UTILIZING REGRESSION TECHNIQUES FOR ESTIMATING THE NUTRIENT COMPOSITION OF GROUND BEEF PRODUCTS

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Introduction

Ground beef is a unique meat product in that a wide range of formulations for this product are available in most US retail stores. Until 2003, nutrient composition data for ground beef reported in the USDA National Nutrient Database for Standard Reference (SR) (USDA, 2003) were for products containing 27%, 21%, and 17% fat. However, in response to consumer demand for healthier foods, a much broader selection of ground beef products were marketed at that time, with product offerings as low as 5% fat. The USDA, in collaboration with America's Beef Producers, undertook a study to update the nutrient composition data for ground beef products in SR. However, providing nutrient information for such a range of products presented a unique challenge. In order to provide consumers and industry with the nutrient composition information for this variable product, the study was designed to establish the mathematical relationship between the various nutrients and the total fat content of raw ground beef through regression techniques. The ultimate aim was to use these relationships for prediction of the nutrient composition for ground beef, as purchased, and for broiled, ground beef patties. This report will provide the predictive equations used to estimate nutrient values for proximate components, and for selected vitamins and minerals disseminated in SR.

Materials and Methods

Sampling: Ground beef samples for each of 3 fat categories (label declarations of <12% fat, 12-22% fat, or >22% fat) were purchased from 24 retail outlets nationwide. In this sampling plan developed for the National Food and Nutrient Analysis Program (Pehrsson *et al.*, 2000), the country was divided into 4 regions, with 3 consolidated metropolitan statistical areas (CMSA) within each region; 2 retail stores were selected within each CMSA.

Sample preparation: Ground beef products were analyzed in raw and cooked form (broiled patty). To achieve uniform sizing for the broiled patties, 112 g of ground beef were pressed into a patty mold. Patties were broiled in a preheated conventional oven for 8.7 min at 71°C. Patties were cut in half to evaluate degree of doneness based on color, then stored at –24°C in sealed vacuum bags until homogenization and analysis.

Sample analyses: Samples from each location and each fat level (n=72) were analyzed for moisture, nitrogen, total fat, ash, and selenium. Samples were pooled by CMSA (n=36) for analyses of minerals (calcium, magnesium, potassium, manganese, iron, phosphorus, sodium, copper, zinc), niacin, thiamin, riboflavin, vitamins B_6 and B_{12}, cholesterol, and fatty acids (C8 - C22); twelve samples (pooled by region) were analyzed for total choline and vitamin K. A commercial testing laboratory using AOAC methods analyzed proximate components, vitamins, and minerals. Selenium was analyzed by isotope dilution gas chromatography/mass spectrometry (Reimer and Veillon, 1981); Vitamin K was analyzed by high performance liquid chromatography (Dumont *et al.*, 2003); choline and betaine were analyzed by liquid chromatography/electrospray ionization-isotope dilution mass spectrometry (Koc *et al.*, 2002). Quality control measures included duplicate sampling, and the use of control composites and NIST standard reference materials (SRM 1546: Meat Homogenate).

Statistics: Data were analyzed using mixed model regression analysis (SAS, 2004) to obtain a regression equation for each nutrient and preparation method (raw and broiled).

Results and Discussion

For each nutrient in the raw product, the relationship between nutrient levels and total fat content could best be defined by a simple linear expression. Simple linear equations and second-degree polynomial models appropriately described the relationship between nutrient level of broiled patties and total fat content of the raw product. Quadratic equations were the 'best fit' models for cholesterol and total fatty acids (saturated, monounsaturated and polyunsaturated) with respect to total fat content. The best regression model to explain the relationship of moisture to total fat was also a quadratic equation. Higher levels of polynomial regressions did not improve the fit of the model for any nutrient analyzed. Table 1 presents the equations for predicting nutrient values for raw ground beef and broiled ground beef patties based on the total fat content of raw ground beef. Table 1 also illustrates the use of these equations and provides the nutrient composition of 93% lean ground beef (raw and broiled patty) as derived from these equations.

Table 1: Regression equations for determining nutrient content of ground beef products and the estimated nutrient values for ground beef containing 93% lean meat/7% fat (values per 100g ground beef).

