Research Note

Thiamin, Riboflavin, and α-Tocopherol Content of Exotic Meats and Loss Due to Gamma Radiation†

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ABSTRACT

Changes in thiamin, riboflavin, and α-tocopherol concentrations due to gamma irradiation were followed in alligator, caiman, bison, and ostrich (exotic) meats. The proximate composition showed that the exotic meats generally had lower fat content than domestic animal meats and that the thiamin content of the reptiles was lower. The changes in the vitamins due to irradiation were similar to those previously observed for domestic species. The results indicate that the loss of vitamins in these species is negligible insofar as the American diet is concerned, and that the concept of "chemiclearance" is applicable to exotic meats.

The marketing of exotic meats, (e.g., alligator, ostrich, and bison) is expanding. Since exotic meats have a relatively low fat content, they are perceived to be healthy foods *(11, 12)*. Bison in particular is prized for its low fat content *(12)*. But the marketing of exotic meats represents a special problem as the turnover times are significantly longer than for the more common meats. The industry is very interested in irradiation pasteurization, which will give their products a longer shelf life as well as greater microbiological safety *(14)*. As vitamins are the muscle components most sensitive to destruction by radiation, the questions are whether these meats are a significant source of vitamins and how stable are they to irradiation. Compositional studies of bison *(6, 9, 16)*, crocodile *(11)*, and ostrich *(5)* have been made, but only the U.S. Department of Agriculture *(16)* tables provide data on the vitamin content of bison. We found no studies on the stability to irradiation of vitamins in these meats.

It has been proposed that the effect of ionizing radiation is the same for any given tissue, regardless of species or source, and that the process of pasteurization or sterilization by gamma, X-ray or electron-beam radiation can be approved on a blanket basis (chemiclearance) *(10)*. Our studies to date have confirmed the validity of chemiclearance for low (pasteurizing) doses of gamma radiation for meat of domestic species *(3, 7)*. We studied thiamin, riboflavin, and unesterified α-tocopherol levels in alligator, caiman, bison, and ostrich meats before and after pasteurizing doses of gamma radiation up to 10 kGy to determine if the concept of chemiclearance could be validated in exotic meats.

MATERIALS AND METHODS

Substrate. Alligator (*Alligator mississippiensis*) and caiman (*Melanosuchus crocodilas*) meats were the gift of Mr. Stewart Pocock of Ocean Treats, Pompano Beach, Fla. The alligator was classified as "red" and the caiman as "white" meat. Ostrich (*Struthio camelus*) steak was the gift of Ostrich Farms of North America, Inc., Riverview, Fla. Ground ostrich meat was purchased from the Breezy Hill Meat Company, Bowie, Tex. Bison (*Bison bison*) top round from three animals was the gift of RC Western Meats, Inc, Rapid City, S.D. Except for the ostrich steak, the samples from each species were from three individual animals. The ground ostrich meat was from a number of individual birds. All samples were raw unprocessed commercial products shipped either frozen or refrigerated. No information regarding age, feed, etc., was available. All the whole meats were thawed and ground under nitrogen through a ⅛-in (ca. 0.3 cm) die plate and packaged in no. 400 stomacher bags (Seward, London, UK) and overwrapped under a vacuum in foil packages (Bell Fiber Products, Columbus, Ga.). All samples were stored at −50°C and were irradiated within 5 days.

Radiation source and temperature control. The self-contained ^{137}Cs gamma-radiation source (Lockheed-Georgia, Marietta, Ga., model LG 20000) had an activity of about 117,454 Ci (ca. 4.35 PBq) and a dose rate of 0.104 kGy min^{-1}. The temperature of the samples during irradiation was 5°C and maintained by thermostatically controlled injection of cold gaseous nitrogen into the irradiation chamber. The dosimetry for this study has been described previously *(14)*. The doses were 0.0, 0.25, 0.50, 0.75, 1.00, 2.00, 3.00, 6.00 and 10.00 kGy.

Vitamin and proximate analysis. Thiamin, riboflavin, and proximate analysis were determined as described *(2)*. Unesterified α-tocopherol was extracted from tissue, isolated by high-

performance liquid chromatography, and the level determined fluorometrically *(8)*.

Analysis of variance (ANOVA). The ANOVA of the data was performed by the general linear model procedure of SAS *(13)*. We had previously established that the data for the loss of thiamin and α-tocopherol were first order *(4)*, so the data were analyzed as the natural log of the percent vitamin concentration. Vitamin concentrations were calculated as percent loss from the original unirradiated species to compensate for sample-to-sample variation.

RESULTS AND DISCUSSION

Vitamin content. Proximate analyses of the unirradiated meats are in Table 1. The values are within expected ranges when compared with our previous studies on domestic animals *(3)*, except that the fat contents of the exotic meats were lower by ca. 1%. The ostrich hamburger had about eight times the fat content of the ostrich steak because adipose tissue had been ground with the lean. The low fat content of the ostrich steak has also been observed for domestic turkeys *(7)* and Duewer et al. *(1)* reported that ostrich had a lower fat content than chicken. We did not observe any great differences in the rest of the proximate values between domestic and farmed exotic species.

