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The application of hierarchical clusters analysis to the study of the composition of foods

Elizabeth Aparecida Ferraz da Silva Torres [b,*], Maria Lima Garbelotti [a], José Machado Moita Neto [c]

[a] Division of Food Science and Chemistry of the Adolfo Lutz Institute, Brazil
[b] Department of Nutrition of the School of Public Health of the University of São Paulo (Universidade de São Paulo), Brazil
[c] Department of Chemistry of the Federal University of Piauí (Universidade Federal do Piauí), Brazil

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Abstract

The nutritional value of prepared foods is frequently questioned or requested at restaurants by its costumers. Therefore, this paper aimed to apply HCA to categorize foods according to their nutritive values. Fifty three samples of prepared foods from four different restaurants were analyzed for proximate composition using the AOAC methods [AOAC (1995). Association of Official Analytical Chemists. Official method of analysis. Arlington, Cereal foods, Supplement (pp. 7–11).]. The multivariate statistical analysis of data using the hierarchical cluster analysis (HCA) technique was obtained through the SPSS (10.0) program. French fries were the most caloric preparation; they also have considerable total fiber content. Milled white rice is rich in carbohydrates; and calories and fiber-poor. Arugula offers the highest protein and total fiber content, whereas lettuce presented the smallest amount of these two nutrients. Beans are the main source of dietary fiber and have a low caloric value. The most caloric preparations are French fries and fried zucchini Milanese Type of processing employed in preparing the foods might account for the variation in results between the establishments studied HCA was a useful guide for looking at and analyzing the different types of foods comparatively. Given how easy it is to calculate this with software, it is recommendable to be used even as an exploratory tool, capable of aiding intuition in the analysis of the set of data. HCA can be useful guide/tools to educate consumers on the nutritive values of foods selling in a restaurant and to help the consumers to select the foods which are suitable to their help, if required.

Keywords: Proximate composition; Dietary fiber; "By weight" restaurants; Hierarchical clusters analysis; HCA

1. Introduction

The study of the chemical composition of foods is necessary for: developing the science of nutrition (Greenfield & Southgate, 1992); knowledge of this field is important for professionals who work: in the field of nutrition, food data composition, food security planning, prevent non communicable diseases and in healthcare in general terms (Burlingame, 2003). Because of the changes that have taken place in the daily life of the population, it is currently rare in São Paulo to find a family that has its meals at home, whether due to lack of time or the distance between home and the workplace. Therefore, restaurants that sell food by weight have become an increasingly common alternative.

The complexity and number of parameters that can be used to evaluate the chemical and nutritional composition of food point to the need to use statistical techniques capable of providing an overview of all the data at the same time, thereby making it possible for one to understand all the statistical information of the set of data (Forina & Lanteri, 1984).

Although it is common in the scientific community to use univariate statistics, through the values of the mean

* Corresponding author. Tel.: +55 11 30667771; fax: +55 11 37724145.
E-mail address: eatorres@usp.br (E.A.F. da Silva Torres).

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and the standard deviation of each analyzed variable, this does not help one to obtain an overview of the set of analyzed samples (Forina & Lanteri, 1984). Multivariate statistical techniques are the right tools for viewing and analyzing a matrix of complex data. The hierarchical cluster analysis (HCA) used in this paper is a simple way of grouping the set of available data through their similarities, according to the set of selected variables.

Hierarchical cluster analysis consists of mathematically treating each sample as a point in the multidimensional space described by the chosen variables (Bruns & Faigle, 1995; Moita Neto & Moita, 1998). It is also possible, according to this technique, to treat each variable as a point in the multidimensional space described by the samples. In other words, one can have a cluster of samples or of variables, depending on what one is looking for in each situation. When a given sample is taken as a point in the space defined by the variables, one can calculate the distance between this point and all the other points, thereby establishing a matrix that describes the proximity between all the samples studied. There are several ways of calculating the distance between two points, the best known and most often used one being Euclidean distance (Forina & Lanteri, 1984). Based on this matrix of proximity between the samples, one can construct a similarity diagram called a dendrogram. There are many ways of mathematically grouping these points in multidimensional space in order to form hierarchical clusters. Each one corresponds to a specific algorithm, which relies on the information of the proximity matrix to create a similarity dendrogram (Forina & Lanteri, 1984). The interpretation of a similarity dendrogram between samples is based on intuition: two samples that are close to each other ought also to have similar values where the measured variables are concerned, i.e., they ought to be mathematically close to each other in the multidimensional space. Therefore, the greater the proximity between the measures that concern the samples, the greater the similarity between the studied samples. The dendrogram imposes a hierarchy on this similarity, so that we can have a two-dimensional vision of the similarity or dissimilarity of the entire set of samples used in the study. When the constructed dendrogram is one of variables, the similarity between two variables indicates a strong correlation between these variables of the set of data under study. The dendrograms of samples are the most common kind and were the ones employed in this paper. The use of hierarchical cluster analysis when we have different scale variables, as is the case of food analysis, in which each variable is represented by a different unit, calls for the data to be treated previously. The most commonly used pre-treatment is Z transformation, which transforms the measures of each variable in such a way as to cause the set to have a mean of zero and a variance of one. The purpose of this procedure is to equalize the statistical importance of all the variables employed. The mathematical difficulties involved in these calculations have now been eliminated, thanks to statistical software packages of a broad scope that are also easy to use, such as SPSS (Statistical Package for the Social Sciences), employed in this work. SPSS offers all the tools for obtaining similarity dendrograms, including several distance options, cluster methods and means of transforming the original data.

