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Nutrient Content of Selected Indigenous Leafy Vegetables Consumed by the Kekchi People of Alta Verapaz, Guatemala

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Nutrient composition data is presented for 13 species of indigenous leafy vegetables currently consumed by the Kekchi-speaking people of Alta Verapaz, Guatemala. Data from the leafy portions of at least five species, *Cnidoscolus chayamansa*, *Dahlia imperialis* (bell tree dahlia), *Tinantia erecta* Jacq., *Vigna sesquipedalis* Fruwirth (cowpea), and *Xanthosoma violaceum* Schott. (malanga), have not been reported previously. Proximate composition including moisture, total fat, crude fiber, and protein, with calculated carbohydrate content, and the minerals calcium, phosphorus, iron, potassium, and magnesium, were determined for both raw and cooked samples. Total carotene content was determined for both raw and cooked samples, using open-column chromatography. β-Carotene was also measured by HPLC in five species. *Amaranthus caudatus* L. (amaranth) in the raw form had the highest observed total carotene content and overall mineral content of the raw samples, whereas *Sechium edule* Sw. (chayote) had the lowest.

INTRODUCTION

With the current renewal of interest in traditional food sources, attention is being focused on the potential of promoting leafy vegetables in household gardens among populations in developing countries (FAO, 1987). It is argued that these plants provide an important source of provitamin A and increase the iron content of the diet among populations that cannot otherwise afford expensive foods that are also rich in these nutrients (Yang, 1979).

An extensive study of the nutrient composition of food plants in Central America was initiated in the late 1940s (Munsell *et al.*, 1949). Green vegetables were found to have the highest values for most of the micronutrients analyzed, which included iron, total carotene, ascorbic acid, calcium, thiamine, and niacin (Harris and Munsell, 1950). That indigenous greens as a general rule had higher nutrient values compared to domesticated green vegetables strengthens the argument that these plants are important food sources. Other studies of indigenous food plants consumed by populations in Central America confirm this (Arroyave *et al.*, 1954; Cravioto, 1951). The Latin American Food Composition Table and the Central American Food Composition Table list nutrient values for certain indigenous species that are common in the Guatemalan diet, including *Crotalaria longirostrata* (crotalaria), *Sechium edule* (chayote), and *Solanum americanum* (black nightshade) (Flores *et al.*, 1971; INCAP-ICCND, 1961). The general trend of higher nutrient values associated with indigenous greens

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is also documented in this food table. Unfortunately the number of studies from which the values are calculated are few in number for indigenous plants, with some nutrient values, in particular those of vitamin A, averaged from only two studies. The authors state that despite a large volume of food composition data, many potential source studies exclude crucial information on the botanical name, the method of collection, and the moisture content of the sample. As a consequence, much of the earlier literature is not appropriate for computing food composition tables. More recently, studies of a smaller scope have focused on the more common greens (Figueroa, 1983; Zelada, 1988). The existing data are limited to a few species of indigenous leafy vegetables, with little consideration to sources of variation or the role these greens may have in the diet. In addition, the reporting of data per dry weight exclude comparison with other studies.

The focus of this study is greens contained in the diet of Kekchi-speaking people living in the municipality of San Pedro Carcha, within the Department of Alta Verapaz, Guatemala. The region has a temperate climate, and is very humid, with an average of 3500 to 4000 mm of rainfall per year (IGN, 1978). The principal source of economic activity in the region is agriculture (DGE, 1981). The incidence of malnutrition among Kekchi children in Alta Verapaz is estimated at 29% (COGAAT, 1988). Hypovitaminosis A among these children has been identified using ophthamological screening (IEF, 1990), a retinol screening program, and dietary intake data (Quan de Serrano and de Gonzalez, 1987). However, there have been no ethnographic descriptions of traditional food species currently used by the Kekchi-speaking people of this region, despite the potential nutrient contribution these foods may have. The following study is part of the dietary evaluation of the use of indigenous leafy vegetables in this region.

METHODS

Identification and Collection

Indigenous leafy vegetables known to be regularly consumed in the diet were identified in the municipality of San Pedro Carcha, Alta Verapaz, with the assistance of Kekchi-speaking community members. Botanical specimens were collected in the field in duplicate, then transferred to the Botanical Garden of the University of San Carlos, Guatemala, for identification. Herbarium specimens were deposited at the University of San Carlos or transferred to McGill University, Canada.