The thiamin concentration was the same in bison as observed for most meats *(3)*, except pork, which was assayed to have 10 to 20 μg/g of tissue. The level of thiamin in the meat of both reptiles, especially alligator, was very low and presented a detection problem since the fluorescence was barely above background. Measurements could be obtained on only one set of data from the alligator and indicated a thiamin concentration of 0.07 μg or less per g of wet tissue. The thiamin content of caiman was also low, 0.33 μg/g. These were all fresh meats with minimal oxidative loss of the vitamin, which indicates that the thiamin content of poikilothermal animals is lower than homothermal animals. Riboflavin concentration in alligator, bison, and ostrich meat was in the same range as for domestic species, ca. 1 μg/g of wet tissue, but was lower in caiman. α-Tocopherol was in the same concentration range as observed for domestic animals. In summary, while there were individual variations in the concentrations of different components of the several species, there did not appear to be any noteworthy differences between the exotic and domestic species.

Vitamin loss due to gamma irradiation. The losses of vitamins due to irradiation were analyzed by ANOVA and the effect of dose on each species is summarized in Table 2. The percent values for riboflavin were used for the ANOVA since there was no discernable loss. The logs of the percent values for thiamin and α-tocopherol were used for the ANOVA since it has previously been established that these are first-order reactions *(4)*.

Because of the low concentration of thiamin in alligator meat we could not obtain significant data for the loss of thiamin during irradiation, so the data are not included in the ANOVA of Table 2. Caiman did not show a thiamin loss in one sample, but the statistical analysis showed the average loss for all the samples to be significant. The rate constant for the of loss in ostrich was about twice that of the maximum loss observed in the domestic animal study reported previously *(3)*, but was not outside the 95% confidence limits. The rate of loss of thiamin in bison was the same as for beef.

The pooled riboflavin data was subjected to an ANOVA and showed losses for all four meats, but the loss was not significant. On an individual basis, nine of the meats showed losses while in two samples there were gains in the measured concentrations. In only one sample of bison was the loss significant. This is in accord with previous data, where no loss was observed in the riboflavin content of irradiated domestic species *(3)*. Unesterified α-tocopherol showed a significant loss which was not affected by the species. Again, the magnitude of the loss was similar to that of domestic species.

The results of this study do not reveal any great differences between exotic and the more common domestic species of meat animals, either in the composition of their tissues or the loss of vitamins during ionizing radiation treatment. The only departures from domestic animals were the low fat content of the exotic animals and the very low thiamin concentration of the reptile muscle tissues. As noted previously *(4)*, meat is not a major source of B or E vitamins in the human diet, and the losses observed for the exotic animals do not appear to constitute any significant loss in the human diet at large, especially in the amounts consumed. The vitamins examined in this study are the most sensitive metabolites in muscle tissue, yet there were little or no

TABLE 1. *Proximate analysis of alligator, bison, caiman, and ostrich*

	Proximate analysis[a]							
Meat	% Moisture	% Fat	% Ash	% Protein	Total %	α-Tocopherol[b]	Riboflavin[b]	Thiamin[b,c]
Alligator	73.6 ± 0.1	0.85 ± 0.57	0.46 ± 0.06	18.4 ± 1.5	92.1 ± 2.1	1.88 ± 1.62	0.45 ± 0.14	0.07[d]
Bison	72.7 ± 0.3	1.24 ± 0.24	0.59 ± 0.08	18.8 ± 1.4	93.7 ± 1.5	0.74 ± 0.18	0.72 ± 0.21	1.35 ± 0.28
Caiman	71.4 ± 0.4	0.95 ± 1.41	0.40 ± 0.11	22.6 ± 0.7	94.3 ± 2.0	1.19 ± 0.38	0.17 ± 0.06	0.33 ± 0.18
Ostrich (ground)	73.4 ± 1.2	1.87 ± 0.35	0.38 ± 0.13	19.5 ± 0.4	95.1 ± 1.3	0.65	0.69	1.15
Ostrich (steak)	73.8 ± 0.2	0.26 ± 0.05	0.50 ± 0.01	20.5 ± 0.3	96.5 ± 2.0	0.17	0.86	0.32
Lean beef (rib)[d]	66.0	13.4	0.65	19.8	99.9			

[a] Averages of three determinations each.
[b] Concentration of unesterified α-tocopherol in nanograms per gram, concentrations of thiamin and riboflavin in micrograms per gram.
[c] Thiamin concentration in only one sample of alligator tissue. Fluorescent peak just above background.
[d] Values from *USDA Agricultural Handbook* included for comparison *(15)*.

TABLE 2. *The rates of loss by gamma irradiation of riboflavin, thiamin, and α-tocopherol in exotic meats (alligator, bison, caiman, and ostrich)*

		Rate of loss		
			1st-order rate constant (kGy^{-1})[a]	
Meat	n	% Riboflavin/ kGy^{-1}	Thiamin	α-Tocopherol
Alligator	3	−0.83	n.d.[b]	−0.344
Bison	3	−1.39	−0.090	−0.175
Caiman	3	−0.164	−0.116	−0.139
Ostrich	1	−1.44	0.463	−0.683

[a] Statistically significant at the 95% level.
[b] n.d., not detectable.

significant differences in their loss due to irradiation between the exotic and domestic species. The results support the concept of "chemiclearance," and we conclude that the use of ionizing radiation for the pasteurization of meats may be approved as a generally applicable treatment without regard for the specific animal.

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