2. Objectives

1. To analyze the chemical composition of foods sold at restaurants.
2. To apply the HCA to categorize foods according to their nutritive values.

3. Materials and methods

3.1. Materials

53 food preparations were analyzed, as follows: 18 main dishes, 20 salads, 10 side dishes and 5 desserts (Table 1).

Proximate composition (moisture, ash, lipid and protein contents) were determined as described by AOAC (1995). Nitrogen was determined by the KJELDAHL method and a conversion of factor 6.25 (Association of Official Analytical Chemists, 1995). Total dietary fibre (TDF) was determined by the enzyme gravimetric method as cited by Garbelotti, Marsiglia, and Torres (2003). Energy: the energy value was calculated using average conversion factors for protein, fat and carbohydrates (by difference), according to Atwater.

4. Statistical analysis

The data obtained from the analysis of the composition of the foods were analyzed by means of multivariate analysis; employing hierarchical cluster analysis. The method used was linkage Between-groups. The distances between samples were calculated using square Euclidean distances. As pre-treatment of data was carried transform values of variables (average zero and standard deviation 1) called Z scores.

The dendrogram similarity scales that are generated by the SPSS program range from zero (greater similarity) to 25 (lower similarity). The similarities between the analyzed samples were presented in the dendrograms for each restaurant.

5. Results and discussion

5.1. Restaurant I

Table 2 data show that the preparations of restaurant I containing the greatest amount of ash are the potatoes au gratin, the "feijoada" black bean and meat stew and the meat roll. One must stress that the latter has higher protein content than the others, due to using a greater quantity of animal ingredients. The beetroot and vegetable salads have a low energy content (16 and 17 kcal/100 g), whereas the

Table 1
Food preparations in four "by weight" restaurants

Salads	Main courses	Side dishes	Desserts
Lettuce	Milled rice	Fried zucchini Milanese	Orange melon******
Watercress	Milled rice	Sautéed wild chicory	Strawberry
Eggplant w/pimento*	Milled rice	Baked bananas	Kiwi******
Beetroot**	Milled rice	French fries	Fruit salad
Broccoli***	Milled rice w/broccoli	French fries	Strawberry pie
Bean sprout***	Milled rice w/mushrooms	French fries	–
Carrot**	Milled rice w/vegetables	Potatoes au gratin	–
Chayote**	"Carioca" beans	Sautéed collard greens	–
White bean***	"Carioca" beans	Macaroni w/Italian sausage	–
Chickpea***	"Carioca" beans	Meat roll	–
Mixed	"Carioca" beans	–	–
Legumes/mayonnaise-1	Feijoada (meat stew w/black beans)	–	–
Legumes/mayonnaise-2	Feijoada (meat stew w/black beans)	–	–
Legumes-1	Feijoada (meat stew w/black beans)	–	–
Heart of palm	Feijoada (meat stew w/black beans)	–	–
Cucumber****	Feijoada (meat stew w/black beans)	–	–
Radish****	"Carioca" bean puree w/manioc flour	–	–
Arugula	Chicken/heart-of-palm pancake	–	–
Tomato*****	–	–	–
Haricot bean/carrot***	–	–	–

*Cooked with the skin and seasoned; **cooked without its skin ***cooked; mixed: Kanikama crab sticks, tomatoes and mushrooms; vegetable-1: string beans, carrots, turnips and chayote; vegetable-2: potatoes, carrots, corn and peas; ****with the skin; *****whole; fruit salad: papaya, melon and stewed peaches; ******with no skin.

Table 2
Proximate composition and caloric value of the preparations of restaurant I

