International Food Research Journal 21(4): 1675-1681 (2014)
Journal homepage: *http://www.ifrj.upm.edu.my*

Functional capacity of flour obtained from residues of fruit and vegetables

Roberta, M. S. A., Mariana, S. L. F. and *Édira, C. B. A. G.

Department of Food Technology, Nutrition School, Food and Nutrition Master Program, Federal University of Rio de Janeiro State- UNIRIO. Av. Pasteur, 296, Urca, 22290-240, Rio de Janeiro, Brazil

Article history

Received: 30 December 2013
Received in revised form: 12 February 2014
Accepted: 13 February 2014

Keywords

Fruits and vegetables
Residue flour
Bowel function
Constipation
Dietary fibres
Antioxidant capacity

Abstract

Food residues represent a rich source of functional compounds such as dietary fibres that may improve bowel function and help to overcome constipation. In this study, fruit and vegetable residue (FVR) flour was evaluated according to the antioxidant activity, dietary fibres and functional capacity through the bowel function improvement. Sixteen female volunteers answered a survey after daily consumption of FVR flour (10 g) for 10 days. The methanolic extract showed a noteworthy antioxidant capacity (61% DPPH inhibition). The insoluble dietary fibres represented 80% total dietary fibres (48.4%). The daily consumption of FVR flour improved constipation symptoms in 87.5% volunteers. After 3 days, 70% volunteers presented significant progress in the bowel function. Body mass index presented a positive relation with constipation symptoms after the consumption of FVR flour. Remarkable dietary fibre content associated with the antioxidant capacity appointed to the strong potential of FVR to overcome constipation and to add nutritional value.

Introduction

In the last decades, the food industry has been marked by the large volume of waste produced (FAO, 2011). Fruits and vegetables are extensively processed generating a large amount of residue which is frequently discarded. However, agro-industrial residues obtained from fruits and vegetables processing represent a nutritional, inexpensive and environmentally friendly raw material. These residues have called attention to be considered a good source of bioactive compounds, such as polyphenols, carotenoids, vitamins and dietary fibres (Figuerola *et al*., 2005; Makris *et al*., 2007; Ajila and Prasada Rao, 2013).

The bioactive compounds have received increasing attention due to their potential role in the prevention and treatment of human diseases through a variety of mechanisms, mainly related to gastrointestinal health and prevention of chronic degenerative diseases (ADA, 2008; Saura-Calixto and Goñi, 2009; Chong *et al*., 2010; Sun-Waterhouse, 2011). Due to these health benefits, there is a growing demand for functional food and ingredients by consumers (Figuerola *et al*., 2005). Among the functional compounds, several recent researches have focused on the physiological effects resulting from the human consumption of a wide variety of dietary fibres (Papathanasopoulos and Camilleri, 2010; Montella *et al*., 2013; Waitzberg *et al*., 2013). In an exhaustive study, about the relation between fibre intake and constipation, were found that increasing fibre intake may represent an important, inexpensive and feasible therapeutic measure for this widespread digestive complaint (Dukas *et al*., 2003).

The prevalence of constipation in the worldwide general population can reach 79% being more prevalent and symptomatic in women than men (Mugie *et al*., 2011). Constipation is a symptom that, although caused by many different disorders, is mostly attributable to functional constipation, which is not associated to organic and anatomic causes or intake of medication. Lack of dietary fibre is known to contribute to constipation, and the primary therapy is based on the increase of fibre intake, along with lifestyle modifications such as improved hydration (Grigelmo-Miguel *et al*., 1999; Suares and Ford, 2011; Yang *et al*., 2012).

Dietary fibre can be divided into two categories: the water-soluble and insoluble fractions, presenting different properties. The SDF, such as pectin and gums, dissolves in water forming a gel and is associated with the reduction of cholesterol in blood (Chao *et al*., 1993). In addition, the SDF can be fermented by bacteria in the colon in a greater extent than IDF, reducing intestinal glucose absorption (Montella *et al*., 2013). The insoluble part formed by cellulose, hemicelluloses and lignin is related to both water absorption and intestinal regulation.

In terms of health benefits, a balanced ratio of 70-50% insoluble and 30-50% soluble dietary fraction is considered satisfactory. In fruits, the ratio between

*Corresponding author.
Email: *ediracba@analisedealimentos.com.br*
Tel: +55 21 2542 7418; Fax +55 21 2542 7294

IDF and SDF fractions is more balanced compared to cereal (Saura-Calixto, 1993; Ajila and Prasada Rao, 2013). Although extensively used as fibre source in food products, the SDF in cereal outer layer fractions attained only about 3% (dry basis) (Griguelmo-Miguel *et al*., 1999). Thus, plant residues have substantial amounts of total and soluble dietary fibre and may represent a suitable fibre source for use as food ingredient (Nawirska and Kwasniewska, 2005). In fruits and vegetables, the insoluble fraction, mainly represented by cellulose, is resistant to digestion and adsorption in the human small intestine, presenting a complete or partial fermentation in the large intestine, contributing to the acceleration of intestinal transit time (Nawirska and Kwasniewska, 2005; Suares and Ford, 2011; Ajila and Prasada Rao, 2013).