Plant species selected for nutrient analyses were obtained from San Pedro Carcha during two collection periods, November/December, 1989, and June, 1990. For each species, a composite sample of 5–20 plants was collected from household gardens or maize fields with the assistance of community members. Whenever possible, 200 g of each species was collected. Only edible portions (in the physiological stage of the plant preferred by the Kekchi people) were selected. Each sample was cleaned with a paper towel to remove soil and other contaminants, weighed to the nearest 0.1 g, and then placed in preweighed sterile plastic bags. Plant samples were selected from the same locations for the two collection periods with the assistance of the same community members. Fertilizers were not reported as being used during either period. For those species that were available, a second set of plant samples was purchased from local markets. Although the same vendors were visited for the two collection periods, the source of the plants and possible use of fertilizers could not be confirmed. Moreover, a single market sample may have included plants from different locations. A third set

of samples was collected for cooking for those species that were available in quantities exceeding 400 g. Each plant sample was cleaned, weighed, and then boiled by a Kekchi-speaking community member in local water in an aluminum pot over an open fire as is the traditional method of cooking plants in the region. The same woman cooked the samples during both collection periods for approximately 15 to 45 min. For purposes of this study, additional ingredients usually included in the preparation of cooked green plants were excluded. Once boiled, each cooked sample was drained and blotted dry with clean paper towels, reweighed, and then placed in preweighed sterile plastic bags.

The bags were placed in a portable cooler filled with ice, and transported by road to Guatemala City (3–4 h). Samples were stored at the Institute of Nutrition for Central America and Panama (INCAP) at −20°C in a metal container to prevent entry of light, until the time of analyses.

Analyses

All analyses were carried out within 10 months of sample collection. The time of frozen storage prior to carotene analysis varied from 2 to 10 months.

All samples were lyophilized within a week of collection in a Virtis Freezemobile II, in their original sample bags (opened for the purpose of drying). Freeze-dried samples were ground to a fine powder using an electric grinding mill, and then transferred to 150-ml sterile plastic containers. With multiple sample bags containing a single sample, the contents of all the bags were mixed together and then transferred to the mill in small quantities at a time to ensure a homogenous sample. All plastic sample containers were stored at −20°C.

AOAC (1984) standard methods were used for determination of moisture (#22.018), crude fiber (#7.069), crude fat (#7.056), and ash (#14.006). Standard procedures for Tecator Kjeltec Auto 1030 analyzer were used to determine protein ($N \times 6.25$) content. Carbohydrate content was calculated by difference. Minerals were determined using standard procedures for Perkin–Elmer atomic absorption spectrophotometers 103 and 2380, and colorimeter 295e. Total carotenes were analyzed in all samples using the AOAC (1984) standard method for dried plant material (#43.018). The saponification step was eliminated after preliminary trials confirmed similar results with and without saponification. The entire separation and extraction procedure was performed under red light. Selected samples were also analyzed for β-carotene using reversed-phase HPLC as described by Bushway (1985). These samples were first separated and extracted following the AOAC (1984) method (#43.018). A Waters Novapak C18 column was used, with a mobile phase of acetonitrile–methanol–tetrahydrofuran (58/35/7) and flow rate of 2 ml/min. Carotenes were monitored at 460 nm using a Varian DHS 90 UV visible spectrophotometer.

All samples were analyzed in duplicate, with the exception of those selected for HPLC determination of β-carotene which were done as single samples.

RESULTS AND DISCUSSION

Samples collected of indigenous green plants consumed by the Kekchi people in the municipality of San Pedro Carcha, Alta Verapaz, are listed in Table 1 with a description of the physiological stage that is considered edible for each plant. Most species are consumed in a "caldo," which is a soup that includes large volumes of

