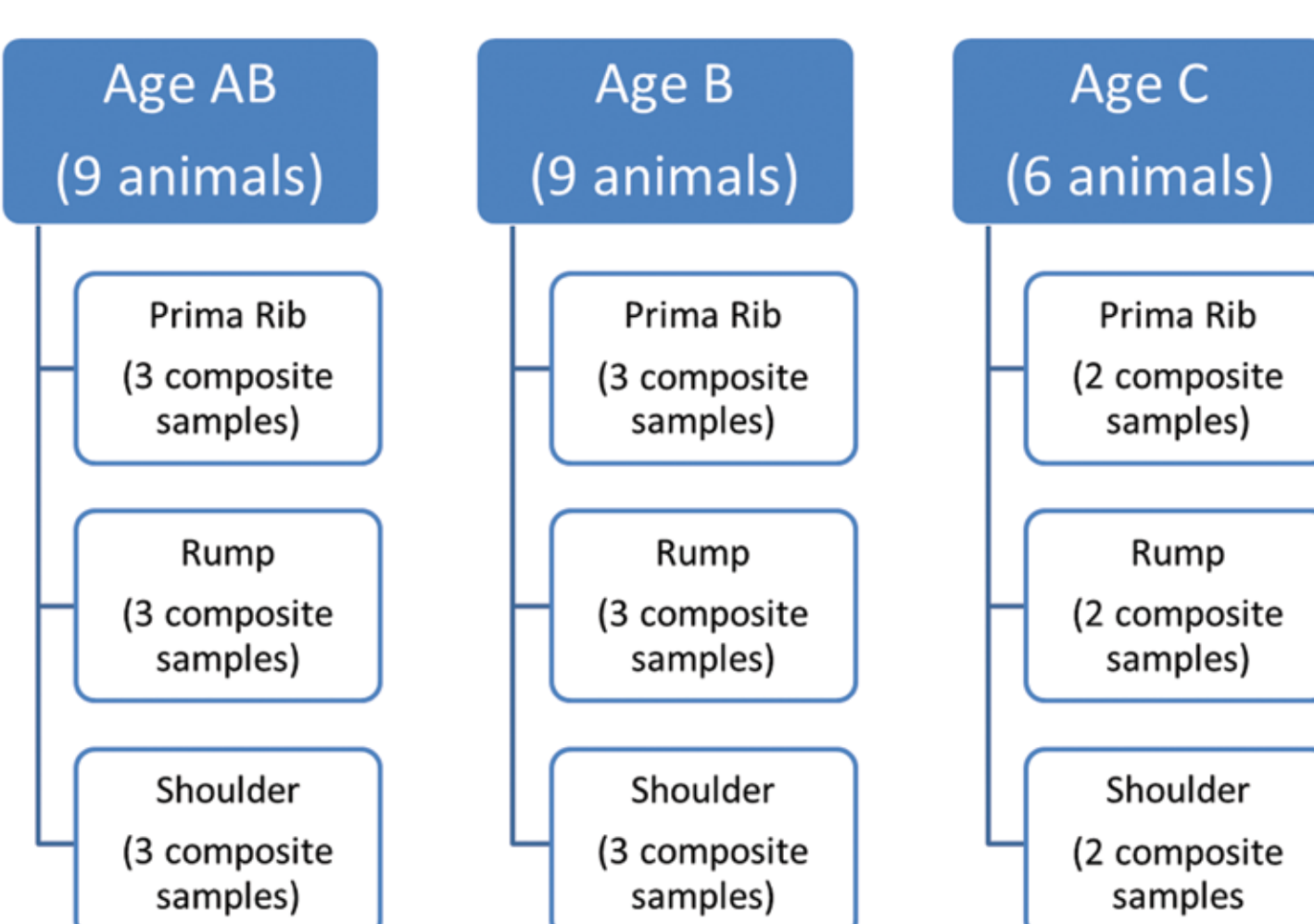Figure 1: Sampling design for lamb, pork and chicken samples.

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

Sample preparation and Analysis

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.

Table 1: Methods used to determine heme and nonheme iron content of South African animal products

Nutrient	Method
Moisture	Gravimetric determination of moisture (AOAC, 2005) [7].
Total iron content	Giron, et al. (1973) [8]
Heme Iron content	Hornsey Method [8]

RESULTS AND DISCUSSION

Beef and lamb meat had the highest total iron and heme iron content with chicken and pork meat having the lowest values (Table 2, 3, 4). The total iron content in lamb, beef, pork and chicken meat was in the range generally reported for these meats (Table 5). 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 2: 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 (%)
Lamb[a]	72.26	2.29	1.89	82
Pork[b]	72.13	0.76	0.64	84
Chicken[a]	75.47	0.75	0.57	76
Beef[c]	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 3: Moisture, Total Iron (TFe), Heme Iron (HFe), Non-heme 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
[a]Lamb, Leg	72.63	1.69	1.42	85
[a]Lamb, Shoulder	73.64	1.51	0.81	53
[a]Pork, Rump	72.66	0.82	0.69	85
[a]Pork, Loin	71.59	0.70	0.58	84
[a]Chicken, Drumsticks	76.68	0.75	0.65	88
[a]Chicken, Thighs	74.46	0.86	0.64	75
[a]Chicken, Breasts	75.25	0.65	0.43	66
[b]Beef, Prima Rib	72.26	2.29	1.89	82
[b]Beef, Rump	74.27	2.93	2.19	77
[b]Beef, 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 4: 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

