Food Chemistry 193 (2016) 128–133

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Short communication

Impact of dietary fiber energy on the calculation of food total energy value in the Brazilian Food Composition Database

Elizabete Wenzel de Menezes [a,b,c,*,1], Fernanda Grande [a,b,c], Eliana Bistriche Giuntini [a,b,c], Tássia do Vale Cardoso Lopes [a,b,c], Milana Cara Tanasov Dan [a,b,c], Samira Bernardino Ramos do Prado [a,b,c], Bernadette Dora Gombossy de Melo Franco [a,b,c], U. Ruth Charrondière [d], Franco Maria Lajolo [a,b,c,1]

[a] *Department of Food and Experimental Nutrition, Faculty of Pharmaceutical Sciences, University of São Paulo (USP), São Paulo, SP, Brazil*
[b] *Food and Nutrition Research Center (NAPAN) – USP, São Paulo, SP, Brazil*
[c] *Food Research Center (FoRC/CEPID/FAPESP), São Paulo, SP, Brazil*
[d] *FAO, Rome, ESN, Viale delle Terme di Caracalla 1, 00153 Rome, Italy*

ARTICLE INFO

Article history:
Received 17 December 2013
Received in revised form 19 December 2014
Accepted 7 January 2015
Available online 20 January 2015

Keywords:
Dietary fiber energy
Food composition database
Energy content
Energy calculation

ABSTRACT

Dietary fiber (DF) contributes to the energy value of foods and including it in the calculation of total food energy has been recommended for food composition databases. The present study aimed to investigate the impact of including energy provided by the DF fermentation in the calculation of food energy. Total energy values of 1753 foods from the Brazilian Food Composition Database were calculated with or without the inclusion of DF energy. The energy values were compared, through the use of percentage difference (D%), in individual foods and in daily menus. Appreciable energy D% ($\geqslant$10) was observed in 321 foods, mainly in the group of vegetables, legumes and fruits. However, in the Brazilian typical menus containing foods from all groups, only D% <3 was observed. In mixed diets, the DF energy may cause slight variations in total energy; on the other hand, there is appreciable energy D% for certain foods, when individually considered.

1. Introduction

National food composition databases must contain information about energy value and chemical composition of foods that are produced and/or consumed in a certain country. Food energy is determined as the sum of energy values of each macronutrient, which is calculated through the use of conversion factors for nutrients that potentially provide energy to the human body (mainly carbohydrates, proteins, lipids and alcohol) (Charrondière, Chevassus-Agnes, Marroni, & Burlingame, 2004). Energy values are generally expressed as metabolizable energy, defined as the food energy that is available for energy expenditure (heat production) and weight gain. This concept is used in most food composition databases and in food labeling, and it is compatible with the definition of intake recommendation (Warwick, 2005).

However, the Food and Agriculture Organization of the United Nations (FAO) recommends that the energy provided by dietary fiber (DF) fermentation, which is equal to approximately 8 kJ/g, should also be included in the calculation of total energy value (FAO, 2003). The value of 8 kJ/g is based on the fact that around 70% of DF is fermented in the colon and that a part of the energy resulting from this process is lost in the form of gas and in the feces (bacterial biomass) (FAO, 2003; Elia & Cummings, 2007). Most part of the short-chain fatty acids produced during the fermentation process is absorbed in the colon and metabolized by human tissues (Elia & Cummings, 2007).

Since 2008, the European Union established that DF must be included in the calculation of food total energy value for nutritional labeling (European Commission, 2008), which caused changes in some food composition databases. In Brazil, the legislation about mandatory nutritional labeling does not demand this inclusion (Brazil, 2003a). The Brazilian resolution follows the same definitions adopted by the country members of the Southern Common Market Agreement (MERCOSUL) and the nutritional labeling can be provided by food composition databases.

The Brazilian Food Composition Database (BFCD) was created in 1998 and it has been continuously updated (Menezes, Giuntini,

* Corresponding author at: Depto. Alimentos e Nutrição Experimental, Faculdade de Ciências Farmacêuticas, Universidade de São Paulo, Av. Prof. Lineu Prestes, 580, Butantan, 05508-000 São Paulo, SP, Brazil. Tel.: +55 11 3091 3624; fax: +55 11 3815 4410.

E-mail address: wenzelde@usp.br (E.W.d. Menezes).

[1] Coordinators of BRASILFOODS.

http://dx.doi.org/10.1016/j.foodchem.2015.01.051
0308-8146/

Dan, & Lajolo, 2009). This database is currently being reformulated under the coordination of Brazilian Network of Food Data Systems (BRASILFOODS), together with the Food and Nutrition Research Center (NAPAN) and Food Research Center (FoRC/CEPID/FAPESP).

In order to comply with the guidelines adopted by other countries and aiming to harmonize databases in relation to energy values, it is necessary to include the DF energy in the calculation of food total energy values in the BFCD. Regarding food carbohydrates, the BFCD considers only the available ones in the calculation of energy; therefore, the inclusion of energy provided by DF may cause an increase in the calculated energy value of foods (Westenbrink, Brunt, & Kamp, 2013). The present work aims to evaluate the impact of including the energy provided by DF fermentation in the calculation of food total energy value in Brazil.

