DETERMINATIONS OF SELECTED TRACE MINERALS IN TURKEY MUSCLES

by

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INTRODUCTION

There are 92 trace minerals detectable in water, plants, and animals; 17 have a known biological function in animals. The Food and Nutrition Board of the National Research Council currently considers 10 trace minerals to be essential for man: fluorine, chromium, iodine, manganese, iron, cobalt, copper, zinc, selenium, and molybdenum. Recommended Dietary Allowances (RDA) have been established for iodine, iron, and zinc. Nutritional problems have been shown to exist in the United States because of deficient intakes of iron, fluorine, and iodine. In addition, recent evidence suggests that some diets provide marginal intakes of chromium, manganese, and zinc (Schroeder, 1971; NRC, 1974).

Although some data have been published recently on trace mineral content of foodstuffs, no comprehensive information on trace minerals in turkey muscle is available. Cooking losses of trace minerals are also difficult to determine because few researchers have done analysis on raw and cooked samples for the same bird. Much of the data that is available on trace minerals in turkey is conflicting because older methods are less sensitive for the detection of minute quantities of trace minerals than newer methods.

In this study we compared two newer methods, neutron activation analysis and x-ray fluorescence, and an established method, atomic absorption spectrophotometry for determining selected trace minerals in turkey breast muscle. A desirable method is simple, non-destructive, accurate, and precise for minute amounts and also one in which simultaneous multi-element analysis can be performed.

Due to increased interest in nutrition and nutrition labeling there is a need for more reliable and up to date data on trace mineral content of

turkey muscle. This study also determined the copper, zinc, and iron values for light and dark turkey muscle and compared the raw and cooked values to determine the effect of cooking on those three minerals in turkey muscle.

REVIEW OF LITERATURE

Methods of Analysis for Trace Minerals

The determination of trace minerals in foods has been a subject of recent research because of an increased interest in nutrition and nutrition labeling regulations. This recognition of the importance of trace elements in nutrition has led to requirements for more specific and sensitive methods of analysis for trace elements in foods. Several analytical methods such as emission spectroscopy, colorimetry, fluorometry, and amperometric titrations have been used for trace mineral analysis but these are non-specific, less accurate, and more complicated than some newer methods such as atomic absorption spectrophotometry, useful for single element analysis; neutron activation analysis and x-ray fluorescence, useful for single and multi-element analysis (Koch and Roesmer, 1962; Morris and Levander, 1970).

Atomic Absorption Spectrophotometry

Atomic absorption spectrophotometry (AAS) is recommended as a standard procedure for most minerals because it is fast, less prone to interference effects and a fairly simple method (Rogers, 1968). Atomic absorption spectrophotometry is recognized as an official AOAC (Association of Official Analytical Chemists) method for the majority of minerals and is a preferred method in terms of sensitivity, accuracy, and expense (Higgins and Pickering, 1971; AOAC, 1975).

This method can be used to determine more than 60 elements. It is accurate

at concentrations in aqueous media of 0.5 to 0.003 µg/g and has sensitivities of 0.2 to 9.01 µg/g per 0.01 absorbance with reproducibility in the order of 5-10% (Schroeder, 1971). Sample preparation is important, elements are usually concentrated by ashing and must be in an aqueous state for aspiration. Methods of sample preparation are dry ashing, wet ashing, solvent extraction, acid extraction or direct aspiration of liquid (Szarski, 1971).

The components of the AAS system are the source, an aspirating device and burner, a monochromator and read out device. The elements are aspirated into a flame and an atom absorbs energy promoting an electron from it's ground state level into a higher energy level. The energy absorbed in raising an atom from the ground state to the excited state is measured. The quantity of this energy for a given element corresponds with the amount of that element in the sample (Rogers, 1968; Smith and Schrenk, 1972).

X-Ray Fluorescence

Irradiation of metals by electrons can produce x-rays. In x-ray fluorescence (XRF), the sample absorbs primary x-rays that contain wavelengths shorter than those of the absorption edge, and emit secondary x-rays. Only the excited electrons in the K, L, and M shells of the atom are of interest. For quantitative analysis, the intensity of emission can be measured (Natelson, 1968). This method of analysis is useful for multi-element detection of 22 elements in biological samples. Sensitivities range from 1 to 5 parts per million (ppm) in environmental samples for elements between vanadium and molybdenum, future predictions are for sensitivities to tenths ppm (Cooper, 1973).