TABLE I

INDIGENOUS LEAFY VEGETABLES USED BY THE KEKCHI PEOPLE

Botanical Name	Common Names		Dietary Uses of Leaves
	English	Other[1]	
Amaranthus caudatus L.	amaranth	bledo (S)	leaves are boiled, and drained before consumed. Sometimes fried in lard or oil.
Cnidoscolus chayamansa Mill.	---	roctish (K)	young leaves are boiled, and drained. Usually fried.
Coriandrum sativum L.	coriander	culantro (S)	leaves boiled in meat broth.
Cucurbita ficifolia Bouche	malabar gourd	ayote (S)	shoots are boiled in water, with shoots and liquid consumed.
Dahlia imperialis Roezl.	bell tree dahlia	txoloj (K)	leaves are boiled, and drained before being consumed. Fried in lard or oil.
Eryngium foetidum L.	---	samat (K)	leaves boiled in meat broth.
Mentha citrata Ehrh.	mint	yerba buena (S)	boiled in meat broth.
Petroselinum crispum Nym.	parsley	perejil (S)	boiled in water, with leaves and liquid consumed.
Sechium edule Sw.	chayote	guisguil (S)	shoots are boiled in water, with shoots and liquid consumed.
Solanum americanum Mill.	nightshade	macuy (S)	boiled in water, with leaves and liquid consumed.
Tinantia erecta Jacq.	---	tziton (K)	boiled in water, with leaves and liquid consumed.
Vigna sesquipedalis Fruwirth	cowpea	frijol (S)	young leaves are boiled, with leaves and liquid consumed.
Xanthosoma violaceum Schott.	malanga	osh (K)	immature, unfolded leaves are boiled, with leaves and liquid consumed.

[1] (K) is the Kekchi name, (S) is the Spanish name, also used by some Kekchi people.

water in which the green plants are boiled with additional ingredients which may include meat, tomato, onion, garlic, salt, or egg. *Cnidoscolus chayamansa, Dahlia imperialis* (bell tree dahlia), *Amaranthus caudatus* (amaranth) and *Tinantia erecta* are boiled, drained, and then fried in lard or cooking oil, sometimes with tomato and onion.

The results of the various analyses are expressed per 100 g fresh wt in Tables 2, 3, and 4. Nutrient values are presented for each species in raw and cooked forms whenever possible. The values obtained from two or more independently collected samples are presented as a mean value for the raw or cooked form of a given species. Certain plant species are seasonal in their availability, hence their consumption is as well, so their nutrient values are only representative for the first collection period. These include the leaves of *Vigna sesquipedalis* (cowpea), *Tinantia erecta*, and *Amaranthus caudatus*. *Coriandrum sativum* (coriander) and *Petroselinum crispum* (parsley) are consumed

year-round, but the quantities available in the local markets during the second collection period were too small to accomodate complete nutrient analyses.

Most of the nutrient composition data available in the literature is limited to the leaves of *Solanum americanum* (nightshade), *C. sativum*, *P. crispum*, *Mentha citrata* (mint), and the shoots of *Sechium edule* (chayote). One study has also reported nutrient composition data for raw samples of the shoots of *Cucurbita ficifolia* (malabar gourd) and *Eryngium foetidum* (Munsell *et al.*, 1950a). The shoots of *C. ficifolia* and *A. caudatus* consumed by the Kekchi-speaking people in this study are of different species of *Cucurbita* and *Amaranthus* from that reported in the Food Composition Table (INCAP-ICCND, 1961). Nutrient composition data for other edible parts, including the fruit, root, and seed, exist for *S. edule*, *C. ficifolia*, *Xanthosoma violaceum* (malanga), *V. sesquipedalis*, and *A. caudatus*. Generally speaking, the leafy portions of these species have not been incorporated in analyses (Arroyave *et al.*, 1954; Munsell *et al.*, 1950b) reflecting the limited dietary intake data available for this plant part.

In the specimens in the current analyses, moisture content ranged from 79.3 to 93.7% of fresh weight (Table 2). Of the two values for moisture, residual refers to the moisture content of the freeze-dried sample, which is used in the calculation for carbohydrate content by difference. Crude fat varied between 0.4 and 2.5 g/100 g fresh wt, crude fiber between 0.7 and 5.3 g, protein from 1.7 to 7.8 g, and carbohydrate from 1.8 to 6.5 g/100 g fresh wt. This variability was more evident in cooked samples, which had values consistently higher than those observed in the raw samples. This large variation within and between species of leafy greens has been well documented in the literature, with threefold differences reported for certain nutrients within a single species for any one period of collection (Bureau and Bushway, 1986). An earlier study that examined the chemical composition of *Amaranthus* spp., *Crotalaria longirostrata* (Crotalaria), and *Solanum* spp. documented large variability between different cultivars for each species (Figueroa, 1983). Other explanations that have been suggested for this variability include differences in conditions of collection and storage, including those between samples collected from gardens and from markets (Bushway *et al.*, 1986).