2. Methodology

The following analytical methods accepted for proximate composition data and conversion factors were adopted by the BFCD: moisture content based on weight loss after the sample was heated in a vacuum oven at 70 °C or in an oven at 105 °C; protein by total nitrogen, obtained by micro-Kjeldahl or similar (considering nitrogen conversion factors of FAO, 1973); lipids by Soxhlet or acid hydrolysis; ash by incineration in muffle furnace at 550 °C (Horwitz & Latimer, 2006). Total dietary fiber by enzymatic–gravimetric (Lee, Prosky, & Vries, 1992) or nonenzymatic–gravimetric method (for foods with low starch content) of AOAC (Li & Cardozo, 1992). Available carbohydrates were calculated by difference [100 − (moisture + ash + protein + fat + dietary fiber)]. Data were expressed as g/100 g in wet weight. Only data with the sum of the proximate composition (moisture, ash, available carbohydrate, protein, lipid and dietary fiber) falling within the range 97–103% of analytical sample weight was considered acceptable (Greenfield & Southgate, 2003) and included in the database. Energy conversion factors: protein 17 kJ/g; fat 37 kJ/g; available carbohydrates 17 kJ/g; dietary fiber 8 kJ/g and alcohol 29 kJ/g (FAO, 2003).

2.1. Percentage difference (D%)

The previous energy values (without considering energy provided by DF) were compared to the new ones (considering energy from DF fermentation) according to the following equation:

$$D\% = [(\text{new energy value} - \text{previous energy value})/\text{previous energy value}] \times 100.$$

The D% was considered appreciable when $\geqslant$10% (Padovani, Lima, Colugnati, & Rodriguez-Amaya, 2007; Summer et al., 2013).

In order to evaluate the impact of different calculations of total energy value, the D% was calculated in the BFCD foods individually and in three theoretical complete menus.

2.2. Theoretical daily menus

An estimate of energy intake was done based on theoretical daily menus, that are typically consumed in three different regions of Brazil. The menus were based on data from a Brazilian household budget survey carried out between 2008 and 2009 (IBGE (Brazilian Institute of Geography, 2011) and on the Dietary Guidelines for the Brazilian Population (Brazil, 2014).

Three typical menus were created, each one simulating 4 daily meals of the urban Brazilian population (breakfast, lunch, in-between meal and dinner). The theoretical menus contained foods that are routinely consumed by the Brazilian population, considering the portions recommended by the Brazilian legislation of nutritional labeling in a diet of 8420 kJ (Brazil, 2003b).

- *Southeast Region:* Breakfast – milk, coffee, sugar, bread, butter, cheese; lunch – rice, *feijoada* (made of black beans, sausage and pork meat), *farofa* (made with manioc flour), kale and orange; in-between meal – cheese bread and coffee; dinner – noodles with tomato sauce, roasted chicken, lettuce, papaya.
- *Midwest Region:* Breakfast – milk, coffee, sugar, coconut cake, cheese, papaya; lunch – rice, beans, beef, salad with leaves and tomato, pineapple; in-between meal – milk, coffee, sugar, corn cake; dinner – rice, beans, minced meat with carrots and green beans.
- *Northeast Region:* Breakfast – milk, sugar, *tapioca* (similar to a crepe, made with manioc starch and water), banana; lunch – rice, beans, fish with sauce, lettuce, *cocada* (dessert made with coconut and sugar); in-between meal – milk, coffee, sugar, *cuscuz* (made with corn flour); dinner – rice, beans, grilled chicken breast, squash, *goiabada* (dessert made with guava and sugar).

2.3. Statistical analysis

Pearson's correlation coefficient was calculated using the software Statistica 11.0 (StatSoft Inc., Tulsa, OK, USA) in order to verify the relation between DF content and energy D% of foods from the BFCD after the inclusion of energy provided by DF fermentation.

3. Results and discussion

The BFCD currently contains information on proximate composition of 1753 foods. In 321 foods appreciable percentage difference (D% $\geqslant$ 10) was found between previous (without considering energy from DF) and new (considering energy from DF fermentation) energy values. As expected, a large number of foods belonging to DF-source groups presented appreciable energy D%, which was observed in 152 out of 228 foods belonging to the group of vegetables, in 55 out of 83 foods from the group of legumes, followed by 79 out of 238 foods from the group of fruits. However in the case of the group of cereals, an appreciable D% was observed only in 12 out of 247 foods. Among the foods that presented the highest D% after including DF energy, it is possible to mention: jambo (*Eugenia malaccencis* L.) (D% = 97) and cooked jalo beans (*Phaseolus vulgaris* L.) (D% = 66). On the other hand, it is possible to observe little D% in foods such as raw green pepper (*Capsicum annuum* L.) (D% = 6), raw yellow manioc (*Manihot esculenta* Crantz) (D% = 3), *in natura* palmer mango (*Mangifera indica* L.) (D% = 4) and *in natura* watermelon (*Citrullus lanatus* Thunb) (D% = 1).

Table 1 shows the energy D% found in some foods that are consumed by the Brazilian population. It is possible to observe great variation in foods belonging to the same group. In the group of cereals, cereal bars correspond to the majority of foods that present appreciable D%. In this case, energy D% varied from 2% to 14% due to differences in the DF content and hence in the available carbohydrate contents, which is calculated by difference. The same was observed in two different breakfast cereals: one presented 49.2 g of available carbohydrates and 35 g of DF, while the second one presented 73.9 g of available carbohydrates and 9.3 g of DF, with energy D% of 26% and 5%, respectively (Table 1). Therefore, the DF content can affect the energy value in foods that contain large quantities of this component. It is important to highlight that, in the case of some refined and whole-grain products, although they present great variation in DF content, the D% was similar. This was verified in polished rice (D% = 2) and whole-grain rice