A Research Note

Thiamin, Riboflavin, and Nicotinic Acid Contents of Tropical Root Crops from the South Pacific

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ABSTRACT

The thiamin, riboflavin, and nicotinic acid contents of sweet potato (*Ipomea batatas*, taro (*Colocasia esculenta*), giant taro (*Alocasia macrorrhiza*), giant swamp taro (*Cyrtosperma chamissonis*), taro (*Xanthosoma spp*), yam (*Dioscorea alata* and *D. esculenta*) were determined for fresh and 40°C dried material obtained from six South Pacific countries. Losses on drying at 40°C for 2–3 days were 10–15% for the three vitamins. Sweet potato contained the largest amount of thiamin (40–120 μg/100g fresh weight) and along with *Colocasia esculenta* and *Xanthosoma spp*. the largest amounts of nicotinic acid. The root crops provided inadequate amounts of thiamin, riboflavin, and nicotinic acid with values ranging from 12–123, 12–59 and 220–1310 μg/100g fresh weight, respectively. Losses on cooking were about the same for all vitamins and root crops, with about a 20% loss on boiling (water retained) or baking and about a 40% loss on boiling (water discarded).

INTRODUCTION

THE LEVELS of total vitamin C in tropical root crops were previously determined by Bradbury and Singh (1986). The thiamin, riboflavin and nicotinic acid of foods have been determined including losses during storage and processing (Dwivedi and Arnold, 1973; Girija et al, 1982; Okoh, 1984; Gregory, 1984). The objective of this study was to determine the thiamin, riboflavin and nicotinic acid of cooked and uncooked tropical root crops from the South Pacific.

MATERIALS & METHODS

Materials

Papain (type II), α-amylase, (Type II), and phosphatase (type II) were obtained from Sigma Chem. Co. (St. Louis, Mo). Thiamin, riboflavin, nicotinic acid, cyanogen bromide, and other chemicals were reagent grade. Freshly harvested and weighed roots or stems were air freighted from the South Pacific and stored at 15°C for a short time before processing. Roots or stems were peeled, chopped and dried at 40°C to constant weight to determine moisture loss (Bradbury et al., 1984, 1985). Duplicate analyses for vitamins were made on the dried samples. Fresh sweet potato and giant taro samples were peeled and divided into three parts, proximal, middle, and distal. From each part, two samples were taken from the periphery (2–3 mm beneath the skin) and a third sample from the center. These samples were analyzed and moisture determined at 40°C.

For cooking ~50g cubes of root crop were heated in boiling water for 10, 20, and 30 min. In one case the cooking water was discarded and in another it was retained and evaporated to dryness in the presence of the boiled sample which was then dried at 40°C. Baking of ~50g cubes was at 200°C in an oven for 15, 30, and 45 min. Samples were dried at 40°C to constant weight and analyzed. A control sample was processed as above but without boiling and baking.

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Methods

Thiamin. Fresh (about 4g) or dry (about 1.5g) material was homogenized in 40 mL of 0.1M HCl for 3 min using a Polytron (Kinematica, GMBH, Switzerland). The mixture was heated for 1 hr at 100°C, cooled, and made to 50 mL with 0.1M HCl. After centrifugation at 10,000 *g* for 10 min, 10 mL supernatant was used for analysis. The AOAC (1980) method was used for oxidation. The solution was extracted with 20 mL isobutanol and its fluorescence was measured in a Perkin Elmer Model 512 fluorescence spectrometer in the excitation mode with excitation wavelength 370 nm and emission wave length 445 nm.

In order to study the affect of enzyme extraction on thiamin estimation, the 0.1M HCl extract after heat treatment was adjusted to pH 4.3 with 2M sodium acetate. An enzyme solution (5 mL) containing 100 mg papain, 50 mg α-amylase and 50 mg phosphatase in 100 mL 1M sodium acetate buffer (pH 4.3) was added and incubated for 3 hr at 38°C. The mixture was heated at 100°C for 15 min to inactivate the enzymes and was processed as above. The enzyme blank was prepared in a similar way. Extraction in 1M sodium acetate (pH 4.3) for 16 hr at 38°C instead of 0.1 M HCl was also studied in absence and presence of enzymic digestion.

Riboflavin. About 4g fresh or 1.5g dry material was homogenized in 40 mL of 1M sodium acetate buffer (pH 4.3) for 3 min. The homogenate was heated for 1 hr at 100°C, cooled and made to 50 mL with distilled water. After centrifugation at 10,000 *g* for 10 min, the clear supernatant was collected and 10 mL was used for analysis (AOAC, 1980). The fluorescence was measured with excitation wavelength 440 nm and emission wavelength 530 nm.