The data obtained from mineral analyses as presented in Table 3 confirm the large variation in nutrient content among species of leafy greens. Of those species with mineral composition data included in the Latin American Food Composition Table, there is good agreement with values presented in this study, in particular those for *M. citrata* and *S. americanum* (INCAP-ICCND, 1961). In contrast, iron values reported in this study are almost threefold higher for *C. sativum*, whereas reported phosphorus values for the shoots of *S. edule* and *C. sativum* are lower. Neither magnesium nor potassium values are included in the Food Table.

A. caudatus in the raw form had the highest overall mineral content of all the species analyzed, with its iron value ranking lowest relative to the other minerals. This is in contrast to a recent study that found that the overall mineral content of *S. americanum* was higher than that of *A. caudatus* (Figueroa, 1983), but the value of the latter was based on data from a number of cultivars of different species. *S. edule* shoots, in both the raw and the cooked form, had the lowest calcium and iron values, which is in agreement with Munsell *et al.* (1950b). The cooked form of this species had the lowest overall mineral content of all the samples. As a general rule though, cooked samples were higher in calcium, iron, phosphorus, and magnesium on a fresh weight basis, which may be a consequence of being cooked in a charred pot over an open fire, with

TABLE 2

PROXIMATE COMPOSITION OF INDIGENOUS LEAFY VEGETABLES

Botanical Name	Preparation	N[a]	Moisture		Fat	Fibre	Protein	Carb.
			Fresh	Residual				
			g per 100g fresh weight					
Amaranthus caudatus L.	raw	1	84.6	1.0	0.8	1.5	4.4	5.0
Cnidoscolus chayamansa Mill.	raw	3	91.7 (1.4)[b]	0.3 (0.3)	0.5 (0.1)	1.0 (0.2)	2.2 (0.1)	2.7 (0.5)
	cook	2	92.4 (0)	0.5 (0.1)	0.7 (0.1)	1.5 (0.1)	2.5 (0.1)	1.8 (0.4)
Coriandrum sativum L.	raw	1	91.1	0.6	0.5	0.9	2.3	3.0
	cook	1	79.3	1.9	1.6	4.0	6.4	5.3
Cucurbita ficifolia Bouche	raw	3	91.3 (2.7)	0.4 (0.1)	0.6 (0.4)	1.1 (0.4)	2.5 (1.3)	3.2 (0.6)
Dahlia imperialis Roezl.	raw	3	89.4 (2.9)	0.5 (0.3)	0.7 (0.3)	1.1 (0.2)	3.9 (1.2)	3.6 (1.3)
	cook	2	87.8 (3.9)	0.6 (0.1)	1.0 (0.1)	1.6 (0.6)	4.9 (1.0)	3.6 (2.0)
Eryngium foetidum L.	raw	2	89.9 (2.1)	0.5 (0)	0.6 (0.2)	1.5 (.5)	1.7 (0.9)	4.5 (.1)
	cook	1	74.0	2.0	2.5	5.3	7.8	6.5
Mentha citrata Ehrh.	raw	1	93.7	0.2	0.6	0.7	1.8	2.0
	cook	1	86.2	1.0	1.2	2.3	4.8	3.3
Petroselinum crispum Nym.	raw	1	88.7	0.8	0.4	1.3	2.2	4.7
	cook	1	85.3	1.0	1.2	2.2	4.9	3.9
Sechium edule Sw.	raw	4	91.8 (2.1)	0.6 (0.4)	0.4 (0.1)	1.1 (0.2)	3.0 (0.9)	2.1 (0.8)
	cook	1	92.9	0.2	0.4	0.9	2.8	2.4
Solanum americanum Mill.	raw	4	86.9 (2.3)	0.6 (0.2)	0.7 (0.3)	0.8 (0.3)	4.4 (0.7)	4.7 (1.0)
	cook	3	87.5 (4.2)	0.7 (0.6)	0.9 (0.4)	1.4 (0.8)	3.9 (1.3)	3.8 (1.2)
Tinantia erecta Jacq.	raw	2	91.0 (2.6)	0.4 (0)	0.7 (0.2)	0.9 (0.2)	2.5 (0.8)	3.4 (0.9)
Vigna sesquipedalis Fruwirth	raw	1	84.8	0.7	1.2	2.6	4.8	4.6
Xanthosoma violaceum Schott.	raw	2	88.0 (1.1)	0.6 (0.4)	0.7 (0.1)	1.8 (0.1)	3.5 (0.1)	4.2 (1.2)

[a] Number of independently collected samples.

