JOURNAL OF FOOD COMPOSITION AND ANALYSIS (2002) **15,** 499–505
doi:10.1006/jfca.2002.1092
Available online at http://www.idealibrary.com on IDEAL®

REPORT

Sampling Plan for the Brazilian TACO Project

Maria Antonia Martins Galeazzi, Dag Mendonça Lima, Fernando A. B. Colugnati, Renata Maria Padovani, and Delia B. Rodriguez-Amaya[1]

Núcleo de Estudos e Pesquisa em Alimentação, Universidade Estadual de Campinas, 13083-970 Campinas, SP, Brazil

Received November 18, 2001, and in revised form June 21, 2002

The TACO project (Brazilian Table of Food Composition), sponsored by the Brazilian Ministry of Health and executed by NEPA-UNICAMP (Center for Studies and Research on Foods—State University of Campinas), is generating new data on the most consumed foods in Brazil, based on a national sampling plan and analyses carried out by laboratories with demonstrated laboratory capability in nutrient analysis. Key foods have been chosen according to a national multicentric survey of food consumption, starting with 200 food items. The sampling plan covers nine cities in the five official Brazilian geopolitical regions (North, Northeast, South, Southeast and Centralwest), corresponding to approximately 16.8 million inhabitants out of a total Brazilian population of about 170 million. Samples of principal brands (maximum of five for each food) are collected from supermarkets/hypermarkets where 84–85% of total food purchases are made by the Brazilian population. Two units of each principal brand of each product are taken at each sampling site. The total units for each food from all regions are mixed and packed in cans, and three final composites of 100–200 g for each food are sent for analyses in approved laboratories.

Key Words: food composition table; database; sampling; Brazil.

INTRODUCTION

The TACO (“Tabela Brasileira de Composição de Alimentos”, Brazilian Table of Food Composition) project was initiated in 1996 with the objective of bringing together Brazilian universities and research institutes with laboratory capability to generate new and reliable analytical data for a national database on the composition of Brazilian foods. Recognizing the need for analytical data that truly represent the composition of Brazilian foods and for reliable information on food consumption that can serve as a basis for formulating policies and action plans in insuring food

[1]To whom correspondence and reprint requests should be addressed. Fax: +55-19-3788-7320. E-mail: delia@fea.unicamp.br

0889-1575/02/040499 + 07 $35.00/0

and nutritional security, the Brazilian Ministry of Health approved financial support to this project. The grant was made official on November 16, 1996, but funds have been made available only starting July 1997. The project is being executed by the Núcleo de Estudos e Pesquisas em Alimentação, Universidade Estadual de Campinas (NEPA-UNICAMP, Center for Studies and Research on Foods—State University of Campinas).

This is the first time that data are being generated in Brazil, using a national sampling plan and analyses carried out by laboratories with demonstrated capability in nutrient analysis. As such, this effort is considered merely the beginning of this endeavor, to be complemented and improved thereafter. Considering the lack of experience, budget constraints and limited human resources, and although guidelines for sampling (Cohran, 1977) and analysis were taken into account as much as possible, this project cannot be compared in magnitude and level of refinement to the USDA food composition program (Pehrsson *et al.*, 2000), consolidated and on-going for so many years.

Presently, three food composition tables are used in Brazil, two that contain mostly data borrowed from other countries (IBGE, 1977; Franco, 1982) and the other a compilation of individual and isolated food analysis work done in Brazilian universities and research institutes (USP, 2001). Moreover, the latter does not include data on minerals and vitamins, except vitamin A, and the number of food items included is limited, except for proximate composition.

PRELIMINARY ACTIVITIES

In Phase 1 of the project, the Advisory Board was composed of Maria Antonia Martins Galeazzi, Semíramis Martins Álvares Domene, Franco Maria Lajolo, José Augusto Aguiar Carrazeddo Taddei. Ademir José Petenate was statistics consultant and the technical staff consisted of Dag Mendonça Lima, Renata Maria Padovani, Myrian T. S. Martins and Frederico Almeida Meireles de Palma. The objectives of this phase were: (1) hold a workshop for laboratories involved in food analysis to formulate recommendations for the implementation of the project; (2) conduct an interlaboratory study to assess the capability of laboratories in nutrient analysis; and (3) identify the foods to be analyzed in the second phase.