Samples used for XRF may be powdered residues from evaporated liquids, particulate matter collected on filter paper or anything that will fit into or on a sample holder. The basic components of a system for XRF consists of three subsystems, the first is the excitation source, the second detects the fluorescent spectrum emitted by the sample and third extracts the information

for qualitative (x-ray energy or wavelength) and quantitative (x-ray intensity) analysis (Keenan, 1975).

The samples are excited which in turn produces the chatacteristic x-rays of the elements in the sample, and in addition, interference (background scattering). This photon flux coming from the sample is detected by a Lithium drifted Silicon [Si(Li)] solid state detector which yields a pulse amplitude proportional to the energy of the detected x-ray. The detector pulses are amplified, processed, and sorted according to amplitude with an amplifier and pulse height analyzer. A pulse height spectrum is the resulting histogram of number of pulses versus pulse height, also called an x-ray energy spectrum since the pulse height from the detector is proportional to the x-ray energy. A single energy x-ray will give rise to a sharp peak in the x-ray spectrum, the area of which is proportional to the intensity of the single energy x-ray. The technique's sensitivity for the analysis of a specific element is determined by the minimum number of peak counts detectable above the background scattering (Cooper, 1973). When this method was compared with atomic absorption in determining five minerals, in environmental samples, values were found to be similar for the two methods (Cooper, 1973).

Neutron Activation Analysis

Since 1966 the Food and Drug Administration has used neutron activation analysis (NAA) to detect minerals in biological materials including foods (Tanner et al., 1970). This method has been used to detect over 70 elements in amounts as small as 10^{-12}g. For a majority of elements NAA is the most sensitive of all methods of trace element analysis (Morris, 1970; Meinke, 1955). This method has been used to determine trace element concentrations in meat. The values ranged from 1000 ppm phosphorus to 10^{-6} ppm cerium with estimated accuracy to $\pm$10% (Koch and Roesmer, 1962).

Sample preparation is minimal, some materials may be activated as they exist in nature, however for greater sensitivity, chemical separations are required usually (Morris, 1970; Tanner, 1970). Drying, dry ashing, and wet ashing are some methods used for sample preparation.

The sample is irradiated in a nuclear reactor for short and long periods of time. In this time the sample is bombarded with neutrons and radioactive elements are formed. The resulting radioactivity is measured by a gamma-ray spectrometer, in energy and intensity. From the gamma-ray spectrum of the sample, elements can be identified by the energy of their characteristic peaks. The concentration of each element is related to the area under the peak (Eckhoff, 1968; Morris and Levander, 1970).

Mineral Composition of Poultry

Poultry is considered a good source of zinc and cobalt; a fair source of copper, iron, and chromium; and a poor source of manganese, iodine, molybdenum, and selenium. Factors which affect the ash and mineral content of poultry are breed of bird (Gilpin et al., 1960) and age. Younger birds have a higher percentage of ash than older (Harshaw and Rector, 1943). Comprehensive tables for the minerals in poultry were not found. Food Composition Handbook No. 456 (Adams, 1975) lists some, but not all, minerals and only one trace mineral, iron.

The percentage ash content of mature roasted turkeys was 1.1% for white meat and 1.0% for dark, this was slightly higher than the ash content of roasted chicken (Harshaw and Rector, 1943; Scott, 1956). Turkey also had greater amounts of zinc, copper, and iron than chicken and similar chromium, manganese, and strontium content. In both turkey and chicken, dark meat had higher values for trace minerals (mg/100 g) than light and cooked values higher than raw (Morris and Levander, 1970; Osis et al., 1972; Pennington and Calloway, 1973; Murphy et al., 1975). Fox et al. (1960) compared magnesium

content of cooked and raw samples of chicken with an equal protein content; values per gram of cooked samples were significantly less than those for corresponding raw samples.

Game birds had more iron than domestic fowl, but zinc and copper values were comparable (Rasanen, 1972). Reported values for trace minerals for poultry are given in Table 1. Methods of analysis most commonly used were atomic absorption, colorimetry, fluorometry and emission spectroscopy.

Effects of Heating on Mineral Composition of Poultry

Meat supplies a variety of minerals, ranging from 10 to 50% of the RDA per 100 g serving. Normal cooking and processing conditions do not appreciably affect the quantity or availability of minerals. Small losses occur on leaching into the cooking liquid or juices, yet it is difficult to evaluate this loss from the nutritional standpoint because the drippings from meat are sometimes eaten as gravies. while cooking water from meats generally is used in soup preparation (Stewart, 1946; Siedler, 1963; Rubin, 1972). During poultry processing, the fowl is held in an ice slush; during this process, inorganic constituents are leached into the ice water (Pippen and Klose, 1955; Zenoble et al., 1976). An appreciable portion of those leached constituents have been shown to be minerals (Pippen and Klose, 1955). Some iron may be lost during processing and cooking since some iron compounds are water soluble.

