[Reprinted from FOOD RESEARCH, 1959, Vol. 24, No. 4, Pages 344–351]

NIACIN CONTENT OF COFFEE IN CENTRAL AMERICA[a]

RICARDO BRESSANI AND DELIA A. NAVARRETE
Institute of Nutrition of Central America and Panama (INCAP), Guatemala, C. A.

(Manuscript received August 5, 1958)

Roasting of coffee beans produces a large increase in their niacin content *(1, 4, 12, 13, 19, 20)*. This niacin is readily extractable with water so that microbiological and chemical analysis of coffee beverage shows it to have a significant niacin content *(19, 20)*. Animal trials *(19, 20)* and metabolic studies in adults *(11)* have confirmed the biological activity of this niacin and shown it to be as available as the niacin in foods and vitamin preparations.

Although high corn diets have frequently been associated with niacin deficiency and clinical pellagra *(5)* this does not appear to be the case for Mexico and Central America where corn is the main dietary staple *(4, 6, 7, 8, 9, 10, 15, 16, 17, 18)*. Nutritional surveys carried out in Guatemala have shown that in adults the total niacin intake is slightly above INCAP recommended allowances *(14)* even without considering the possible contribution of coffee *(6–10)*. Corn contributes about 67.7%, black beans about 10.5% and meat 14.2% of the daily niacin intake *(15, 16, 17, 18)*. In general, all nutritional surveys carried out in the Central American countries *(6–10, 16, 17, 18)* have indicated that niacin is not a nutritional problem in this area for the adult population *(6–10)*, although the niacin intake of pre-school children may be low *(10)*.

Coffee consumption is high in Central America, even in young children, although quantitative data are not available. The amounts of niacin consumed in coffee were considered of possible nutritional importance. Since niacin intakes appear to be borderline in some instances *(6–10)*, the present work investigates the effect of roasting and preparation procedures on the niacin content of coffee samples in Central America and the consumption of coffee as a beverage.

MATERIAL AND METHODS

The roasted coffee bean samples used in the study were purchased at retail in Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama and represented crops grown in each of these countries. Moisture, nitrogen and ether extract determinations were carried out according to the methods of the A.O.A.C. *(2)*. Niacin was determined microbiologically with *Lactobacillus arabinosus* 17-5 as the test organism *(21)*.

EXPERIMENTAL PROCEDURES AND RESULTS

Niacin content of roasted coffee. Twenty-two samples of Guatemalan coffee, having an average moisture content of 5.48% (range, 3.49 to 8.39%), had an average niacin content of 12.79 mg. % (range, 4.40 to 24.62 mg. %). A group of 6 coffee samples from El Salvador averaged 6.66% moisture (range, 5.37 to 8.15 %), with an average of 18.93% niacin content (range, 14.45 to 25.90 mg. %). The 5 samples obtained from Honduras averaged 5.97% moisture (range, 4.72 to 8.00%) with an average nicotinic acid content of 16.61 mg. % (range, 7.50 to 24.20 mg. %). The moisture content of 11 roasted coffee samples from Nicaragua averaged 5.68% (range, 5.11 to 6.43%) and

[a] INCAP Publication I-115.

the average niacin content was 12.07 mg. % (range, 6.85 to 16.75 mg. %). Five samples of Costa Rican coffee, having an average moisture content of 6.47 (range, 5.77 to 7.12%), had an average niacin content of 17.34 mg. % (range, 12.20 to 21.08 mg. %). The 4 samples obtained from Panama averaged 6.83% moisture (range, 5.37 to 8.25%), with an average niacin content of 22.15 mg. % (range, 18.60 to 24.00 mg. %).

Niacin content of green coffee. The niacin content of samples of raw coffee beans from different coffee plantations in Guatemala is shown in Table 1. These green coffee beans varied in niacin content from 0.60 to 1.33 mg. per 100 g.