In addition, pomace, peel and seed fractions of some fruits possess higher antioxidant activity than the pulp fractions. Further attention has been paid to these fractions, since natural antioxidants have been associated with reduced risk of chronic diseases and the protection of essential molecules against damage (Guo *et al.*, 2003; Babbar *et al.*, 2011). A recent study conducted in vivo showed that the aqueous extract of passion fruit can reduce oxidative stress (Silva *et al.*, 2013).

Despite the noticeable benefits and recommendations, the intake of plant foods remains low and, consequently, both dietary fibre and antioxidant compounds are usually deficient in most diets around the world (Saura-Calixto and Goñi, 2009). Since plant residues are rich in essential nutrients and available for the population consumption, they have been applied as food ingredients in the development of functional food products (Ayla-Zavala *et al*., 2011; Sun-Waterhouse, 2011; Ferreira *et al*., in press). In this way, the aim of this study was to characterize the flour obtained from residues of whole fruit and vegetable processing (FVR flour) in terms of dietary fibre content (SDF and IDF) and antioxidant capacity (DPPH assay) and evaluate its functionality through the improvement of bowel function in adult women with constipation.

Materials and Methods

Fruit and vegetable residue (FVR) flour processing

The FVR flour was formulated based on the solid residue obtained after preparation of isotonic beverage by processing whole fruits and vegetables (Martins *et al*., 2011). The FVR flour was composed by the following species: Selecta orange (*Citrus sinensis*), passion fruit (*Passiflora edulis*), watermelon (*Citrullus lanatus*), lettuce (*Lactuca sativa*), courgette (*Cucurbita pepo*), carrot (*Daucus carota*), spinach (*Spinacea oleracea*), mint (*Mentha* sp), taro (*Colocasia esculenta*), cucumber (*Cucumis sativus*) and rocket (*Eruca sativa*). The FVR flour was prepared as previously shown by Ferreira *et al.* (in press).

Determination of DPPH radical scavenging activity

Flour samples (500 mg) were extracted with 40 mL methanol (100%), at room temperature (RT) for 60 minutes. After centrifugation at 1.500 x g for 15 minutes, the supernatant obtained were transferred to 100 mL volumetric flask and completed with distilled water. The antioxidant capacity of the flour was analyzed by DPPH radical scavenging activity, with minor modifications (Brand-Williams *et al*., 1995). In the dark, aliquots of 1.0 mL of the extract were transferred to tubes containing 2.0 mL of 0.06 mM DPPH in methanol and then homogenized. The standard curve was established from 10 µM to 60 µM DPPH in methanol. The absorbance was measured in triplicate at 517 nm after 60 minutes. The radical scavenging activity of FVR flour was expressed in terms of inhibition percentage of DPPH calculated according to the following equation, where control absorbance was the DPPH solution absorbance:

$$\% \text{ Inhibition} = \frac{(\text{control absorbance} - \text{sample absorbance}) \times 100}{(\text{control absorbance})}$$

Total, soluble and insoluble dietary fibre contents

Soluble (SDF) and insoluble dietary fibre (IDF) fractions were analyzed in triplicate, according to the AOAC (2000) Method 991.43 based on the enzymatic-gravimetric procedure (Prosky *et al*., 1984; AOAC, 2000). Total dietary fibre (TDF) was calculated by the sum of soluble and insoluble dietary fibres.

Evaluation of functional capacity of FVR flour

The functional capacity was evaluated by the effect of daily consumption of FVR flour in the improvement of bowel function in adult women with intestinal constipation. Before selecting, female volunteers were submitted to a questionnaire to evaluate inclusion in the group of interest. The evaluation of constipation (dependent variable) was performed according to the Rome II criteria (Drossman *et al*., 2000). The volunteers must have three or more of the criteria fulfilled in the last three months. The independent variables were the clinical features: age (20 to 57 years) and body mass index (BMI) (20 to 29 $kg.m^{-2}$). Exclusion criteria were personal history of colorectal cancer, ulcerative colitis or Crohn's disease and use of synthetic laxatives.