Animal age	Moisture (%)	TFe (mg/100g)	HFe (mg/100g)	HFe (%)
AB (2 permanent incisors)	74.44	2.74	2.02	77
B (3 to 7 teeth)	73.89	2.36	2.00	85
C (8 teeth)	73.27	2.29	1.87	82

Table 5: Moisture, Total Iron (TFe) and Percentage Heme Iron (%HFe) in different meat samples as reported by various authors

	Mean	
	TFe (mg/100g)	HFe (%)
Lamb, Raw		
Current study	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		
Current study	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].	3.34	62
Purchas, et al. [15]	1.75	88
Pork, Raw		
Current study	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		
Current study	0.75	76
Leonhardt & Wenk [13]	2.20	61
Lombardi-Boccia, et al. [11]	0.59	38
Carpenter & Clark [12]	6.40	54

CONCLUSION & RECOMMENDATIONS

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

ACKNOWLEDGEMENTS

REFERENCES

1. Zimmermann, M.B. & Hurrell, R.F. (2007). Nutritional iron deficiency. Lancet 370: 511–520.
2. SAVACG (South African Vitamin A Consultative Group). 1996. Anthropometric, vitamin A, iron and immunization status in children aged 6-71 months in South Africa. South African Medical Journal 86: 354 - 357.
3. NFCS-FB-I (National Food Consumption Survey Fortification Baseline). 2008. Executive Summary of the National Food Consumption Survey Fortification Baseline South Africa, 2005. South African Journal of Clinical Nutrition 21(3): 245–300 (Supplement 2).
4. Pettit, K., Rowley, J. & Brown, N. 2011. Iron deficiency. Paediatrics and Child Health 21(8): 339-343.
5. NFCS (National Food Consumption Survey). 2000. The National Food Consumption Survey: children aged 1-9 years South Africa, 1999, Department of Health, Nutrition Directorate, Pretoria, South Africa.
6. Schonfeldt, H.C. (1998) Effect of age on beef quality. PhD Thesis, University of Pretoria.
7. AOAC (ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS). 2005. Official methods of analysis of the Association of Official Analytical Chemists. In: Horwitz, W. (Ed.), Method 935.29, 18th ed. Association of Official Analytical Chemists, Gaithersburg, USA.
8. Giron, H.C. 1973. Atomic Absorption Newsletter 12, 28. Perkin Elmer Atomic Spectrophotometer.
9. Hornsey, H.C. (1956). the color of cooked cured pork, I. Estimation of the nitric oxide-heme pigments. Journal of Science of Food and Agriculture 7: 534-540.
10. Schricker, B.R., Miller, D.D. & Stouffer, J.R. 1982. Measurement and content of nonheme and total iron in muscle. Journal of Food Science 47: 740-743.
11. Lombardi-Boccia, G., Martinez-Dominguez, B. & Aguzzi, A. 2002. Total heme and non-heme iron in raw and cooked meats. Journal of Food Science 67(5): 1738-1741.
12. Carpenter, C.E. & Clarl, E. 1995. Evaluation of methods used in meat iron analysis and iron content of raw and cooked meats. Journal of Agricultural and Food Chemistry 43: 1824-1827.
13. Leonhardt, M. & Wenk, C. 1997. Variability of selected vitamins and trace elements of different meat cuts. Journal of Food Composition and Analysis 10: 218-224.
14. Kalpalathika, P.V., Clark, E.M., & Mahoney, A.W., 1991. Heme iron content in selected ready-to-serve beef products. Journal of Agriculture and Food Chemistry 39: 1091–1093.
15. Purchas, R.W., Busboom, J.R., & Wilkinson, B.H.P. 2006. Changes in the forms of iron and in concentrations of taurine, carnosine, coenzyme Q10, and creatine in beef longissimus muscle with cooking and simulated stomach and duodenal digestion. Meat Science 74, 443–449.
16. Dagnelie, P.C., Van Dusseldorp, M., Van Staveren,W.A.et al 1994. Effects of macrobiotic diets on linear growth in infants and children until 10 years of age. European Journal of Clinical Nutrition 48: S103-S111.
17. Neumann, C.G., Bwibo, N.O., Murphy, S.P., Sigman, M., Whaley, S. Allen, L.A., Guthrie, D., Weiss, R.E. & Demment, M.W. 2003. Animal source foods improve dietary quality, micronutrient status, growth and cognitive function in Kenyan school children: Background, study design and baseline findings. Journal of Nutrition 133: 3941S-3949S.
18. Monsen, E.R., Hallberg, L., Layrisse, M., Hegsted, D.M., Cook, J.D., Mertz, W., Finch, C.A., 1978. Estimation of available dietary iron. American Journal of Clinical Nutrition 31, 134–141.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Denkleiers • Leading Minds • Dikgopolo tša Dihlalefi

www.up.ac.za