TABLE 1

Moisture and nicotinic acid content of Guatemalan green coffee samples

Coffee variety or type	Moisture	Nicotinic Acid
	%	*mg./100 g.*
Robusta	9.50	1.23
Arábigo—1	9.26	1.02
Arábigo—2	10.50	1.21
Arábigo—3	9.19	1.13
Arábigo—4	4.85	1.18
Pache	10.53	0.60
Bourbon	10.21	0.60
Maragogipe	9.94	1.24
Fair washed	9.35	1.07
Extra prime	8.82	1.23
Strictly hard bean	9.40	1.33
Average	9.23	1.08

Effect of temperature, time and type of coffee on the niacin content upon roasting. Three types of coffee were used for this part of the study. A *strictly hard bean* type cultivated at 5,000 feet, *extra prime,* type which comes from plantations of 3,500 feet and a *fair washed* type cultivated at 1,500 feet. Optimum temperatures and times vary with each type of coffee-type. For the experiments, 1½ pound samples were placed in an electrically heated roaster, already set at the desired temperature, and roasted at 3 different times for each type of coffee and temperature. The roasted coffee was ground, and moisture, ether extract and niacin determined. As shown in Table 2, lengthening the time of roasting increased the amount of niacin in the roasted coffee. The niacin content of the *fair washed* type of coffee increased 13 times its original value after 12 minutes of roasting at 180° C. The increase for the *extra prime* type of coffee was the smallest, amounting to about 5 times the original value in 16 minutes at 210° C., while the niacin content of the *strictly hard bean* type increased about 4 times in 6 minutes and about 24 times in 8 minutes. This latter sample was considered already burned and would not ordinarily be used for the preparation of the beverage.

The ether extractable substances also increased with increasing time of roasting. There was a 2.5 fold increase in the ether extract of the *fair washed* type of coffee after 12 minutes of roasting at 180° C. The increase for the *extra prime* type was not as large, being only about 1.7 times its original value in 16 minutes at a temperature of 210° C. In 8 minutes at a temperature of 275° C. the *strictly hard bean* type increased in crude fat content about 2.3 times its original value of 7.65%. The moisture content decreased with increasing time of roasting for all types of coffee studied. In order to study the changes taking place in the weight, moisture, ether extract and nicotinic acid content of green coffee, 200 g. batches of *extra prime* coffee were roasted for 4, 5, 6, and 10 minutes at approximately 300° C. After roasting the sample was allowed to cool to room temperature and weighed; sub-samples were then withdrawn for the analyses and the results are shown in Table 3. The weight of the roasted coffee decreased rapidly before reaching 5 minutes of roasting but did not change significantly thereafter. The moisture decreased rapidly upon roasting, the decrease having been progressive with the duration of the process. These changes in water content upon roasting are not entirely due to loss of water, since the process gives rise to the production of volatile compounds such as carbon dioxide and others which would be decomposition products

TABLE 2

Effect of temperature, time and type of coffee on the nicotinic acid and ether extract content of coffee upon roasting

Time in minutes	Moisture	Ether Extract	Nicotinic Acid
	Fair Washed Roasting Temperature: 180° C.		
	%	%	*mg./100 g.*
0	9.35	6.56	1.07
7	3.49	9.61	3.93
9	3.13	14.46	10.00
12	0.15	16.35	13.30
	Extra Prime Roasting Temperature: 210° C.		
0	8.82	6.91	1.23
11	2.35	9.66	3.15
14	2.14	8.86	4.40
16	0.50	11.66	5.65
	Strictly Hard Bean Roasting Temperature: 275° C.		
0	9.40	7.65	1.33
5	3.82	9.51	2.65
6	2.03	14.15	5.93
8	1.50	17.55	32.66

of carbohydrates and other organic compounds. Both the ether extract portion and the amount of niacin increased on a percentage and on an absolute basis up to 4 minutes of roasting. The finding of a large increase in the ether extract is unusual and warrants further investigation.