A workshop was held in November 1997 to formulate initial recommendations. The Discussion Group on Sampling made the following recommendations: (1) sampling should consist of collecting samples by region, in cities of representative states for each region, giving preference to the capital cities, but also considering the existence of an institution interested in participating in the project in defining the sampling sites; (2) consumption surveys (Galeazzi *et al.*, 1997, 1998; Galeazzi and Falconi, 1998) should be consulted to verify the main sales sites; (3) products must be collected as marketed, in the original packages; (4) the number of samples to be collected from each site must be proportional to the frequency of consumption; and (5) composite samples should be used for the laboratory analyses. Representative cities were later defined as those with high population density, capable of offering greater variety of products and brands. Except for the sparsely populated Centralwestern region, two states were chosen for each region. David Buss, who was then with the Ministry of Agriculture, Fisheries and Food of the United Kingdom was the consultant of this group in which the following participated: Sonia Tucunduva Philippi and Odair Zenebom (co-chairpersons), Ana Marlúcia Oliveira de Assis, Ângela Rita Pfingstag, Lilian Cuppari, Regina S. M. Rodrigues, Roseana Dantas Mazza and Tania Quilies Lustosa.

An interlaboratory study was held starting August 1998, initiating with 17 participating laboratories and ending with 15 reporting laboratories (Domene *et al*., 1999). Proximate and mineral analyses of certified reference materials were carried out.

Phase 2 of the project started in December 1999 with Maria Antonia Martins Galeazzi as the general coordinator and Delia B. Rodriguez-Amaya as scientific coordinator. Maria Aparecida A. Pereira Silva, Denise Costa Coutinho and Ademir José Petenate were consultants on sensory analysis, nutrition and statistics, respectively. The technical staff was composed of Dag Mendonça Lima, Renata Maria Padovani, Frederico M. de Almeida Palma and Fernando Colugnati. The objectives of this phase were: (1) hold a second workshop to further discuss sampling, analysis, quality control and quality assurance; (2) conduct a second interlaboratory study to include other laboratories and, aside from proximate and minerals, determine vitamins and fatty acids; (3) identify the commercial brands most consumed in the country; (4) elaborate the sampling plan; and (4) carry out the analyses.

The results of the first interlaboratory study did not satisfactorily meet the needs of the project. Except for some previous limited attempts with single analytes, this was the first time this type of evaluation was carried out in Brazil. Thus, there were reluctance and apprehension on the part of some of the laboratories, and there was room for improvement and amplification of the number of laboratories and the nutrients under analysis. Another workshop was held in June 2000, principally to discuss critical points in proximate analysis and analyses of minerals, vitamins and fatty acids, as a prelude to the second interlaboratory study. A lecture on ''Sampling and Sample Preparation'' was given by Joanne Holden, USDA, U.S.A., which gave the participants useful insight into the sampling scheme of USDA.

The second interlaboratory study was carried out in October 2000, involving proximate, mineral, vitamin, cholesterol and fatty acid analyses of certified reference materials (Rodriguez-Amaya *et al*., 2001). Seventeen laboratories participated, including laboratories that did not participate the first time, and all the laboratories reported results.

In both studies, certified reference materials from National Institute of Standards and Technology (NIST) and Bureau of Certified References of the European Comission (BCR) were used. The basic criterion for approval was: Z-score$=$ $\blacksquare - V_{\text{cert}}/\sigma < 3$, where $\blacksquare$ is the means of the determinations carried out by the laboratory, V_{cert} is the certified value given by the supplier and σ is the expanded uncertainty. The results of the interlaboratory studies will be published separately.

FOOD PRODUCTS

The most consumed foods were selected according to multicentric family food consumption surveys (Galeazzi *et al*., 1997, 1998), based on the monthly purchase of each family. Two hundred foods under the following categories were chosen: cereals and cereal products, sugar and sweets, nuts, legumes, vegetable and vegetable products, roots and tubers, fruit and fruit products, meat and meat products, fish and fish products, eggs and poultry products, milk and dairy products, fats and oils, beverages, spices and herbs.

Through a series of meetings of the technical group, presided by the general and the scientific coordinators, the details of the sampling plan were established.