[b] Standard deviation is reported when two or more independently collected samples were analyzed.

ashes falling into the pot, and/or the addition of minerals from local water used in the cooking process. Alternatively, leaching of other nutrients during cooking and/or the overall increase in the percentage of solids given a lower moisture content may result in a larger proportion of minerals per dry weight as compared to the raw form. In contrast, all cooked samples were lower in potassium when compared to the raw samples of the same species.

Table 4 presents a comparison of the β-carotene content as determined by the two methods, open-column chromatography and HPLC. Although the AOAC (1984)

TABLE 3

MINERAL CONTENT OF INDIGENOUS LEAFY VEGETABLES

Botanical Name	Preparation	N[a]	Ash g	Ca mg	P mg	Fe mg	K mg	Mg mg
			per 100 g fresh weight					
Amaranthus caudatus L.	raw	1	2.8	339	64	5	653	146
Cnidoscolus chayamansa Mill.	raw	3	1.5 (0.4)[b]	90 (21)	39 (16)	2 (1)	271 (160)	31 (7)
	cook	2	0.7 (0)	121 (3)	25 (4)	2 (0)	133 (9)	21 (4)
Coriandrum sativum L.	raw	1	1.6	96	37	11	555	30
	cook	1	1.5	220	67	11	339	42
Cucurbita ficifolia Bouche	raw	3	1.1 (0.3)	134 (129)	54 (4)	2 (2)	186 (56)	32 (4)
Dahlia imperialis Roezl.	raw	3	0.9 (0.3)	101 (48)	58 (23)	1 (1)	221 (83)	49 (23)
	cook	2	0.7 (0.1)	109 (37)	55 (13)	4 (2)	94 (13)	33 (2)
Eryngium foetidum L.	raw	2	1.4 (0.4)	174 (100)	36 (17)	10 (2)	285 (11)	38 (14)
	cook	1	1.9	434	87	25	191	59
Mentha citrata Ehrh.	raw	1	0.9	99	37	4	230	31
	cook	1	1.1	209	77	9	152	43
Petroselinum crispum Nym.	raw	1	1.8	129	58	3	559	19
	cook	1	1.5	229	65	4	391	29
Sechium edule Sw.	raw	4	1.1 (0.3)	30 (8)	70 (19)	2 (1)	316 (145)	26 (8)
	cook	1	0.4	41	45	1	81	16
Solanum americanum Mill.	raw	4	1.5 (0.3)	220 (56)	53 (7)	3 (1)	322 (101)	54 (13)
	cook	3	1.2 (0.4)	180 (120)	53 (33)	6 (8)	129 (30)	81 (58)
Tinantia erecta Jacq.	raw	2	1.3 (0.4)	203 (71)	32 (15)	2 (1)	285 (127)	40 (12)
Vigna sesquipedalis Fruwirth	raw	1	1.3	159	71	2	355	40
Xanthosoma violaceum Schott.	raw	2	1.4 (0.1)	92 (21)	69 (4)	2 (1)	301 (17)	32 (4)

[a] Number of independently collected samples.

[b] Standard deviation is reported when two or more independently collected samples were analyzed.

method quantifies total carotenes, HPLC confirmed that, in these samples, carotenes other than β-carotene were negligible. This is in contrast to values for vitamin A activity for those species included in the Latin American Food Composition Table, which include some contribution from other carotenes (INCAP-ICCND, 1961). Observed β-carotene values of the raw samples are in agreement for the two methods. Some disparities however existed between the two methods when comparing the plants in their cooked form, with the largest difference being observed between cooked samples of *C. sativum*.