Nicotinic acid extraction by percolation. For the percolation studies, 10 g. of a low (7.75 mg. per 100 g.), an intermediate (13.66 mg. per 100 g.) and a high (20.64 mg. per 100 g.) niacin content coffee sample were ground to approximately 40 mesh and percolated in a 4-cup capacity aluminum percolator, heated on a hot plate, with 250 ml. of water for 3, 6, 9, 12 and 15 minutes after the water started boiling. The volume of the infusion was measured after cooling and diluted to 250 ml. with distilled water. The pH of the solution was measured with a Beckman pH meter.

Under the conditions of the experiment, 75% of the niacin in the low niacin sample was extracted. There was no relation to percolation time since niacin extraction was nearly as great after 3 as after 15 minutes of percolation. The percentage extraction for

TABLE 3

Effect of roasting time on the ether extract and nicotinic acid content of roasted coffee

Roasting time in minutes	Wt. of roasted coffee	Moisture	Ether extract		Nicotinic acid	
				Total [1]		Total [1]
	g.	*g.%*	*g.%*	*g.*	*mg.%*	*mg.*
0	200.0	7.84	6.88	14.93	1.25	2.71
4	169.1	1.75	14.58	25.09	14.20	24.44
5	110.8	1.05	19.60	21.95	19.70	22.06
6	110.4	1.52	19.30	21.64	19.30	21.64
10	117.8	0.80	18.20	21.61	21.65	25.73

[1] Ether extract and nicotinic acid content of total sample on a moisture-free basis.

the intermediate niacin coffee varied from 95 to 111%, in a manner unrelated to length of percolation. The high nicotinic acid containing coffee sample gave 52% extraction at the end of 3 minutes of percolation, the extraction increasing to slightly over 100% with increasing percolation time. The highest percentage obtained was 120%, when the coffee was percolated for 15 minutes. The niacin recoveries over 100% might be due either to error in the nicotinic acid assay technique, or more likely to the possible conversion of trigonelline into nicotinic acid during the percolating process.

NIACIN EXTRACTION BY BOILING AND DRIPPING

Boiling. Ten-gram samples of a low (9.40 mg. per 100 g.), an intermediate (16.35 mg. per 100 g.) and a high (25.40 mg. per 100 g.) niacin containing roasted coffees were added to 250 ml. of boiling water. The slurry was then boiled for 2 minutes, filtered, cooled and its volume and pH measured. The preparation was brought to pH 6.8 and a volume of 250 ml. before the niacin assays. The low nicotinic acid containing coffee sample gave 73% extraction of its niacin, while the intermediate and high nicotinic acid coffees gave 82 and 84% extraction, respectively. Nicotinic acid recoveries were 86, 98 and 99% for the low, intermediate and high niacin samples, respectively.

Dripping. A ten-gram sample of each of the 3 roasted coffee samples used in boiling studies was placed on a funnel with a filter paper and washed continuously 16 times with 15 ml. portions of boiling water, in such a way that there was a constant flow of water through the sample. The pH was measured and adjusted to 6.8 and the volume brought to 250 ml. The low niacin containing coffee gave 93% extraction of its niacin, while the intermediate and high nicotinic acid containing coffees gave 84 and 89% respectively. Vitamin recoveries were 100% for the low nicotinic acid containing coffee, 91 and 99% for the intermediate and low coffee samples, respectively.

To investigate if increasing the boiling time would increase the amount of vitamin in the infusion, a 10-g. sample of coffee containing 9.40 mg. of niacin per 100 g. was boiled with 250 ml. for niacin assay. The residue was hydrolyzed and its vitamin content determined.

The results indicate that there appears to be an increase in percentage extraction with boiling time from 72% at the end of 2 minutes to 91% at the end of 6 minutes. Nicotinic acid recoveries varied from 85% at 2 minutes boiling time to 112% at the end of 6 minutes. At the same time, the effect of the amount of sample used on the amount of niacin in the infusion when boiling time and volume were constant was studied by boiling 5, 10, 15 and 20 g. with 250 ml. of water for 2 minutes. Niacin was also determined on the individual residues. Highest extraction and recovery was obtained when 15 g. of coffee were boiled. With this amount the percentage extraction amounted to 94%, while the nicotinic acid recovery was 106%.