Researchers in Norway (Rognerud, 1972) analyzed raw and cooked chicken for ash, calcium, and iron. The total ash content of raw chicken was 1.1%, calcium, 10.9 mg/100 g; iron, 1.3 mg/100 g; and moisture, 74.9%. For cooked chicken the total ash was 1.4%; calcium, 16.3 mg/100 g; iron, 1.4 mg/100 g; and moisture, 65.4%. The influence of various cooking and heating treatments on the selenium content of some foodstuffs typical to the American diet was investigated by Higgs et al. (1972). Baking and broiling had little or no effect on the amounts

Table 1-Trace minerals in poultry mg/100g edible portion.

	Zn	Cu	Fe	Mn	Co	Ch	Sr	Se	Ta	Ti	Sn	Ge	Cd	V
Turkey		.16[a]	1.4-3.8[a,m]	.033[a]										
raw														
cooked			3.8[b]											
Light meat														
raw	1.6-1.8[k,t]	.04-.15[k,r]	.73[k]	.02[k]		.03[k]	.012[k]							
cooked	2.1[t]													
Dark meat														
raw	2.4-3.1[k,t]	.04-.12[k,r]	1.5[k]	.02[k]		.03[k]	.01[k]							
cooked	4.4[t]													
Chicken			.7-2.8[b,o,a,m]											
raw		.01-.41[r]	1.3[s]											
cooked			1.4-2.6[b,m,s]								.173[e]	.015[h]		
Light meat								.0115[l]	.012[f]	.016[c]				
raw	.59-.7[k,t]	.01-.27[k,r]	.08[k]	.2[k]		.03[k]	.01[k]	.047[n]						
cooked	0.9[t]						.05[q]	.049[n]						
Dark meat	2.6[j]				25[i]			.036[l]	.058[f]				.15[j]	.014[d]
raw	1.5-1.8[k,t]	.02-.41[k,r]	1.1[k]	.02[k]		.03[k]	.011[k]							
cooked	2.8[t]													
Duck		.41[r]	5.8[b]											
Goose		.33[r]	4.6[b]											
Pheasant (breast)	.43[o]	.08[o]	0.8[o]											
Willow Grouse	.54[o]	.29[o]	3.9-7.6[b,o]											
Mallard (breast)	.74[o]	.30[o]	4.1[o]											
Poultry - cooked			1.6[p]											

[a]Hoiges and Peterson, 1931;
[b]McCance and Widdowson, 1960;
[c]Schroeder et al., 1963a;
[d]Schroeder et al., 1963b;
[e]Schroeder et al., 1964;
[f]Schroeder et al., 1965;
[g]Schroeder et al., 1966;
[h]Schroeder et al., 1967a;
[i]Schroeder et al., 1967b;
[j]Schroeder et al., 1967c;
[k]Gormican, 1970;
[l]Morris and Levander, 1970;
[m]Byerly, 1971
[n]Higgs et al., 1972;
[o]Rasanen et al., 1972;
[p]Rubin, 1972;
[q]Schroeder et al., 1972;
[r]Pennington and Calloway, 1973;
[s]Rognerud, 1973;
[t]Murphy et al., 1975.

of selenium in meat products. Selenium was lost in vegetables however, suggesting a difference in the chemical form of the selenium in those two food systems. For raw and baked chicken, selenium content was 0.47 mg/100 g, dry weight basis.

Several tables are available which list nutrient composition of raw and cooked meats (McCance and Widdowson, 1960; Adams, 1975; Church and Church, 1975) but the values for a given mineral expressed as mg/100 g differ in many cases. Since existing tables have been compiled from many laboratories using different methods and laboratory procedures they are not adequate tools to evaluate losses during processing.

EXPERIMENTAL PROCEDURE

Two studies were conducted: (1) to compare methods of determining trace minerals in cooked turkey breast muscle and (2) to compare the zinc, copper, and iron content in raw and cooked breast and thigh muscles.