TABLE 4

TOTAL CAROTENES CONTENT OF INDIGENOUS LEAFY VEGETABLES (AOAC VERSUS HPLC METHOD)

Botanical Name	Preparation	N[a]	AOAC	HPLC
			mg per 100 g fresh weight	
Amaranthus caudatus L.	raw	1	7.7	-[b]
Cnidoscolus chayamansa Mill.	raw	3	2.7 (0.9)[d]	4.9[c]
	cook	2	4.9 (0.1)	9.1
Coriandrum sativum L.	raw	1	3.0	3.9
	cook	1	10.8	20.0
Cucurbita ficifolia Bouche	raw	3	1.5 (0.2)	-
Dahlia imperialis Roezl.	raw	3	3.0 (1.2)	1.3
	cook	2	6.1 (0.1)	8.9
Eryngium foetidum L.	raw	2	2.9 (1.7)	2.1
	cook	1	17.9	22.4
Mentha citrata Ehrh.	raw	1	2.6	-
	cook	1	8.9	-
Petroselinum crispum Nym.	raw	1	3.6	-
	cook	1	6.9	-
Sechium edule Sw.	raw	4	1.0 (0.5)	-
	cook	1	0.4	-
Solanum americanum Mill.	raw	4	5.3 (1.7)	3.6
	cook	3	4.4 (3.7)	undetectable
Tinantia erecta Jacq.	raw	2	5.0 (0.7)	-
Vigna sesquipedalis Fruwirth	raw	1	4.5	-
Xanthosoma violaceum Schott.	raw	2	3.5 (1.6)	-

[a] Number of independently collected samples.
[b] Not analyzed.
[c] All values are obtained from a single sample.
[d] Standard deviation is reported when two or more independently collected samples were analyzed.

Using the AOAC (1984) method, the β-carotene content of the samples analyzed ranged from 0.4 to 17.9 mg/100 g fresh wt. *A. caudatus* in the raw form had the highest observed β-carotene content of the raw samples, whereas the *S. edule* shoots had the lowest. This same pattern was observed with the mineral values. The cooked sample of *E. foetidum* had the highest observed β-carotene value, 17.9 mg/100 g fresh wt, as well as the highest iron, calcium, and potassium values of the cooked samples. The values for vitamin A content of the raw forms of *Amaranthus* spp., *P. crispum*, *M. citrata*, and *S. americanum* presented in the Latin American Food Composition Table are generally lower than those reported in this study, with other carotenes contributing to the overall vitamin A activity (INCAP-ICCND, 1961).

When comparing the β-carotene content between raw and cooked samples, there was a general trend of increased values following cooking. This supports results from another study which also demonstrated an increase in carotene content of sweet potatoes, depending on the treatment used (Chandler and Schwartz, 1988). *S. americanum* leaves and *S. edule* shoots, however, both had decreases in their β-carotene content,

which is in agreement with most of the current literature in which losses of up to 59% are associated with cooking (Mujibur Rahman *et al.*, 1990; Nagra and Khan, 1988; Sweeney and Marsh, 1971). Lee *et al.* (1989) argue that errors in reported provitamin A values arise from inaccurate analytical procedures, variation among cultivars that confound differences associated with processing, values expressed per dry weight, and the effect of enzymatic activity. It has been found that some plants in their raw form require blanching prior to storage to inactivate lipoxidase enzymes which can increase the destruction of carotenes during storage (Thompson, 1986). Cooking plants could arrest this enzymatic activity, and consequently would have higher β-carotene values as compared to their nonblanched raw counterparts. Therefore in this current study the apparently higher carotene values in the cooked samples may be an indication of large carotene losses in the raw samples due to enzymatic destruction prior to lyophilization. However, given the inconsistencies between raw and cooked values both in this study and in the literature, further research is necessary in this area. This is particularly the case with plant parts which in their cooked form are being promoted as good sources of provitamin A in regions of hypovitaminosis A.

Neither of the two methods was able to separate the all *trans* stereoisomer of β-carotene from the *cis* form associated with cooking. *Cis* and *trans* isomers have differing biological activity, which means that an increase in carotene content during cooking will not be equivalent in biological activity (Bushway, 1985; Simpson *et al.*, 1985). Moreover, disparities in carotene values in cooked samples of the same species using two different analytical methods confirm the need for further investigation into appropriate analytical procedures for processed samples.

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