Urban coffee consumption and niacin intake. A sample of both the roasted coffee and of the beverage from the morning meal was obtained from 21 persons working in the Institute of Nutrition of Central America and Panama (INCAP). One beverage sample was prepared by the drip method while seven were prepared by boiling, and 13 by percolation as shown in Table 4. The 21 roasted coffee samples averaged 14.31 mg. with a variation of 7.69 to 25.45 mg. of niacin per 100 g. The beverage ranged in niacin content from 0.34 to 2.85 mg. per cup, with an average of 1.03 mg. per cup (175 ml.). The number of cups consumed per person per day ranged from 1 to 8 and averaged 3.3 cups. The niacin intake, therefore, ranged from 0.3 to 16.9 mg. with an average of about 4 mg. Thus the niacin intake varied from 2% to 125% of the INCAP recommended allowances for the Central American area *(14)*.

Coffee consumption in Guatemalan rural villages. Three rural villages in the highlands in Guatemala were chosen for the survey. From 114 to 192 homes per town (representing approximately 2/3 of the population in each case) were visited to determine the brand, number of cups and method of preparation of coffee. In general, it was found that the families bought either coffee blends known to contain roasted cereal grains or brands not common to the city markets. In the town San Lorenzo el Cubo, whose people live next to highland coffee plantations, 55% of the families interviewed consumed coffee harvested and roasted at home, while about 32% of the families consumed a coffee brand whose name indicated it was not pure coffee. The rest of the families consumed little known coffee brands. Of the total number of families interviewed, samples of the coffee and beverage were obtained, representing equal percentages of each

TABLE 4

Nicotinic acid intakes from coffee by persons at INCAP

Method of preparation	Niacin in coffee	pH	Niacin per cup	Cups per day	Niacin intake	Niacin intake % of requirement [1]
	mg./100 g.		*mg.*		*mg./day*	
B [2]	24.62	5.8	2.85	3	8.55	63
P [3]	14.74	6.0	1.23	3	3.69	27
P	20.70	5.6	2.11	8	16.88	125
P	17.45	5.5	1.99	3	5.97	44
P	14.30	5.1	0.83	2	1.66	12
B	13.70	5.6	0.41	3	1.23	9
B	14.45	5.7	0.62	3	1.86	14
P	7.75	5.2	1.19	3	3.57	26
P	9.72	5.6	0.65	6	3.90	29
D [4]	9.98	5.3	0.48	5	2.40	18
P	25.45	6.3	0.83	2	1.66	12
P	13.68	5.5	0.95	3	2.85	21
P	8.27	5.3	0.36	3	1.08	8
P	12.92	5.0	0.84	5	4.20	31
P	13.55	5.3	0.96	3	2.88	21
B	13.40	5.4	1.11	2	2.22	16
B	18.72	4.8	0.64	2	1.28	9
P	15.15	4.9	0.34	1	0.34	2
B	11.40	5.8	0.41	2	0.82	6
P	7.69	5.9	0.92	4	3.68	27
B	12.82	5.0	1.95	4	7.80	58
Average	14.31	—	1.03	3	3.74	28

[1] For the adult in the Central American area, the nicotinic acid requirement is around 13.5 mg./day *(14)*.
[2] Boiling; [3] Percolation; 4 Dripping.