Comparison of Methods

Eight frozen turkeys of similar age and weight (10-14 lbs) and processed under similar conditions were obtained locally. Turkeys were sawed in half and one-half of each turkey (selected at random) was roasted in an electric oven maintained at 177° C to an internal temperature of 80° C in the pectoralis major (PM) muscle. The PM muscle was removed and ground in a Kenmore Electric Food Grinder (1/8 in. plate). Ground samples were dried in a C.W. Brabender and held frozen until analyzed.

Measurements

Cooking time. Total cooking time in minutes was recorded, and cooking time in min/kg was calculated based on the weight of the uncooked half bird.

Cooking weight losses. Percentage total, drip and volatile losses, based

on the weight of the uncooked half bird were calculated.

Percentage total moisture of muscle. Percentage total moisture was determined by drying ten 10 g samples in a C. W. Brabender Semi-Automatic Rapid Moisture Tester at 121° C for 1 hr.

Percentage ether extract. Percentage ether extract of ground PM muscle was determined by extracting duplicate dried samples with anhydrous diethyl ether for 16 hrs on a Goldfisch extraction apparatus (AOAC, 1975).

Trace mineral analysis. Trace minerals were determined by three methods: x-ray fluorescence, neutron activation and atomic absorption spectrophotometry.

X-ray fluorescence. Duplicate 6-7 g samples of dried, ground turkey were charred in a porcelain crucible over a bunsen burner for 2 hrs then ashed in a Muffle furnace for 10 hrs at 500° C. Samples (0.1-0.2 g) were weighed in acrylic sample holders 5 cm across with a 0.3 cm deep circular indentation 1.4 cm in diameter, and exposed for 3000 seconds to x-rays using a Cd^{109} source with an activity of 0.5 mC (milli-Curies). Elements with atomic weights of 39.10 to 95.94 (K to Mo) emitted chatacteristic x-rays which were detected with a Si(Li) solid state detector, analyzed and stored in a pulse height analyzer. The resulting spectra were read out on paper tape, and later transferred to magnetic tape. A computer analysis of the fluorescence spectrum was used to determine the area under each peak. The area was compared with previously determined standards to determine the ppm of each element per sample. Standards for each element were made by adding 1% of the element to the ashed turkey breast.

Neutron activation analysis. Duplicate 2-g dried turkey samples were weighed into polyethylene vials, and irradiated in the K.S.U. Triga Mark II Reactor at a power of 225 KW, a flux equal to 23.33×10^{15} (thermal) neutrons/ cm^2 second. Samples were allowed to decay (15 days) to let the radioactivity reach a safe working level, then removed to a Northern NS-636 4096 Multiparameter Channel analyzer and the emitting gamma rays counted and recorded on magnetic

tape. The counts per channel of each trace mineral were compared with a known amount of each mineral to determine the ppm.

Atomic absorption spectrophotometry. Duplicate 2-g samples of dried turkey were digested with perchloric acid. The digestant was then aspirated into an air acetylene flame in a Jarrell Ash flame atomic absorption spectrophotometer equipped with a Sargent S R recorder. Iron, copper, and zinc were determined by this procedure.

Analysis of Data

Data were analyzed by analysis of variance, with unequal subclasses, with methods as the only source of variation. When F values were significant, least significant differences (LSD) at the 5% level were calculated. Bartlett's test for homogeniety and 2-tailed F tests were used to determine homogeniety of variances.

Comparison of Kind and State of Meat

Nine frozen turkeys of similar age and weight (10-14 lbs) and processed locally under similar conditions were obtained. Turkeys were sawed in half and one-half of each turkey (selected at random) was roasted in an electric oven maintained at 177° C to an internal temperature of 80° C in the PM muscle. While the turkey halves were cooking the PM muscle and thigh muscles were removed from the raw half and each ground twice in a Kenmore Electric Food Grinder (1/8 in plate). Samples were taken for the corresponding cooked halves in the same manner and all were held frozen (-17° C) until analyzed.

Measurements of cooking time, cooking weight losses, percentages of ether extract and copper, zinc, and iron as determined by atomic absorption were made by the procedures outlined in the first study. Total moisture was determined by drying duplicate samples in a vacuum oven to a constant weight.

Data were analyzed using analysis of variance with a split plot design:

Source	df
Turkeys	8
White vs dark (K)	1
Error A	8
Raw vs cooked (S)	1
Interaction	1
Error B	16

When F values were significant, LSD's at the 5% level were calculated.