Evaluation of consumption of FVR flour on bowel function

The study protocol was approved by the Ethics Committee of the Federal University of the Rio de Janeiro State with Certificate of Presentation for Ethics Appreciation number 0009.0.313.000-08. Written informed consent was signed by all participants in accordance with the Ethics Committee of the University. The selected 16 female volunteers consumed on a daily basis for 10 days, 10 g of FVR flour and answered a survey which assessed the frequency of bowel movements, the time that the FVR flour was consumed like with which food it was consumed and changes in lifestyle during the period. It was not request that the volunteers alter their diet in any stage of the research, and the FVR flour was consumed along with any food.

Statistical analyses

All analyzes were performed in triplicate and the results presented as mean followed by standard deviation (SD). Constipation symptoms improvement was expressed as a day score (≤ Day 3 and Day 4 - Day 10) as well as the number of bowel movements (evacuations). Comparisons between two groups were performed by Tukey's test and the significance threshold was set at 5% ($P < 0.05$). The statistical analysis of the results was performed by the software program XLSTAT 2012, Addinsoft.

Results and Discussion

Fruit and vegetable residues, consisting of stalks, peels, seeds, stems and pomace, although largely wasted, are important sources of nutrients and have been used to develop new products with enhanced functional and nutritional value (Figuerola *et al*., 2005; Sun-Waterhouse, 2011; Ferreira *et al.*, in press). In a recent study conducted by our research group, the FVR flour obtained was incorporated into cereal bars and biscuits formulations. The chemical, microbiological and sensorial results of the designed products attested the aptness for the use of FVR flour in food products as a new low-caloric and functional raw material (Ferreira *et al*., in press). Remarkably, the FVR flour showed high contents of available carbohydrates (53%), crude fibre (21.5%), and significant protein (9.5%) and lipid (5%) contents and were very similar to the proximate composition of fibre concentrates from apple pomace and citrus peel (Figuerola *et al*., 2005). Altogether, in the present study the FVR flour (Figure 1) was evaluated as potential functional product applied in the improvement of gastrointestinal disorders.

Table 1. Total, soluble and insoluble dietary fibre content and inhibition percentage of DPPH of FVR flour

Parameters	Values (%)
Soluble dietary fiber	9.56 ± 0.88
Insoluble dietary fiber	38.82 ± 0.55
Total dietary fiber	48.42 ± 1.43
% Inhibition of DPPH.	60.98 ± 0.56

Total, soluble and insoluble dietary fibers are expressed on dry matter basis. All data are the mean ± SD of three replicates.

Figure 1. Fruit and vegetable residue (FVR) flour

Total, soluble and insoluble dietary fibre contents and Inhibition percentage of DPPH

As expected, the TDF content (Table 1) was significantly higher than the crude fibre content of the FVR flour (21.52 ± 1.61%) (Ferreira *et al.*, in press). Indeed, the crude fibre content gives just a relative idea of the total amount of fibres and may underestimate the true amount from 2 to 16 fold (DeMan, 1999). This is due to the steps performed on the crude fibre determination, where the most part of soluble fraction is lost during the acid digestion to eliminate interfering components such as proteins and carbohydrates. To receive claim of high fibre content, food should have at least 6 g of dietary fibre per 100 g (CODEX, 2009). Thus, FVR flour can be considered a high fibre product, which may help supply the daily requirement of fibre that is 25 g dietary fibre for adult women and 38 g for adult men (IOM, 2002).

The TDF content of FVR flour (48.42% DM) was similar to those reported on grape seed flour (47%) (Özvural and Vural, 2011), raw mango peels (41%) (Ajila and Prasada Rao, 2013) and slight higher than fibre concentrates extracted of peach (30-36% DM) (Grigelmo-Miguel *et al*., 1999) and grapefruit peel (44.2% DM) (Figuerola *et al*., 2005). Nonetheless, the TDF of the FVR flour was considerably lower than fruit and vegetable pomace, which ranged between 54-99% DM (Nawirska and Kwaśniewska, 2005).

The content of insoluble fibre (38.82% DM) of FVR flour represented 80% of total dietary fibres. Compared to previous studies, this IDF content was similar to that reported on grapefruit peel (37% DM) (Figuerola *et al*., 2005) and higher than that of raw mango peels (28%) (Ajila and Prasada Rao, 2013) and peach fibre concentrates (20-23% DM) (Grigelmo-Miguel *et al*., 1999). Moreover, the insoluble fraction in FVR flour was also higher for vegetable pomace, which ranged 18% to 35% DM (Nawirska and Uklańska, 2008). Nevertheless, the same authors found superior values (34% to 98% DM) when another method for the determination of dietary fibres fractions were used (Nawirska and Kwaśniewska, 2005), showing the strong influence of the chosen method in these determinations (Li *et al*., 2002). In this study, the method used was the same adopted for nutrition labelling of dietary fibre by the U.S. Food and Drug Administration (AOAC Method 991.43) (AOAC, 2000).