		Raw		Broiled	
Nutrient	N	Regression Equation[1]	93% lean meat	Regression Equation[1]	93% lean meat
Protein, g	72	Y=22.8261 - 0.2826X	20.85	Y=26.4707 - 0.0363X	26.22
Total Fat, g	72	Y=0.0000 + 1.0000X	7.00	$Y=(-0.0369) + 1.4601X - 0.0284X^2$	11.58
Ash, g	72	Y=1.1141 - 0.0137X	1.02	Y=1.0736 - 0.0036X	1.05
Moisture, g	72	Y=77.0618 - 0.7560X	71.77	$Y=72.0784 - 1.3458X + 0.0273X^2$	64.00
Calcium, g	36	Y=6.2241 + 0.5864X	10	Y=1.3947 + 1.1347X	9
Iron, g	36	Y=2.5329 - 0.0296X	2.33	Y=2.9465 - 0.0232X	2.78
Magnesium, mg	36	Y=23.2122 - 0.3216X	21	Y=23.1760 - 0.1453X	22
Phosphorus, mg	36	Y=210.7459 - 2.6304X	192	Y=210.5172 - 0.8434X	205
Potassium, g	36	Y=372.0656 - 5.1254X	336	Y=362.0251 - 2.9055X	342
Sodium, mg	36	Y=65.3488 + 0.0699X	66	Y=61.7564 + 0.6534X	66
Zinc, mg	36	Y=5.3958 - 0.0609X	4.97	Y=6.4899 - 0.0118X	6.41
Copper, mg	36	Y=0.0829 - 0.0011X	0.075	Y=0.1011 - 0.0011X	0.093
Manganese, mg	36	Y=0.0107 + 0.0000X	0.011	Y=0.0153 - 0.0002X	0.014
Selenium, mg	72	Y=18.167 - 0.1565X	17.1	Y=21.7719 - 0.0139X	21.7
Thiamin, mg	36	Y=0.0406 + 0.0001X	0.041	Y=0.0404 + 0.0004X	0.043
Riboflavin, mg	36	Y=0.1647 - 0.0008X	0.159	Y=0.1714 + 0.0003X	0.174
Niacin, mg	36	Y=5.9167 - 0.0845X	5.325	Y=6.2196 - 0.0561X	5.827
Vitamin B_6, mg	36	Y=0.4150 - 0.0046X	0.383	Y=0.4275 - 0.0030X	0.407
Vitamin B_{12}, mg	36	Y=2.2786 - 0.0069X	2.23	Y=2.3861 + 0.0171X	2.51
Choline, mg	12	Y=75.6921 - 0.9630X	68.95	Y=86.9261 - 0.3047X	84.79
Vitamin K, mg	12	Y=(-0.2039) + 0.1024X	0.5	$Y=1.6773 - 0.1048X + 0.0050X^2$	1.2
Betaine, mg	12	Y=7.6230 + 0.0299X	7.83	Y=6.8812 + 0.1065X	7.63
Cholesterol, mg	36	Y=58.2332 + 0.6534X	63	$Y=62.6671 + 3.0539X - 0.0806X^2$	80
SFA[2], g	35	Y=0.4424 + 0.3615X	2.973	$Y=0.9357 + 0.4471X - 0.0078X^2$	3.683
MUFA[3], g	35	Y=(-0.0509) + 0.4404X	3.032	$Y=(-0.0013) + 0.5942X - 0.0100X^2$	3.668
PUFA[4], g	35	Y=0.1686 + 0.0176X	0.292	$Y=0.2026 + 0.0278X - 0.0006X^2$	0.368

[1]X=% total fat; [2]total saturated fatty acids; [3]total monounsaturated fatty acids; [4]total polyunsaturated fatty acids

Conclusion

USDA has been developing food composition tables and electronic databases for more than 100 years (Atwater and Woods, 1891; Nutrient Data Laboratory, 2003). SR is provided to the scientific community and national population free of charge, and is widely used for many purposes, including nutrition monitoring, nutrition policy development, health research and food product development. The results of this study provide a mechanism by which the nutrient content of ground beef can be estimated for any product formulated with a fat content ranging from 5% to 30%. Nutrient information derived from these equations will be used by consumers to estimate dietary intakes. These data will also be used by industry to meet anticipated mandatory labeling requirements.

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