brand of coffee used and the results are shown in Table 5. In Magdalena Milpas Altas the nicotinic acid content of the coffee samples varied from 7.38 to 22.96 mg. per 100 g. and the volume of the cup used varied from 175 to 240 ml. The niacin content per cup varied from 0.24 to 1.46 mg., and an average of 3 cups per person per day were consumed. The niacin intake per person per day from coffee alone varied from 0.72 to 4.38 mg. equivalent to 5 and 32% of the recommended allowance, respectively. In Santa Marìa Cauqué, the nicotinic acid content of the coffee varied from 10.28 to 22.98 mg. per 100 g. The volume of the cup used by the families varied from 150 to 360 ml. The niacin content per cup ranged from 0.20 to 1.90 mg., while the number of cups per day varied from 2 to 4, mostly 3. The niacin intake per day ranged from 0.60 to 6.76 mg., corresponding to 4 and 50% of the nicotinic acid requirement for this area. Finally, in San Lorenzo el Cubo, the 9 samples studied ranged in nicotinic acid content from 4.82 to 43.87 mg. per 100 g. The volume of the cup was smaller than in the two other towns, all of them of 180 ml., except in one case, which was 150 ml. Of the 9 families interviewed, in five the number of cups per person per day was 3, while 4 families consumed an average of 2 cups per person per day. According to this, the niacin intake varied from 0.54 mg., 4% of the requirement, to 1.46 mg. equal to 11% of the recommended allowance for this Guatemalan area.

DISCUSSION

The results of the studies reported in this paper agree with the results of other investigators *(4, 12, 13, 19, 20)* who have reported a marked increase in the niacin of coffee during the roasting process. The variation in niacin content, however, was found greater in the retail roasted coffee bean samples studied, than reported by Gross Daum *(12)* in Venezuela. In general, the nicotinic acid content of roasted coffee sold at retail in

the Central American countries is lower than that reported by other investigators, probably because light-roasting of the coffee is preferred in most cases. Exceptions to this were found in the coffees from El Salvador and from Panama.

As was also found by Teply, Krehl and Elvehjem *(19)*, Teply and Prier *(20)* and Gross Daum *(12)*, the niacin is easily extracted regardless of the method of coffee preparation, since percolation, dripping, or boiling gave over 71% extraction of the niacin present.

TABLE 5

Coffee consumption and niacin intake in three rural villages in Guatemala

Family	Niacin in coffee	pH	Ml. per cup	Niacin per cup	Cups per day	Niacin intake	Niacin intake % of requirement
			Magdalena Milpas Altas				
	mg./100 g.			*mg.*		*mg./day*	
1	13.86	6.8	240	0.38	3	1.14	8
2	8.92	7.3	240	1.46	3	4.38	32
3	9.50	5.8	240	0.64	2	1.28	9
4	7.80	6.3	180	0.28	3	0.84	6
5	7.38	5.8	240	0.26	3	0.78	6
6	12.94	6.0	240	1.00	3	3.00	22
7	9.40	5.6	175	0.73	3	2.19	16
8	12.86	6.4	240	0.38	3	1.14	8
9	18.74	5.9	240	0.56	3	1.68	12
10	22.96	6.5	240	0.24	3	0.72	5
Average	12.44		228	0.59	3	1.72	12
			Santa María Cauqué				
1	22.70	5.5	150	0.71	4	2.84	21
2	11.26	6.3	180	0.65	3	1.95	14
3	13.20	6.0	360	0.44	2	0.88	6
4	18.47	5.8	360	0.56	2	1.12	8
5	21.98	6.2	180	1.69	4	6.76	50
6	10.28	6.2	180	0.20	3	0.60	4
7	20.48	5.9	360	1.90	3	5.70	42
8	22.98	6.1	180	0.39	3	1.17	9
9	14.28	7.2	240	0.42	3	1.26	9
Average	17.29		243	0.77	3	2.48	18
			San Lorenzo el Cubo				
1	14.34	6.3	180	0.45	3	1.35	10
2	7.28	6.4	180	0.29	2	0.58	4
3	8.38	6.5	180	0.33	2	0.66	5
4	43.87	7.7	180	0.73	2	1.46	11
5	29.30	6.7	150	0.33	3	0.99	7
6	13.56	6.9	180	0.37	3	1.11	8
7	34.53	7.0	180	0.27	2	0.54	4
8	4.82	7.6	180	0.19	3	0.57	4
9	5.17	6.6	180	0.18	3	0.54	4
Average	17.92		177	0.35	3	0.87	6