Nicotinic acid. Fresh sample (about 5g) or dry powder (about 2.5g) was homogenized in 40 mL of 0.5M H_2SO_4 for 3 min. The mixture was refluxed for 1 hr, cooled and pH adjusted to 4.5 with 10M NaOH. The AOAC (1980) colorimetric method was followed.

RESULTS & DISCUSSION

FOUR DIFFERENT PROCEDURES were compared for extraction of thiamin. Extraction of sweet potato and yam by acetate buffer (pH 4.3) alone gave 25–37% lower results than extraction with 0.1M HCl. Addition of enzymes increased the degree of extraction of sweet potato, but results were 10% lower than using 0.1M HCl. Additional treatment with enzymes after the 0.1M HCl extraction, caused no increase in recovery of thiamin. With taro and giant taro, extraction was maximal in all cases. Thus, the extraction procedure with boiling 0.1M HCl (no enzymes) was found satisfactory in all cases in confirmation of Gubler (1984).

Analysis of fresh samples of sweet potato, taro, and giant taro and the same samples after drying to constant weight at 40°C showed losses of about 15% of thiamin, 12% of riboflavin and 10% of nicotinic acid in the samples dried at 40°C. These losses, which were outside experimental error, may have been due to decomposition on drying for 3 days at 40°C, or perhaps due to inability to extract fully the vitamins from dried powder. Sun drying of Nigerian vegetables caused losses of thiamin and riboflavin, due to photochemical and heat degradation (Okoh, 1984).

Riboflavin was found to be constant across a sweet potato root and giant taro stem. Thiamin of sweet potato was twice as large 2–3 mm below the skin compared with the center and for giant taro it was 30% higher near the skin than at the center.

Table 1—Thiamin (T), riboflavin (R), and nicotinic acid (N) content of tropical root crops from various South Pacific countries[a]

Crops	No. of cultivars per entry	Vitamin analysed	Vitamin content from South Pacific countries: Papua New Guinea	Solomon Islands[a]	Tonga	Fiji	Western Samoa	Kiribati	Total range of values
Sweet potato	3	T	85(30)	73(20)	99(18)				43- 123
		R	25(2)	41(13)	27(6)				19- 59
		N	770(96)	656(121)	384(94)				259- 887
Taro	4	T		37(22)		35(13)	25(6)		15- 71
(*C. esculenta*)		R		17(6)		34(7)	25(6)		16- 40
		N		678(368)		932(268)	671(205)		268-1310
Giant taro	4	T					23(6)		15- 32
Alocasia		R					20(6)		12- 29
macrorrihiza		N					531(203)		220- 769
Giant swamp taro	4	T						25(19)	12- 59
Cyrtosperma		R						19(5)	12- 26
chamissonis		N						463(112)	385- 644
Taro	3	T			24(7)				14- 29
Xanthosoma spp.		R			28(8)				25- 36
		N			798(202)				711-1078
Yam	5	T	31(7)	63(24)					23- 90
D. alata		R	24(7)	36(10)					15- 53
		N	335(77)	408(72)					245- 490
Yam	5	T	45(17)	44(11)					24- 72
D. esculenta		R	26(3)	30(10)					18- 44
		N	378(150)	450(147)					251- 691

[a] Mean values (standard deviation in brackets) in μg/100g fresh weight. Cultivars of root crops used are as follows: *Sweet potato* (PNG) K-9, WMN, KO-2, (Sol. Is.) reef jimi, bugotu, dingale, (Tonga) tongamai, hawaii, halasika; *Taro* (Sol. Is.) PD-41, sasagiha, PD-1, PD-12, (Fiji) samoa normal, samoa hybrid, toakula, tausala ni samoa, (W. Samoa) niue, manua, fae'k'ele, pae'pae' *Giant taro* (W. Samoa) sega, toga, fui, niukini; *Giant swamp taro* (Kiribati) katuta red, ikarao red, ikarao green, atimainiku; *Taro Xanthosoma spp.* (Tonga) futuna, maheleuli, tea; *Yam D. alata* (PNG) takua yaimbi, du kupmi, yavovi, tolai, kpmora, (Sol. Is.) UL-5, toki, WCH-9, GU-147, A-172; *Yam D. esculenta* (PNG) mangilmu, glame, saikidi, kualika, martka, (Sol. Is.) fananiu, NGP-3, GUP-11, GUP-5, GUP-7.

There was no gradient of thiamin concentration from proximal to distal end in sweet potato or giant taro. No measurements were made for nicotinic acid.