RESULTS AND DISCUSSION

Comparison of Methods

Amounts of copper, zinc, and iron in cooked turkey breast muscle were determined by: AAS, XRF, and NAA (Table 2). Values for zinc as determined by AAS and NAA were similar but values by XRF were significantly higher. XRF also gave significantly higher values for iron than did AAS. Other researchers have compared some of these methods for determining amounts of minerals in other kinds of materials. Meinke (1955) found NAA gave higher values for zinc in standardized samples than other conventional methods of analysis (not AAS). Rhodes (1973) compared XRF and AAS as methods for determining five minerals in particulate air samples; generally values were lower for zinc as determined by XRF but higher for iron when determined by XRF as compared with AAS.

Rubidium values in cooked turkey breast muscle were similar when determined by NAA and XRF. This mineral was not determined by AAS. Copper, the mineral detected with lowest concentration, was not detectable by NAA and XRF, although Meinke (1955) found NAA had good sensitivity for copper. Cobalt, not determined by AAS was detectable by NAA but not XRF.

Table 2-Values for selected minerals in dried cooked turkey breast

Mineral	AAS	NAA	XRF
ZINC, µg/g			
Mean	37.99[a]	35.14[c]	61.08[a]
Range	31.45-45.90	24.35-52.22	51.25-71.80
Variance	27.55	108.64	47.33
IRON, µg/g			
Mean	24.14[b]		31.29[a]
Range	16.92-31.27		21.05-42.30
Variance	13.83		88.93
RUBIDIUM, µg/g			
Mean		29.47[d]	30.45[a]
Range		17.96-35.06	19.14-45.24
Variance		110.24	9.70
COPPER, µg/g			
Mean	1.32[b]		
Range	1.06-1.46		
COBALT, µg/g			
Mean		1.45[e]	
Range		0.92-1.95	

a-8 turkeys, duplicate determinations; b-8 turkeys, quadruplicate determinations;
c-8 turkeys, single determinations; d-7 turkeys, single determinations;
e-6 turkeys, single determinations; *, **-significance at 5 and 1% respectively

Newer methods for mineral analyses such as XRF and NAA may yield lower values for minerals than older methods because of greater specificity; the improved sensitivity of these methods may also detect some trace minerals in foods previously reported to have none. In this study, however neither of the newer methods were able to detect copper and NAA did not detect iron. Neutron activation did detect cobalt, but for XRF analysis, the small amount of cobalt present was masked by the large amount of iron. Generally the newer methods gave relatively close values to AAS with the exception of the XRF value for zinc. The speed and simplicity of this method warrants further investigation of its possibilities. Neutron activation analysis was a more complex method, yet required minimal sample preparation and gave similar results to AAS for the two minerals compared in this study.

The precision of the methods varied, though with some minerals the mean values were comparable. The upper and lower limit values observed for each mineral for each method and the variances are given in Table 2. The variances of the means of the three methods did not differ significantly for determinations of zinc in turkey breast muscle, though the variance for NAA was higher than XRF and AAS; AAS had the smallest variance for zinc. For iron XRF had a significantly higher variance than AAS. The precision and repeatibility of AAS as a method of determining iron exceeds that of XRF, iron was not detectable by NAA. The variance for rubidium was significantly higher for NAA than XRF; indicating XRF to be a more precise method for determining rubidium. Generally, for most minerals the most precise method was AAS.

The precision of a method may also be affected by the amount of mineral present in the sample. When using coefficients of variation to measure precision Rogers (1968) reported an increase in coefficient of variation with a decrease in mineral content. He also reported greater precision in AAS when samples were wet ashed, rather than dry ashed. In this study samples for AAS were wet

ashed, for XRF dry ashed and minerals were determined in the dried turkey samples for NAA.

Comparison of Kind and State of Muscle

Percentages of fat, moisture and the zinc, iron, and copper content of turkey muscle are presented in Table 3. Values for minerals are given as μg/g of the edible weight and on a moisture free-fat free (MF-FF) basis. Edible weight values are given for ease in comparing our values with published data and food composition tables. Moisture free-fat free values were calculated to remove the variable of differences in percentage moisture and fat for comparison of the mineral values in breast and thigh muscles and also to determine the effects of cooking on selected minerals.

Comparison of Type of Meat

Values for all minerals were significantly higher in the thigh muscle than in the breast muscle. This agrees with all of the literature reviewed on poultry (Morris and Levander, 1970; Osis et al., 1972; Pennington and Calloway, 1973; Murphy et al., 1975) except Gormican (1970) who reported no difference in copper content between breast and thigh of raw turkey, but found zinc and iron content higher in thigh muscle.