Preparations	Physical chemical composition (g/100 g)				Caloric value		
	Moisture**	Ashes**	Lipids**	Proteins**	TDF[a]	Carbohydrates**	kcal/100 g**
Milled rice*	49.75 ± 0.01	1.53 ± 0.01	4.62 ± 0.16	3.66 ± 0.01	1.24 ± 0.04	39.20 ± 0.15	213 ± 1
French fries	54.42 ± 0.56	1.59 ± 0.02	10.78 ± 0.06	3.15 ± 0.01	3.50 ± 0.16	26.56 ± 0.15	216 ± 3
Potatoes au gratin	60.32 ± 0.01	2.34 ± 0.01	3.68 ± 0.08	5.92 ± 0.12	2.15 ± 0.09	25.61 ± 0.04	159 ± 0
Collard greens*	85.02 ± 0.01	0.91 ± 0.01	6.23 ± 0.20	2.40 ± 0.02	5.44 ± 0.03	0.00	66 ± 1
"Carioca" beans*	74.38 ± 0.59	1.68 ± 0.01	1.49 ± 0.04	3.49 ± 0.01	6.13 ± 0.45	12.83 ± 0.56	79 ± 3
Feijoada (meat stew w/black beans)	69.36 ± 0.30	2.53 ± 0.01	9.17 ± 0.01	10.43 ± 0.13	4.14 ± 0.01	4.37 ± 0.20	142 ± 1
Macaroni w/Italian sausage	75.01 ± 0.04	1.10 ± 0.04	3.37 ± 0.49	5.37 ± 0.44	3.00 ± 0.07	12.15 ± 0.94	100 ± 2
Meat roll	66.15 ± 0.26	2.47 ± 0.39	6.20 ± 0.20	16.63 ± 0.88	1.44 ± 0.01	7.11 ± 1.73	151 ± 2
Watercress****	95.05 ± 0.01	0.80 ± 0.04	0.20 ± 0.01	2.03 ± 0.10	1.92 ± 0.01	0.00	10 ± 0
Lettuce****	97.16 ± 0.01	0.45 ± 0.14	0.18 ± 0.01	0.75 ± 0.06	1.04 ± 0.06	0.42 ± 0.20	6 ± 0.
Beetroot*****	93.43 ± 0.16	0.71 ± 0.01	0.59 ± 0.05	1.31 ± 0.10	2.72 ± 0.15	1.24 ± 0.30	16 ± 0
Legumes*****	92.71 ± 0.25	0.83 ± 0.01	0.21 ± 0.01	1.35 ± 0.30	2.41 ± 0.07	2.49 ± 0.20	17 ± 1
Legumes w/mayonnaise*****	77.47 ± 0.08	1.82 ± 0.01	4.07 ± 0.42	2.09 ± 0.12	2.31 ± 0.04	12.24 ± 0.47	94 ± 3
Passion fruit pie	54.97 ± 0.66	0.79 + 0.04	5.89 ± 0.10	5.18 ± 0.35	1.08 ± 0.10	32.09 ± 0.95	202 ± 3

*Cooked; **$n = 2$; ***$n = 3$; vegetable: string beans, carrots, turnip and chayote; ****uncooked salad; *****cooked salad.
[a] Total dietary fiber.

mayonnaise salad with the same vegetables has a high lipid content and caloric value, because of the fat of the added mayonnaise, and values that are quite similar to those of pasta with Italian sausage (100 and 94 kcal), respectively. The composition and caloric value results shown on Table 2 indicate that rice (213 kcal/100 g) and French fries (216 kcal/100 g) are richer in calories. The latter has a greater fat content (0.78 g/100 g).

Fig. 1 shows that the meat roll mentioned in Table 2 is different from the other preparations in that it has greater protein content. The dendrogram allows one to identify the various groups of foods. The first great division in-groups A and B separates foods according to their calorie content. Group A consists of vegetable salad, beetroot, water cress, lettuce, beans and cooked collard greens; therefore, it contains preparations with calorie values that range from 6 to 79 kcal/100 g.

Group B, consisting of vegetable mayonnaise salad, pasta with Italian sausage, potatoes au gratin, rice, passion fruit pie, French fries and "feijoada" black bean and meat stew, is made up of the preparations with calorie contents ranging from 94 to 216 kcal/100 g. They have a higher fat content and consequently a higher energetic value than the foods in-group A.

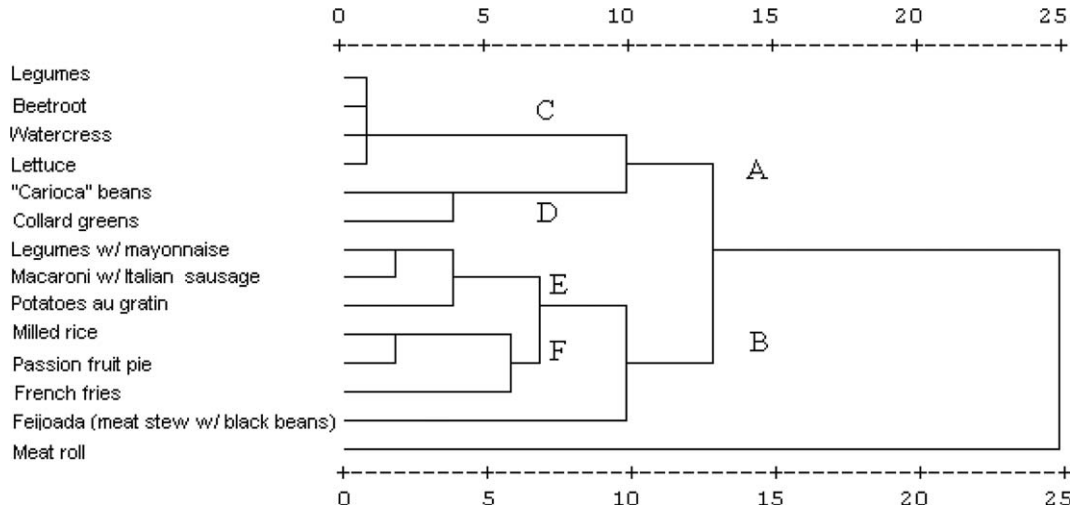

Fig. 1. Dendrogram of the several types of food of Restaurant I, obtained through the following variables: moisture, ashes, lipids, proteins, total fiber, total carbohydrates and caloric value.