Sampling is made difficult by the size of Brazil and the diversity of the foods available and food preferences/diets in the different regions. However, unlike the U.S. where there is a great variety of local and national brands for a given food, industrialized and semi-industrialized products in Brazil have a limited number of brands, which are nationally distributed.

To take advantage of cumulative experience, analyses started with easier, more homogenous, not so perishable samples. Fifty processed products were chosen as initial samples (Table 1). Analyses consisted of proximate, fatty acid, cholesterol, mineral and vitamin determinations for which laboratory capability had been demonstrated (Rodriguez-Amaya *et al*., 2001).

The sampling scheme described herein was used for the first 50 foods (Table 1), the analyses of which had already been completed. This general plan is being applied to the rest of the samples, with some adjustments for a few foods. For example, samples of fresh fruits and vegetables are being collected from the fresh produce distribution centers, instead of supermarkets/hypermarkets, of the major producing states, to have greater representativity and to reduce operational time, considering the perishability of these products.

SAMPLING SITES

Samples were collected from selected sites in the five official geopolitical regions, these sites having a total population of about 16.8 million, out of a total Brazilian population of approximately 170 million (IBGE, 2000). The following cities were chosen as sampling sites (their corresponding states are indicated in parentheses): Northern region—Manaus (Amazonas) and Belen (Para); Northeastern region—Recife (Pernambuco) and Salvador (Bahia); Centralwestern region—Cuiaba (Mato Grosso); Southeastern region—Rio de Janeiro (Rio de Janeiro) and Campinas (São Paulo); Southern region—Curitiba (Parana) and Porto Alegre (Rio Grande do Sul). The geographic location of the regions, cities and states and the population of each city are presented in Figure 1 (IBGE, 2000). Unlike the USDA sampling plan, in which the four regions selected have roughly equal populations, the Brazilian regions have different populations, reflecting the very uneven population density in Brazil. Except for Campinas, capital cities (the most densely populated areas of the states) were chosen. Although Campinas is not a capital, it was chosen for organizational convenience.

Regional representatives were designated as follows: Northern region, Lúcia Kiyoko O. Yuyama; Northeastern region, Nonete Guerra; Centralwestern region, Myriam T. S. Martins; Southeastern region, Technical staff of the TACO project; Southern region, Vera Costa Dias.

As in other parts of the world, retail sites in Brazil can be divided into two types: (1) self-service outlets, which can be classified according to the number of cash registers into convenience stores, supermarkets and hypermarkets; and (2) local or neighborhood traditional stores, with less than three cash registers, such as shops, bakeries and groceries (Souza *et al*., 1998). The first type was grouped into medium markets (10–19 cash registers), supermarkets (20–49 cash registers) and hypermarkets (50 or more cash registers).

All the food samples in the present work were collected from supermarkets/hypermarkets (sites with more than 20 cash registers), where 84–85% of all food purchases are made by the Brazilian population (Table 2) (Souza *et al*., 1998). In regions with both super- and hypermarkets, the preference for sampling site was the latter. Aside from insuring better representativity, this permitted operational

TABLE 1

List of the first 50 foods for the TACO Project

Product	No. of brands[1]	No. of units collected	Total weight (kg)
Beans, black	2–5	56	56.0
Beans, Carioca	2–5	74	74.0
Beef bouillon	3–5	66	4.6
Cake, coconut-flavored	1–5	66	13.2
Cake mix, vanilla-flavored	4–5	86	43.0
Chocolate-milk bars	4–5	82	16.4
Cocoa for beverage	1–5	74	29.6
Coffee, roasted, ground	4–5	86	21.5
Condiment with salt, without pepper	2–5	62	18.6
Cookies with strawberry filling	5	90	18.0
Cookies with chocolate filling	5	90	18.0
Corn, canned	4–5	86	17.2
Corn flakes	0–5	46	9.2
Corn flakes with sugar	2–5	72	14.4
Corn gruel	1–5	56	28.0
Corn meal	2–5	64	32.0
Cornstarch	2–5	54	27.0
Cornstarch cookies	3–5	82	16.4
Cream cracker	3–5	86	17.2
Figs, canned	2–4	52	20.8
Flour, cassava	3–5	66	66.0
Flour, tapioca	1–5	60	30.0
Flour, wheat	4–5	80	80.0
Gelatin powder	4–5	84	7.1
Goiabada, typical guava dessert	3–5	82	41.0
Lentils	2–4	52	26.0
Macaroni with eggs	4–5	86	43.0
Macaroni without eggs	3–5	74	37.0
Milk, condensed, sweetened	4–5	84	33.2
Milk powder, nonfat	2–5	68	20.4
Milk powder, whole	0–5	48	19.2
Noodles, instant	3–5	86	7.7
Oatmeal	2–5	60	15.0
Peach, canned	3–5	82	41.0
Peas, canned	5	90	18.0
Rice, type 1	3–5	82	410.0
Rice, type 2	0–5	44	220.0
Rice, whole	3–5	78	78.0
Sugar, crystallized	1–5	42	42.0
Sugar, refined	2–5	60	60.0
Tomato paste	4–5	88	17.6
Tomato purée	2–5	60	24.0
Vegetables, mixed, canned	3–5	62	12.4
Wafer, strawberry	4–5	88	17.6
Wafer, chocolate	4–5	88	17.6
Wheat-milk instant mix	1–5	60	24.0
Yogurt, natural	4–5	88	17.6
Yogurt, peach	3–5	80	16.0
Yogurt, pineapple	4–5	84	16.8
Yogurt, strawberry	4–5	88	17.6