The darker muscles are generally the most active and thus have the greater blood supply and would be expected to have higher concentrations of iron. Cassens et al. (1963) reported that zinc content in various porcine muscles varies with the color and myoglobin concentrations; darker muscles had the greatest concentrations of zinc. He found increased concentrations of zinc in muscles with greater activity. Rasanen et al. (1972) found that game bird muscles (which have a higher percentage of darker muscles than domestic fowl) have higher concentrations of iron than chicken muscles and similar amounts of zinc and copper.

Table 3- Means[a] of selected minerals and percentage moisture and ether extract in turkey muscle.

Mineral	Breast muscle		Thigh muscle		Sign. of F-value		
	Raw	Cooked	Raw	Cooked	S[b]	K[c]	SxK
ZINC µg/g							
MF-FF[d]	38.34	39.42	116.10—*—105.46		**	**	ns
Edible weight	9.23—*—12.85		24.27—*—30.47		ns	**	ns
IRON µg/g							
MF-FF	35.06—*—26.03		78.30—*—62.59		**	**	ns
Edible weight	8.44	8.49	16.40—*—18.10		ns	**	ns
COPPER µg/g							
MF-FF	2.36—*—1.49		4.70	5.09	ns	**	**
Edible weight	0.57	0.48	0.98—*—1.48		**	**	**
Moisture, %	75.19	66.00	75.65	63.66			
Ether extract, %	0.69	4.00	3.45	7.33			

a-means of duplicate determinations for 9 turkeys
b-state of bird (raw or cooked); c-kind of muscle (breast or thigh)
d-moisture free-fat free; *-significance at 5%; **-significance at 1%
ns-not significant ($p<0.05$)

Effect of Cooking on Light and Dark Meat

When mineral values were expressed on an edible weight basis all cooked meat values were higher or similar to raw meat values. However, when expressed on a MF-FF basis, values for cooked meat were lower or similar to raw meat values. Zinc values were similar in the breast muscle for raw and cooked but were significantly lower in cooked thigh muscle than in raw. Other studies (Murphy et al., 1975) using paired samples showed cooking by either moist or dry heat resulted in almost no loss of zinc. In those studies little zinc was found in the drip.

Iron values were significantly lower for cooked breast and thigh muscles than for raw samples. However, Rognerud (1972) found an increase in iron content of chicken when cooked, but he reported values per 100 g sample of raw and cooked weight and did not account for moisture variation in samples. Copper values were significantly lower in cooked than in raw breast muscle. However, copper values for raw and cooked thigh muscles are similar.

Losses in minerals during preparation are considered to be minimal in poultry; however Fenton (1971) reported losses of several nutrients including ash during roasting. In food composition tables mineral values are generally higher for cooked than raw meat implying no loss of minerals during cooking, but these are expresses as mg/100 g edible weight and no consideration is given to moisture content. In our study we used paired halves of the same turkey and accounted for moisture and fat variation and found there is usually a loss of trace minerals from the raw to the cooked state.

The determinations for zinc, iron, and copper were within ranges of literature values for poultry (Table 1). Gormican (1970) analyzed duplicate samples from one turkey by emission spectroscopy for inorganic elements including zinc, iron, and copper. Our zinc values in raw breast (0.9mg/100g)

edible portion were lower than values reported by Gormican (1970), 1.8mg/100g. However, raw thigh values were the same as those reported by Gormican (1970).

We found slightly higher iron values than those reported by Gormican (1970). For raw breast our values were 0.84mg/100g compared with 0.73mg/100g and raw thigh 1.6mg/100g compared with the previously published values of 1.5mg/100g.

Gormican (1970) found the same concentration of copper in raw breast and thigh (0.037mg/100g); our values were slightly higher for the breast (0.057mg/100g) and much higher in the thigh muscles than her values, (0.098mg/100g). Iron values from our study were higher and values for zinc and copper lower than values from earlier studies (Hodges and Peterson, 1931; McCance and Widdowson, 1960; Osis et al., 1972; Pennington and Calloway, 1973; Murphy et al., 1975). Most of these references reviewed older studies that were not detailed as to materials, and gave ranges or mean values from the studies reviewed.

SUMMARY

Selected trace minerals were determined in dried cooked turkey breast muscle (pectoralis major) by three methods. Atomic absorption spectrophotometry and NAA gave similar values for zinc, but XRF determinations were significantly higher. Iron values were higher when determined by XRF than when determined by AAS. Neutron activation and XRF gave similar values for rubidium. Copper and iron were not detectable by NAA and copper not detectable by XRF.