Group A foods are split into two subgroups, C and D. Subgroup C contains foods with greater moisture (over 90%) and lower fat content, so that they have a lower caloric value (lower than 20%) than foods in group D.

Group B comprises three subgroups, one of which consists of ''feijoada'', which stands out relative to the other subgroups (E and F) due to its high protein content, which probably results from its ingredients of animal origin. The foods in subgroup F (rice, passion fruit pie and French fries) differ from the foods in subgroup E (vegetable mayonnaise salad, pasta with Italian sausage and potatoes au gratin) because they have a low moisture content and high caloric value.

French fries and potatoes au gratin, although they basically consist of the same ingredients, have different compositions, as shown on Fig. 1, and therefore belong to different subgroups (E and F). This can be explained by their preparation processes, which lead to different contents, especially with regard to lipids and total fiber content (10.78 g/100 g and 3.50 g/100 g for the French fries, 3.68 g/100 g and 2.15 g/100 g for the potatoes au gratin).

5.2. Restaurant II

Table 3 presents the composition and caloric value data for the analyzed foods from Restaurant II. One must note that the French fries, although they are the most caloric preparation, have a considerable total quantity of dietary fiber (4.02 g/100 g). One must also stress that sautéed chicory has a high caloric value (93 kcal/100 g) and lipid content (9.50 g/100 g), because high calorie ingredients are added in its preparation.

The Fig. 2 dendrogram shows that the French fries from Table 3 differ from the ones in the other groups because of their centesimal composition; they have less moisture, greater lipid content and consequently a higher caloric value.

Group B consists only of ''feijoada'' black bean and meat stew. Because of its high protein content, this food stands out vs. the large group A. Group D consists only of rice, which stands out vs. the foods in group C because of its high carbohydrate content and caloric value and its low fiber content. Group E has a higher degree of moisture

Table 3
Proximate composition and caloric value of the preparations of restaurant II

Preparations	Physical chemical composition (g/100 g)				Caloric value		
	Moisture**	Ashes**	Lipids**	Proteins**	TDF[a]	Carbohydrates**	kcal/100 g**
Wild chicory*	80.63 ± 1.62	1.45 ± 0.15	9.50 ± 1.11	1.66 ± 0.07	6.71 ± 0.01	0.00	93 ± 1
Milled rice*	60.98 ± 0.35	0.78 ± 0.14	3.99 ± 0.01	3.17 ± 0.01	1.21 ± 0.13	29.87 ± 0.21	168 ± 1
French fries	51.33 ± 0.27	1.19 ± 0.04	13.77 ± 0.17	3.78 ± 0.05	4.02 ± 0.21	25.91 ± 0.19	243 ± 2
Beans******	73.41 ± 0.01	1.37 ± 0.06	2.50 ± 0.11	5.58 ± 0.03	6.87 ± 0.24	10.27 ± 0.21	86 ± 0
Feijoada (meat stew w/black beans)	65.60 ± 0.05	2.54 ± 0.01	3.22 ± 0.05	15.55 ± 0.50	5.24 ± 0.10	7.85 ± 0.47	123 ± 0
Orange melon	94.70 ± 0.04	0.50 + 0.01	0.24 ± 0.06	0.67 ± 0.09	2.67 ± 0.02	1.22 ± 0.07	10 ± 0
Broccoli salad*	90.04 ± 0.20	0.75 ± 0.12	1.09 ± 0.08	4.28 ± 0.26	3.59 ± 0.12	0.25 ± 0.03	28 ± 1
Fruit salad****	89.94 ± 0.01	0.45 ± 0.01	0.20 ± 0.01	0.59 ± 0.01	5.95 ± 0.17	2.87 ± 0.01	16 ± 0
Cucumber salad*******	92.05 ± 0.03	1.39 + 0.04	2.19 ± 0.11	1.39 ± 0.04	1.90 ± 0.01	1.08 ± 0.06	30 ± 1
Tomato salad*****	95.08 ± 0.09	0.38 ± 0.01	0.68 ± 0.02	0.96 ± 0.07	2.23 ± 0.01	0.67 ± 0.18	13 ± 0
Bean puree w/manioc flour******	68.70 + 0.04	1.50 ± 0.02	3.17 ± 0.33	4.48 ± 0.03	5.65 ± 0.03	16.50 ± 0.24	112 ± 2

*Cooked; **$n = 2$; ***$n = 3$; ****papaya, melon and stewed peaches; *****whole; ******''carioca''; ******with skin.
[a] Total dietary fiber.