The results in Table 1 are averages of analyses of 3–5 cultivars of a root crop from a particular country. Close examination of the data for each cultivar (not given in Table 1) failed to show any particular cultivars which contained consistently high levels of all three vitamins compared with others. In Table 1, the thiamin content of sweet potato was significantly greater ($P<0.01$, t-test) than that of the other root crops. The riboflavin content was not significantly different from one root crop to another, but taro (*C. esculenta*) from Fiji contained significantly more riboflavin ($P<0.05$) than taro from Solomon Islands. Nicotinic acid was variable and was higher in taro and sweet potato ($P<0.05$) than in yam.

The values in Table 1 were made more meaningful by calculation of the amount of root crop that would be needed to supply the recommended daily allowance of thiamin (1.4 mg), riboflavin (1.6 mg) and nicotinic acid (19 mg) (Davidson et al., 1979). The amount of fresh root crop required was within the range 1.6–8.4 kg/day. The adequacy of riboflavin was less than for thiamin and nicotinic acid in virtually all cases. Clearly, intake of these vitamins would need to be augmented from other sources.

The breakdown of vitamins on cooking increased with increase in the time of boiling or baking and the loss was independent of the type of root crop and of the vitamin measured. The loss of thiamin, riboflavin, and nicotinic acid averaged 20% (standard deviation, SD 6%) after boiling for 20 min (water retained), 39% (SD 9%) (water removed) and 23% (SD 6%) after baking for 30 min. Samples were edible after 20 min boiling and 30 min baking. The approximate doubling of the vitamin loss on boiling if the water were discarded, was due to extraction of water soluble vitamins, as previously found with total vitamin C (Bradbury and Singh, 1986). The losses of the three vitamins are of the order of 20% on baking or on boiling (water retained) or 40% on boiling (water discarded) and may be compared with other heat treatment studies of these vitamins in sweet potato (Junek and Sistrunk, 1978), rice (Smirnova et al., 1982), legumes (Kilgore and Sistrunk, 1981; Soetrisno et al., 1982) and vegetables (Okoh, 1984).

REFERENCES

AOAC, 1980. "Official Methods of Analysis," 13th ed. Association of Official Analytical Chemists, Washington, DC.

Bradbury, J.H., Baines, J., Hammer, B., Anders, M., and Millar, J.S. 1984. Analysis of sweet potato from the Highlands of Papua New Guinea: relevance to the incidence of enteritis necroticans. J. Agric. Food Chem. 32: 469.

Bradbury, J.H., Hammer, B., Nguyen, T., Anders, M., and Millar, J.S. 1985. Protein quality and trypsin inhibitor content of sweet potato cultivars from the Highlands of Papua New Guinea. J. Agric. Food Chem. 33: 281.

Bradbury, J.H. and Singh, U. 1986. Ascorbic acid and dehydroascorbic acid content of tropical root crops from the South Pacific. J. Food Sci. 51: 915.

Davidson, S., Passmore, R., Brock, J.F., and Truswell, A.S. 1979. "Human Nutrition and Dietetics," p 176. Churchill Livingstone, Edinburgh.

Dwivedi, G.R. and Arnold, R.G. 1973. Chemistry of thiamine degradation in food products and a model system. J. Agric. Food Chem. 21: 54.

Girija, V., Sharda, D., and Pushpamma, P. 1982. Bioavailability of thiamin, riboflavin and niacin from commonly consumed green leafy vegetables in the rural areas of Andhra Pradesh in India. Int. J. Vit. Nut. Res. 52: 9.

Gregory, J.F. 1984. Chemical changes in vitamins during food processing. Food Technol. 38: 51.

Gubler, C.J. 1984. Thiamin. In "Handbook of Vitamins: Nutritional, Biochemical and Clinical Aspects," Ch 6. L.J. Machlin (Ed), p. 245. Marcel Decker Inc., New York.

Junek, J. and Sistrunk, W.A. 1978. Sweet potatoes high in vitamin content but vitamin content is affected by variety and cooking method. Kansas Farm. Res. 27: 7.

Kilgore, S.M. and Sistrunk, W.A. 1981. Effect of soaking treatments and cooking upon selected B vitamins and the quality of blackeyed peas. J. Food Sci. 46: 909.

Okoh, P.N. 1984. An assessment of the protein mineral and vitamin losses in sun-dried Nigerian vegetables. Nut. Rep. Int. 29: 359.

Smirnova, L.V., Khachaturora, T.N., Nekrasova, L.V., and Grigoreva, M.P. 1982. Effect of cooking methods on thiamin, riboflavin and niacin content of rice groats. Voprosy Pitainya (USSR) 2: 62.

Soetrisno, U., Holmes, Z.A., and Miller, L.T. 1982. Effect of heating time on soybean on vitamin B, folacin retention and trypsin inhibitor activity. J. Food Sci. 47: 530.

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