Zinc, iron, and copper were also determined in cooked and raw breast and thigh muscles by AAS. Values for all minerals were significantly higher in the thigh muscles than in the breast muscle. When expressed on an edible weight basis all cooked meat mineral values were higher than raw meat values, except copper in breast muscle which was similar for the two states. However,

when expressed on a moisture free-fat free basis (to account for moisture variation) there was usually a loss of trace minerals from the raw to the cooked state. Zinc values were significanlty lower in the cooked thigh muscle than in raw thigh; breast zinc values were similar in the raw and cooked samples. Cooked breast and cooked thigh had significantly less iron than raw samples. Copper values were significantly lower in cooked than in raw breast muscle, thigh values were similar for the raw and cooked state.

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APPENDIX

Table 4-Values (μg/g) for selected trace minerals in dried cooked turkey pectoralis major muscle.

Factor	Turkey								
	1	2	3	4	5	6	7	8	Mean
Zinc									
Atomic absorption[a]	31.60	36.00	42.30	42.10	35.75	33.70	45.90	36.60	37.99
X-ray flouresence[a]	51.25	69.53	60.97	56.40	64.15	54.36	71.80	60.14	61.07
Neutron activation[b]	43.66	26.37	29.93	45.46	52.22	27.68	31.46	24.35	35.14
Iron									
Atomic absorption[c]	31.28	23.65	16.93	24.87	23.67	25.03	27.25	20.98	24.14
X-ray flouresence[a]	37.72	38.39	21.06	27.21	42.30	23.08	34.61	25.98	31.29
Rubidium									
X-ray flouresence[a]	34.83	28.12	26.70	29.63	33.80	29.44	28.84	30.79	30.45
Neutron activation[b]	17.97	24.99	31.63	25.85	45.24	41.14	19.15	-	29.47
Copper									
Atomic absorption[f]	1.38	1.31	1.06	1.21	1.45	1.43	1.36	1.33	1.32
Cobalt									
Neutron activation[b]	1.95	0.92	1.55	-	1.02	1.55	1.71	-	1.45

-Missing data; a, mean of duplicate determinations; b, single determinations; c, mean of quadruplicate determinations

Table 5-Ether extract, percent moisture and cooking losses for turkey muscles.

Factor	Turkey 1	2	3	4	5	6	7	8	9	Mean
Pectoralis Major										
Cooked										
Moisture, %	66.92	66.91	66.09	66.10	64.40	66.25	67.28	65.20	65.08	66.00
Ether extract, %	2.89	3.64	3.96	4.80	3.45	3.65	3.39	5.72	4.53	4.00
Raw										
Moisture, %	76.88	75.65	74.75	75.48	75.21	74.11	75.41	74.39	74.84	75.19
Ether extract, %	0.59	0.74	0.50	0.36	0.59	0.49	0.26	0.53	2.15	0.69
Thigh muscles										
Cooked										
Moisture, %	63.34	64.45	64.73	64.54	62.48	64.91	67.51	63.16	58.67	63.66
Ether extract, %	6.48	7.59	6.63	7.88	6/88	4.90	6.50	8.72	10.41	7.33
Raw										
Moisture, %	76.75	76.02	76.31	75.40	75.43	75.76	75.26	76.43	73.61	75.65
Ether extract, %	2.48	3.42	2.96	3.13	4.32	3.14	4.37	3.05	4.18	3.45
Total cooking losses, %	27.22	26.02	29.09	31.89	16.52	33.88	24.88	34.84		28.04
Volatile losses, %	24.24	17.95	24.01	26.71	13.98	25.53	20.89	27.57		22.61
Dripping losses, %	2.98	8.07	5.08	5.18	2.54	8.35	3.99	7.27		5.43
Min./kg cooking time	85.48	60.57	66.39	69.72	100.51	65.68	73.32	85.78		75.89

Table 6-Values for selected minerals in pectoralis major turkey muscle, µg/g.