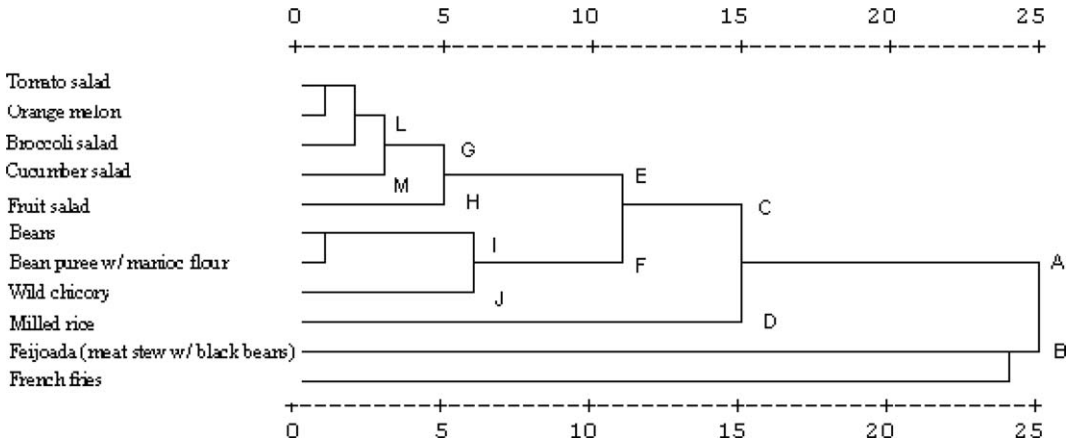

Fig. 2. Dendrogram of the several types of food of Restaurant II, obtained through the following variables: moisture, ashes, lipids, proteins, total fiber, total carbohydrates and caloric value.

and is split into two subgroups, G and H, whereas fruit salad alone constitutes group H. It stands out vs. the elements of group G (tomatoes, melon, broccoli and cucumber) for its high fiber content.

Subgroup G is split into two subgroups, L and M. The latter consists solely of cucumber salad, which stands out from group L (tomatoes, melon and broccoli salad) because of its higher lipid content.

Group F has two subgroups, I and J, and the latter consists only of chicory, which stands out from group I (beans and bean purée) because of its high lipid content and low protein and carbohydrate content.

5.3. Restaurant III

Among the compositions of the preparations of Restaurant III shown in Table 4, once again French fries stand out for their higher caloric value (257 kcal/100 g), followed by fried zucchini Milanese (234 g/100 g) and vegetable mayonnaise (197 kcal/100 g), which have a higher lipid content (17.16 and 17.45 g/100 g, respectively). The basic raw materials of the three preparations have a low energetic value; however, the process of preparation increases the fat content, making these foods calorie-rich.

The Fig. 3 dendrogram presents the results from restaurant III, shown on Table 4; there is an initial division into three groups, A, B and C, according to the moisture content. The foods in group A (arugula, mixed salad, bean sprout salad, cooked carrot salad, chayote salad and heart-of-palm salad) have a greater moisture content, ranging from 88.06 to 96.13 g/100 g. Group B (''feijoada'' black bean and meat stew, beans and white bean salad) has a moisture content ranging from 71.75 to 73.45 g/100 g and group C (French fries, vegetable mayonnaise salad, fried zucchini Milanese and rice) has a moisture content ranging from 45.20 to 66.71 g/100 g.

Group A is broken down into two subgroups, D and E. The heart-of-palm salad alone constitutes subgroup E and stands out vs. the other foods because of its high ash content.

Table 4
Proximate composition and caloric value of the preparations of restaurant III

Preparations	Physical chemical composition (g/100 g)				Caloric value		
	Moisture**	Ashes**	Lipids**	Proteins**	TDF[a]	Carbohydrates**	kcal/100 g**
Fried zucchini Milanese	59.13 ± 0.14	1.26 ± 0.05	17.16 ± 0.20	4.34 ± 0.40	2.65 ± 0.39	15.46 ± 0.33	234 ± 1
Milled rice*	59.02 ± 0.05	0.87 ± 0.01	1.20 + 0.04	3.50+ 0.31	1.42 ± 0.02	33.99 ± 0.23	161 ± 0
French fries	45.20 ± 0.13	2.04 ± 0.21	12.72 ± 0.17	4.90 ± 0.09	4.40 ± 0.14	30.74 ± 0.18	257 ± 1
''Carioca'' beans*	72.54 ± 0.02	1.56 ± 0.05	1.66 ± 0.12	6.24 ± 0.30	7.57 ± 0.21	10.41 ± 0.12	82 ± 0
Feijoada (meat stew w/black beans)	71.75 ± 0.02	2.00 ± 0.06	0.75 ± 0.23	6.81 ± 0.08	5.88 ± 0.16	12.81 ± 0.11	85 ± 1
Bean sprout salad	91.61 ± 0.08	0.28 ± 0.04	0.61 + 0.01	3.35 ± 0.30	3.07 ± 0.03	1.08 ± 0.35	23 ± 0
Carrot salad****	89.93 ± 0.10	0.76 ± 0.21	0.21 ± 0.05	1.15 + 0.01	5.19 ± 0.01	2.76 ± 0.01	18 ± 0
Chayote salad****	95.13 ± 0.07	0.28 ± 0.01	0.13 ± 0.01	0.77 + 0.01	2.45 ± 0.16	1.24 ± 0.08	9 ± 0
White bean salad	73.45 ± 0.04	0.95 ± 0.01	5.72 ± 0.01	5.32 + 0.19	7.30 ± 0.10	7.26 ± 0.19	102 ± 2
Legumes w/mayonnaise*	66.71 ± 0.27	2.02 ± 0.01	17.45 ± 0.60	3.60 ± 0.09	3.93 ± 0.12	6.29 ± 0.90	197 ± 2
Mixed salad*	88.06 ± 0.50	1.07 ± 0.01	0.39 ± 0.01	2.98 ± 0.30	0.44 ± 0.07	5.06 ± 0.23	36 ± 2
Heart of palm salad	90.18 ± 0.02	2.35 ± 0.01	0.18 ± 0.02	3.07 ± 0.06	3.64 ± 0.15	0.58 ± 0.01	16 ± 0
Arugula salad	92.23 ± 0.02	1.20 ± 0.01	0.14 ± 0.01	3.20 ± 0.01	3.13 + 0.02	0.10 ± 0.01	14 ± 0