[1]The number of principal brands varied in the different sites, thus the range is given.

simplicity and lesser cost. In any case, food items sold in local/traditional stores would be among those sold in supermarkets/hypermarkets, but not all items found in the latter would be encountered in the former.

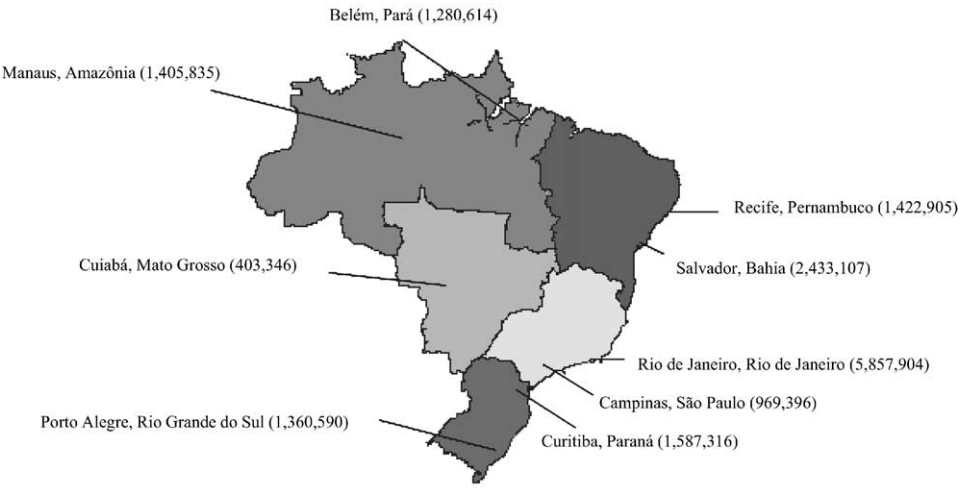

FIGURE 1. Geographic location of the sampling sites (cities, states, populations).

TABLE 2

Percentages of the Brazilian population purchasing foods from two primary sale site types—1991–1995

Sale site type	Year				
	1991	1992	1993	1994	1995
Self-service	84.0	84.4	85.1	84.7	84.4
Traditional	16.0	15.6	14.9	15.3	15.6

Source: Souza *et al.* (1998).

COLLECTION OF SAMPLE INCREMENTS

Attempts to get information from the managers of the supermarkets on the most sold brands failed, thus the principal brands for each product were defined through on-site inquiries by regional representatives with employees responsible for stacking the products on the frequency with which the brands needed to be replaced on the shelves. This strategy was initially tested in Campinas and was found to adequately identify the most purchased and presumably most consumed brands. A principal brand was one that contributed at least 20% of the regional market sale. Thus, the maximum number of brands sampled for a product was five per region. Because of the lack of information on the market share of each principal brand, uniform probability was assumed.

Products were collected at the principal sale sites in the nine cities selected, by the regional representatives. In each site, two units from different factory lots of each brand of each product were taken. The units chosen were the smallest packages available in the site, in perfect condition, and the stated period of validity (labeled expiration date) sufficient to allow that analyses be completed within this period.