Factor	Turkey									
	1	2	3	4	5	6	7	8	9	Mean
Cooked, MF-FF basis										
Copper	1.47	1.41	1.13	1.32	1.56	1.54	1.45	1.46	1.99	1.49
Iron	33.29	25.58	18.12	27.03	25.42	26.85	29.11	22.43	26.44	26.03
Zinc	33.64	38.94	45.28	45.75	38.38	36.16	49.03	40.10	27.54	39.42
Cooked, Edible weight										
Copper	0.47	0.45	0.37	0.42	0.54	0.50	0.46	0.48	0.66	0.48
Iron	10.69	8.23	5.90	8.72	8.74	8.73	9.20	7.37	8.82	8.49
Zinc	10.81	12.53	14.75	14.77	13.19	11.76	15.50	13.16	9118	12.85
Raw, MF-FF basis										
Copper	2.82	1.91	2.17	2.28	2.77	2.62	1.87	2.43	2.41	2.36
Iron	38.04	39.12	32.12	35.64	40.54	38.69	29.68	27.35	34.38	35.06
Zinc	33.87	36.79	41.61	35.10	32.61	33.38	42.75	36.84	52.15	35.34
Raw, edible weight										
Copper	0.64	0.45	0.54	0.55	0.67	0.67	0.45	0.61	0.55	0.57
Iron	8.57	9.24	7.95	8.61	9.81	9.83	7.22	6.86	7.91	8.44
Zinc	7.63	8.69	10.30	8.48	7.89	8.45	10.40	9.24	12.00	9.23

MF-FF-moisture free-fat free

Table 7-Values for selected minerals in composite of turkey thigh muscles, μg/g.

Factor	Turkey									
	1	2	3	4	5	6	7	8	9	Mean
Cooked, MF-FF basis										
Copper	4.11	6.08	5.13	4.39	4.37	4.97	3.93	5.69	7.18	5.09
Iron	58.65	64.38	63.55	56.56	5.191	57.64	60.79	72.55	78.77	62.59
Zinc	77.20	93.35	95.32	100.07	107.38	108.98	116.20	128.38	122.25	105.46
Cooked, edible weight										
Copper	1.24	1.70	1.47	1.21	1.34	1.50	0.02	1.60	2.22	1.48
Iron	17.70	18.00	18.20	15.60	15.60	17.40	15.80	20.40	24.20	18.10
Zinc	23.30	26.10	27.30	27.60	32.90	32.90	30.20	36.10	37.80	30.47
Raw, MF-FF										
Copper	4.55	5.55	4.76	4.57	4.43	5.02	4.45	4.26	4.73	4.70
Iron	62.77	71.50	71.88	82.91	76.54	86.73	82.47	72.61	97.25	78.30
Zinc	108.77	133.76	118.19	109.46	111.61	118.96	114.38	108.19	121.57	116.10
Raw, edible weight										
Copper	0.95	1.14	0.99	0.98	0.90	1.06	0.91	0.87	1.05	0.98
Iron	13.10	14.70	14.90	17.80	15.50	18.30	16.80	14.90	21.60	16.40
Zinc	22.70	27.50	24.50	23.50	22.60	25.10	23.30	22.20	27.00	24.27

MF-FF-moisture free-fat free

DETERMINATIONS OF SELECTED TRACE MINERALS IN TURKEY MUSCLES

by

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ABSTRACT

Selected trace minerals were determined in dried cooked turkey breast muscle (pectoralis major) by three methods: atomic absorption spectrophotometry (AAS), x-ray fluorescence (XRF) and neutron activation analysis (NAA). Determinations for zinc were similar for AAS (37.99 μg/g) and NAA (35.14 μg/g) but XRF (61.08 μg/g) determinations were significantly higher. Iron values were higher when determined by XRF (31.29 μg/g) than when determined by AAS (24.14 μg/g). Neutron activation and XRF gave similar values for rubidium (29.47 - 30.45 μg/g). Copper and iron were not detectable by NAA and copper not detectable by XRF.

Nine frozen turkeys were sawed in half and one-half of each turkey was roasted to an internal temperature of 80° C. Samples of the thigh and breast muscles from raw and cooked halves were analyzed by atomic absorption spectrophotometry (AAS) for copper, zinc and iron.

Values for all minerals were significantly higher in the thigh muscle than in the breast muscle. When expressed on an edible weight basis all cooked meat mineral values were higher than raw meat values, except copper in breast muscle which was similar for the two states. However, when expressed on a moisture free-fat free basis (to account for moisture variation) there was usually a loss of trace minerals from the raw to the cooked state. Zinc values were significantly lower in the cooked thigh muscle than in the raw thigh; however, zinc was similar in the breast for cooked and raw muscle. Cooked breast and cooked thigh had significantly less iron than raw samples. Copper values were significantly lower in cooked than in raw breast muscle, thigh values were similar for the raw and cooked state.