*Cooked; **$n = 2$; ***$n = 3$; legume: potatoes, carrots, corn and peas; ****with no skin, cooked; salad = salad mixed = kanikama crab sticks, tomatoes and mushrooms.

[a] Total dietary fiber.

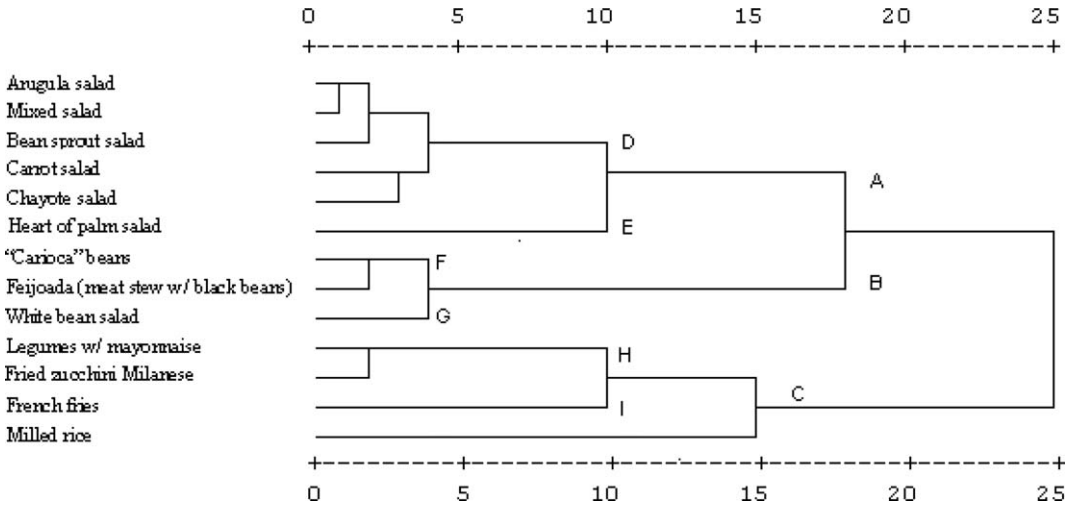

Fig. 3. Dendrogram of the several types of food of restaurant III, obtained through the following variables: moisture, ashes, lipids, proteins, total fiber, total carbohydrates and caloric value.

Group B is broken down into subgroups F and G. Subgroup B consists solely of white beans, which stand out vs. subgroup F because of their higher lipid content and caloric value.

Group C is broken down into three subgroups, one of which consists solely of rice, due to its low content of total fibers (1.42 g/100 g), lipids (1.20 g/100 g) and lower caloric value than the other foods (161 kcal/100 g). The other subgroup, I, consists of French fries and stands out vs. subgroup H (vegetable mayonnaise salad and fried zucchini Milanese) because of its higher total carbohydrate content.

5.4. Restaurant IV

Table 5 data indicates, among the preparations from restaurant IV, that the strawberry pie has a high caloric value (223 kcal/100 g), although strawberries only have 34 kcal/100 g; the rice with mushrooms has a higher lipid content because of the smoked bacon added to its preparation; the rice with vegetables is the least caloric one, because the ingredients (carrots, string beans, tomatoes, peas and Peruvian parsnip) have a low energy value and dilute the total calories of this preparation. Therefore, it is a good alternative for diets limiting calorie intake. Moreover, it has a higher volume of fiber than milled white rice and fiber has the property of increasing the sensation of satiety, therefore helping to control obesity.

From the hierarchical cluster analysis of Fig. 4, one can see that the strawberry pie stands out vs. all the other groups of preparations from restaurant IV, in that it has one of the lowest moisture contents (the moisture content of the milled rice is lower), the highest lipid content and, consequently, the highest caloric value. The other foods are broken down into groups on the basis of their moisture and caloric content.