Besides degree of roast, the type of coffee roasted seems to be of importance in determining the amount of niacin produced. However, no definite conclusions can be drawn from the studies presented here, because temperature was also a variable factor. Variety and processing of the cherry could also be of importance in determining the amount of niacin produced under standardized conditions of roasting, although Hughes and Smith *(13)* reported that the nicotinic acid content of raw coffee is not dependent on variety. The content of trigonelline, however, could be dependent upon variety, altitude, or the cherry processing method and thus determine the niacin content of the roasted product, since trigonelline is the substance which upon heat is changed into nicotinic acid *(12, 20)*.

Green coffee samples varied greatly in niacin content, except for two samples, type "Pache" and type "Bourbon," which contained significantly lower amounts of the vitamin. Since most of the samples came from plantations of altitudes over 3,500 feet over sea level, and were cultivated under very similar conditions, these differences must be primarily due to variety. The amount of ether extractable substances also increases with the time of roasting, due partly to the decrease in moisture with roasting and partly to the loss in weight from a known amount of green coffee. However, other changes are taking place in compounds which become ether soluble upon heat. Since this increase in ether extractable substances may be of importance in determining the flavor of the coffee, it should be studied further.

The surveys of the importance of coffee as a contributor of nicotinic acid indicate that significant quantities of the vitamin are ingested in this beverage although the amount varies with the degree of roasting and the strength of the beverage as well as the number of cups consumed per day. Nevertheless for the people who need the vitamin the most, the amount of niacin ingested by drinking coffee is usually relatively small. Because the cost of the roasted products is relatively high, low-income groups frequently cannot afford to buy pure coffee and purchase instead brands that contain large amounts of foreign materials, especially cereal grains and dried beans. Even though the total niacin intake from coffee in the low-income population of Central America is not high, it should be taken into consideration when carrying out and computing dietary surveys.

Acknowledgments

The authors wish to express their appreciation to Dr. Romeo de León for the collection of the samples, to Dr. Miguel A. Guzmán for suggestions in the selection of the samples and to the "Oficinia Central del Café and the Asociación General de Agricultores de Guatemala" for making available the raw coffee samples.

LITERATURE CITED

1. Adamo, G. Il contenuto in acido nicotinico nel caffe. *Bol. della Societa Italiana di Biologia Sperimentale,* 31, 79 (1955).
2. Assoc. Offic. Agr. Chemists. *Official Methods of Analysis.* 8th. ed. 1955. Washington, D. C.
3. Castillo, A. S., and Flores, M. Estudios dietéticos en El Salvador. II. Cantón Platanillos, Municipio de Quezaltepeque, Departamento de La Libertad. *Suplemento No. 2 del Boletín de la Oficina Sanitaria Panamericana.* "Publicaciones Científicas del Instituto de Nutrición de Centro América y Panamá," p. 54-65 1955.