Considering nine cities, two units of each of five brands in each city, a total of 90 units was estimated for each product. However, for most of the products, the number of principal brands was less than five in some sampling sites, thus the total number of units collected per product was less than 90 (Table 2). This availability limitation in some way approximated the sampling to the frequency of consumption.

The different units of each product were collected from the different sites on the same day and transported by air to the Instituto de Tecnologia de Alimentos in Campinas where homogenization, using procedures appropriate to the product matrix, was undertaken immediately after arrival of the units. This Institute was chosen because of its experience and facilities for handling large volumes of foods. Foods were classified into foods of low density (e.g., coffee, oats); foods of greater density (e.g., rice, beans); particulate, non-fat foods (e.g., macaroni, spaghetti, crackers); particulate, fatty foods (e.g., cookies with fillings, wafer). For the first and second groups, an Apex agitator (Model SHTE) was used at 36 and 48 rpm, respectively, for 5 min. For the third and fourth groups, an angle disintegrator (Rietz model type RP) was used at up to 100 rpm. The total units for each food from all regions were mixed and composite samples of 100–200 g were packed in cans and transported by air to the laboratories. Three composite samples were analyzed for each food product. Analyses commenced upon arrival of the samples in the laboratories.

For chocolate-milk bars, ''goiabada'', yogurts, condensed milk, canned peas, mixed vegetable, figs and peaches, the units collected from the different sampling sites were transported directly to the analytical laboratory where blending was carried out. For the first four products, there was concern that the homogenization process could hasten their deterioration, requiring immediate analysis of the homogenized samples. For the other products, it was thought that the proportion between liquid and drained weight could be better maintained in the laboratory. In any case, these were products which could be easily homogenized in the laboratory. Yogurt was refrigerated during transport.

REFERENCES

Cohran, W. G. (1977). *Sampling Techniques*. John Wiley & Sons, New York.

Domene, S. M. A., Lima, D. M., Padovani, R. M., Lajolo, F. M., Taddei, J. A. A. C., and Galeazzi, M. A. M. (1999). TACO project—Brazilian food composition database. Paper presented at the *Third International Food Data Conference*, Rome.

Franco, G. V. E. (1982). *Nutrição: Texto Básico e Tabela de Composição Química dos Alimentos*, 6th edn. Atheneu, São Paulo.

Galeazzi, M. A. M., Domene, S. M. A., and Sichieri, R. (Eds.) (1997). Estudo multicêntrico sobre consumo alimentar. *Caderno de Debates*, special volume, pp. 1–62.

Galeazzi, M. A. M., Domene, S. M. A., and Zabotto C. (1998). Inquérito de consumo alimentar familiar de Belém. Relatório Técnico para o Centro Colaborador da Região Norte, Ministério da Saúde.

Galeazzi, M. A. M. and Falconi, P. J. (1998). Inquérito de consumo alimentar famíliar (INCAF) de Brasília. Relatório Técnico para Secretaria de Saúde do DF.

IBGE. (1977). *Estudo Nacional de Despesa Familiar—ENDEF: Tabela de Composição de Alimentos*. Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro.

IBGE. (2000). *Censo Demográfico*. Instituto Brasileiro de Geografia e Estatística. Retrieved June 3, 2002 from the World Wide Web: http://www.ibge.gov.br.

Pehrsson, P. R., Haytowitz, D. B., Holden, J. M., Perry, C. R., and Beckler, D. G. (2000). USDA's national food and nutrient analysis program: food sampling. *J. Food Comp. Anal.* **13,** 379–389.

Rodriguez-Amaya, D. B., Colugnati, F. A. B., Padovani, R. M., Lima, D. M., and Galeazzi, M. A. M. (2001). Evaluation of the laboratory capability in Brazil. Paper presented at the *Fourth International Food Data Base Conference*, Bratislava.

Souza, R. A. M. de, Silva, R. O. P., Mandelli, C. S., and Tasco, A. M. P. (1998). Comercialização hortícola: Análise de alguns setores do Mercado varejista de São Paulo. *Inform. Econ.* **28,** 7–23.

USP. (2001). *Tabela Brasileira de Composição de Alimentos*. Universidade de São Paulo. Retrieved on June 4, 2002 from the World Wide Web: http://www.fcf.usp.br/tabe.