The common characteristic of the group A foods is to have a moisture content higher than 85%, a protein content lower than 2% and a caloric value of up to 50%. In this group, the eggplant with pimiento stands out for its high fiber content (5.31 g/100 g) and ash content (1.83 g/100 g).

Group B is broken down into two subgroups, C and D. Group C (beans, ''feijoada'', chickpea salad and fried banana Milanese) stands out for its high fiber content (greater than 6 g/100 g).

5.5. Preparations found in the four restaurants

Kiwis are the fruit richest in carbohydrates, lipids, protein and caloric value. Fruit salad is the preparation that contributes the most to the total fiber content. The preparations made with meat (chicken and heart-of-palm pancakes and pasta with Italian sausage) have a similar total fiber content: 3.22% and 3.00%, respectively. Of the various preparations, mayonnaise salad 1 and fried zucchini Milanese have the greatest amount of lipids and, consequently, the higher caloric value. Fried banana Milanese is the food with the highest fiber and carbohydrate content.

Regarding rice-based preparations, in comparing the total fiber content of white rice with the other rice-based preparations, one can say that the mushrooms add virtually nothing to the fiber content, perhaps because they were only used in a small quantity. Furthermore, the information in the literature regarding mushroom fiber content only refers to the uncooked and dehydrated kind rather than to processed mushrooms, which hinders the evaluation; this information is important, because this ingredient is consumed after having been processed.

The rice with vegetables and rice with broccoli preparations have greater total fiber content, a lower carbohydrate value and are less caloric than their white rice and rice with mushrooms counterparts; the latter has the highest protein content.

The values of the composition of the preparations found in the four restaurants indicate that the white rice has a

Table 5
Proximate composition and caloric value of the preparations of restaurant IV

Preparations	Physical chemical composition (g/100 g)				Caloric value		
	Moisture**	Ashes**	Lipids**	Proteins**	TDF[a]	Carbohydrates**	kcal/100 g**
Rice w/vegetables	67.20 ± 0.12	0.96 ± 0.13	1.21 ± 0.08	2.86 ± 0.05	1.86 ± 0.14	25.91 ± 0.05	126 ± 0
Rice w/broccoli*	61.01 ± 0.21	1.67 ± 0.01	3.36 ± 0.01	3.03 ± 0.03	2.14 ± 0.10	28.79 ± 0.17	157 ± 1
Rice w/mushrooms****	58.88 ± 0.23	1.50 + 0.06	4.06 ± 0.03	4.24 + 0.11	1.17 ± 0.11	30.15 ± 0.04	174 ± 1
Milled rice*	54.39 ± 0.12	1.96 ± 0.08	1.44 ± 0.11	3.32 ± 0.13	1.14 ± 0.15	37.75 ± 0.45	177 ± 0
Baked bananas	61.97 ± 0.46	0.87 + 0.01	2.01 ± 0.01	2.67 ± 0.01	10.69 ± 0.88	21.79 ± 048	116 ± 2
"Carioca" beans*	75.37 ± 0.01	1.49 ± 0.06	0.66 ± 0.06	5.30 ± 0.18	7.24 ± 0.04	9.94 ± 0.16	67 ± 0
Feijoada (meat stew w/black beans)	72.41 ± 0.01	2.22 ± 0.07	5.58 ± 0.23	10.04+0.90	6.26 ± 0.10	3.49 ± 0.76	104 ± 0
Kiwi *****	85.55 ± 0.11	0.75 ± 0.01	0.91 ± 0.06	0.96 ± 0.30	2.44 ± 0.25	9.39 ± 0.12	50 ± 0
Strawberry	89.74 ± 0.01	0.45 ± 0.01	0.12 ± 0.01	0.91 ± 0.04	0.56 ± 0.11	7.22 ± 0.06	34 ± 0
Chicken/heart-of-palm pancake	69.38 + 0.20	1.59 ± 0.05	5.71 ± 0.24	1.48 ± 0.15	3.22 ± 0.02	18.62 ± 0.34	132 ± 0
Eggplant ******* w/pimento	86.78 ± 0.01	1.83 ± 0.01	4.83+ 0.10	1.25 ± 0.01	5.31 ± 0.01	0.00	48 ± 1
Chickpeas*	61.77 ± 0.36	1.28 ± 0.01	3.17 ± 0.08	8.80 ± 0.08	7.11 ± 0.15	17.87 ± 0.52	135 ± 1
Radish******	94.33 + 0.01	0.47 ± 0.01	0.38 + 0.01	0.60 ± 0.01	1.02 ± 0.01	3.20 ± 0.03	19 ± 0
String beans/carrots*******	93.51 ± 0.24	0.44 ± 0.01	0.77 ± 0.08	1.26 + 0.17	2.53 ± 0.58	1.49±0.49	18 ± 0
Strawberry pie	56.98 ± 0.54	0.65 + 0.04	12.87 ± 0.25	4.76 ± 0.03	2.75 ± 0.31	21.99 ± 0.30	223 ± 4

*Cooked; **$n = 2$; ***$n = 3$; ****milled rice with bacon; *****with no skin; ******salad with skin; salad******* rice with vegetables: milled rice, carrots, string beans, tomatoes, peas and Peruvian parsnip.
[a] Total dietary fiber.

higher lipid content in restaurants I and II than in restaurants III and IV; additionally, in restaurants I and IV it also has a higher ash content than in restaurants II and III. A variation in moisture content, ranging from 49.75% to 60.98%, was found in these preparations, which can be explained by the cooking process. However, there was lower variability in the fiber and protein content among the four restaurants.