4. Cravioto, R. O., Guzman, G. J. and Suarez, M. L. Incremento del contenido de niacina (vitamina antipelagrosa) durante la torrefacción del café y su significado en el aporte de esta vitamina a la dieta. *Ciencia* (Mexico), 15, 24 (1955).
5. Food and Agriculture Organization of the United Nations—Maize and Maize Diets, A Nutritional Survey. *FAO Nutritional Studies No. 9*, Food and Agriculture Organization of the United Nations, Rome, Italy (1954).
6. Flores, M. and Reh, E. Estudios de hábitos dietéticos en poblaciones de Guatemala. I. Magdalena Milpas Altas. *Suplemento No. 2 del Boletín de la Oficina Sanitaria Panamericana,* "Publicaciones Científicas del Instituto de Nutrición de Centro América y Panamá," p. 90–128, 1955.
7. Flores, M. and Reh, E. Estudios de hábitos dietéticos en poblaciones de Guatemala. II. Santo Domingo Xenacoj. *Suplemento No. 2 del Boletín de la Oficina Sanitaria Panamericana,* "Publicaciones Científicas del Instituto de Nutrición de Centro América y Panamá," p. 129–148, 1955.
8. Flores, M. and Reh, E. Estudios de hábitos dietéticos en poblaciones de Guatemala. III. San Antonio Aguas Calientes y su Aldea, San Andres Ceballos. *Suplemento No. 2 del Boletín de la Oficina Sanitaria Panamericana,* "Publicaciones Científicas del Instituto de Nutrición de Centro América y Panamá," p. 149–162, 1955.
9. Flores, M., and Reh, E. Estudios de hábitos dietéticos en poblaciones de Guatemala. IV. Santa María Cauqué. *Suplemento No. 2 del Boletín de la Oficina Sanitaria Panamericana,* "Publicaciones Científicas del Instituto de Nutrición de Centro América y Panamá," p. 163–173, 1955.
10. Flores, M., García, B., Cruz, E., Meneses, B., Mazariegos, A. de, and Sierra, A. de. Estudios de hábitos dietéticos entre pre-escolares del área de demonstración sanitaria de Amatitlán. (In preparation.)
11. Goldsmith, G. A. Personal Communication.
12. Gross Daum, M. La niacina en el café y su importancia nutricional en Venezuela. *Arch. Venezolanos de Nutrición,* 6, 61 (1955).
13. Hughes, E. B., and Smith, R. F. Nicotinic acid content of coffee. *J. Soc. Chem. Ind.,* 65, 284 (1946).
14. Instituto de Nutrición de Centro América y Panamá. Recomendaciones nutricionales diarias para las poblaciones de Centro América y Panamá. Revisadas, Septiembre de 1954. *Suplemento No. 2 del Boletín de la Oficina Sanitaria Panamericana,* "Publicaciones Científicas del Instituto de Nutricion de Centro América y Panamá," p. 225–226, 1955.
15. Reh, E. and Fernandez, C. Condiciones de vida y de alimentación en cuatro grupos de población de la Zona Central de Costa Rica. *Suplemento No. 2 del Boletín de la Oficina Sanitaria Panamericana,* "Publicaciones Científicas del Instituto de Nutrición de Centro América y Panamá," p. 66–89, 1955.
16. Sogandares, L., Galindo, A. P. de, Mejía, H. P. Estudios dietéticos de grupos urbanos y rurales de la República de El Salvador. *Suplemento No. 1 del Boletín de la Oficina Sanitaria Panamericana,* "Publicaciones Científicas del Instituto de Nutrición de Centro América y Panamá," p. 27–37, 1953.
17. Sogandares, L. and Barrios, G. Estudios dietéticos en Panamá. I. La Mesa, Provincia de Veraguas. *Suplemento No. 2 del Boletín de la Oficina Sanitaria Panamericana,* "Publicaciones Científicas del Instituto de Nutrición de Centro América y Panamá," p. 38–46, 1955.
18. Sogandares, L., Barrios, G. de, Corcó, E. Z. de. Estudios dietéticos en Panamá. II. Barrio El Chorrillo, Ciudad de Panamá. *Suplemento No. 2 del Boletín de la Oficina Sanitaria Panamericana,* "Publicaciones Científicas del Instituto de Nutrición de Centro América y Panamá," p. 47–53, 1955.
19. Teply, L. J., Krehl, W. A. and Elvehjem, C. A. Studies on the nicotinic acid content of coffee. *Arch. Biochem.,* 6, 139 (1945).
20. Teply, L. J. and Prier, R. F. Nutrients in coffee. Nutritional evaluation of coffee including niacin bioassay. *J. Agr. Food Chem.,* 5, 375 (1958).
21. The Pharmacopoeia of the United States of America, 12th ed., 1st. Sup., p. 69, 1943.

PRINTED IN THE U.S.A.