Regarding the preparation of beans, one sees that in restaurant I they had a low protein content (3.49%) as compared to what was found in the other restaurants. Restaurant II has greater lipid content and caloric value, indicating that a greater amount of fat was added in preparing this food, whereas in restaurant IV the beans had a lower lipid content and caloric value than those of the other establishments.

One can also see that the "feijoada" in restaurant I has a high lipid content (9.17%) and caloric value (142 kcal), which is quite different from restaurant III, where this dish had 0.75% of lipids and a caloric value of 85 kcal, offsetting the latter with a carbohydrate content higher than found in the other establishments.

The variability of the moisture, lipid and caloric value results of common foods in the four restaurants is explained by their different processing and the addition of certain ingredients that can influence their end composition.

As for leafy greens, arugula is the food that offers the highest fiber content, at 3.13%; it is also the richest in pro-

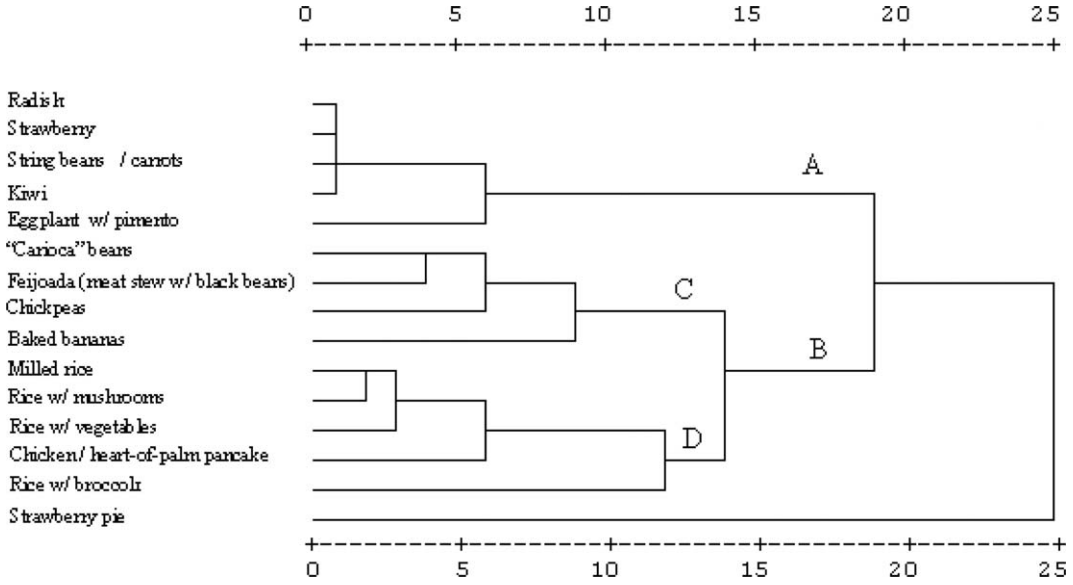

Fig. 4. Dendrogram of the several types of food of restaurant IV, obtained through the following variables: moisture, ashes, lipids, proteins, total fiber, total carbohydrates and caloric value.

tein and caloric value. Concerning uncooked vegetables, tomatoes have the highest fiber content (2.23%). Cooked vegetables, such as string beans and carrots, beetroot, vegetable salads and chayote have similar fiber contents: 2.53%, 2.72%, 2.41% and 2.45%; collard greens, eggplant with pimiento and carrots, have, respectively, 5.44%, 5.31% and 5.19%.

6. Conclusions

Hierarchical cluster analysis (HCA), as applied to the data obtained on the composition of foods in restaurants, was a useful guide for obtaining an overview and conducting a comparative analysis of the several types of food. Because it is easy to carry out with computers, with the use of SPSS, it is recommended that HCA be employed even as an exploratory tool for helping intuition in the analysis of the set of data.

French fries are the most caloric preparation, with considerable total fiber content. White rice is a food that is rich in carbohydrates, with a high caloric value and low fiber content. Of the vegetables analyzed, arugula has the highest protein and total fiber content, whereas lettuce is the one with the smallest amount of these nutrients. Beans constitute the chief source of dietary fiber and have a low caloric value. The more caloric preparations are French fries and fried zucchini Milanese, both from restaurant III. The type of processing used in the preparation of the foods found in the four restaurants may be responsible for the variability of results between the establishments that were studied regarding lipid contents, the caloric value of rice and beans, and the protein and lipid content of ''feijoada'' beans and meat stew.

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