Fibre derived from fruit (pulp) and vegetables (leaves and flowers) has been described to contain a significant proportion of soluble dietary fibre compared to other foods. However, the proportion of IDF to SDF varies according to the species and the part of the plant in which it was extracted. The vegetable residues (i.e. pomace, stem and seeds) generally have higher proportion of IDF mainly due to the lignin and cellulose contents (Li *et al*., 2002; Figuerola *et al.*, 2005; Nawirska and Kwaśniewska, 2005). In this study, even if the SDF fraction presented low levels than the previous cited works (Figuerola *et al.*, 2005; Nawirska and Kwaśniewska, 2005; Nawirska and Uklańska, 2008; Ajila and Prasada Rao, 2013) the ratio IDF/SDF was about 4:1 remaining attractive in terms of functionality. It is interesting to note, that despite the quite low level of SDF, the FVR flour presented a high water holding capacity (7.43 g water g^{-1} FVR flour DM) (Ferreira *et al*., in press), which can be associated with the high levels of IDF (Figuerola *et al.*, 2005).

Scavenging activity of FVR flour was expressed as inhibition percentage of DPPH and was found in the range of antioxidant activity (43 to 83%) reported in a previous study conducted on several plant residues, such as kinnow seed, kinnow peel, litchi seed, litchi pericarp, grape seed and banana peel (Babbar *et al.*, 2011). In addition, the methanolic extract of the FVR flour presented higher antioxidant activity than fruit residues obtained from pineapple and passion fruit (20-25%) (Oliveira *et al*., 2009). The FVR flour presented promising results as a natural antioxidant and may even be evaluated as an alternative to synthetic antioxidant. Natural antioxidants compounds increase the food stability not only by preventing lipid peroxidation, but also protecting biomolecules from oxidative damage (Babbar *et al*., 2011).

Polyphenols, soluble vitamins C and B, vitamins A, B and E and also carotenoids are the most abundant antioxidants in fruits and vegetables. However, by applying a sequential extraction procedure, Pellegrini *et al.* (2007) showed that vitamin C and phenolic compounds present in water and acetone extracts were the main contributors to the strong antioxidant activity in some fruits and vegetables. These authors suggested that the total antioxidant capacity of food samples are affected by the solvents used during extraction. Since the FVR flour presented important lipid content, it can be crucial to ensure the complete recovery of antioxidants compounds in a sequential extraction procedure. Indeed, the synergistic effect of these antioxidants in combination with other compounds, such as dietary fibre, may contribute to the protective effects of fruits and vegetables against disease (Saura-Calixto and Goñi, 2009). The FVR flour presented a high antioxidant activity added to significant dietary fibre content, which support its functional properties.

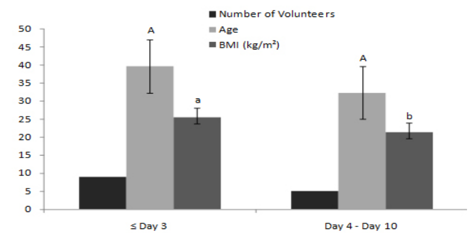

Figure 2. Number of volunteers, mean age and BMI (kg/ m^2) who showed improvement of constipation in less than 3 days of flour consumption ($\leq$ Day 3) and after 4 days (Day 4 - Day 10). Means followed by different letter means significant difference ($p > 0.05$).

Functional capacity evaluation of RVF flour

In the Figure 2 is represented the number of volunteers who reported constipation symptoms improvement during the daily consumption of the FVR flour. Over the 10 days of the evaluation of bowel function, 87.5% of the volunteers reported a significant improvement in constipation symptoms without changing the habitual diet. Among them, about 70% showed improvement in just 3 days of consumption ($\leq$ 3 Days). These findings clearly suggest that the daily use of the flour may improve symptoms of constipation within a week. The improvement can be directly related to the high total and insoluble dietary fibre content in the FVR flour. As shown before, fruit and vegetable residues (peels, seeds, stems, etc.) are rich sources of insoluble fibre (cellulose and hemicelluloses) and the fibre undergoes minimal change in the digestive tract and shortens colonic transit, causing an increase in the faecal mass and improving the symptoms of constipation (Bijkerk *et al.*, 2004; Ajila and Prasada Rao, 2013).

Low fibre intake is commonly associated with a delay in intestinal transit time. In an exhaustive study conducted with adult women was found that fibre intake was inversely associated with low bowel

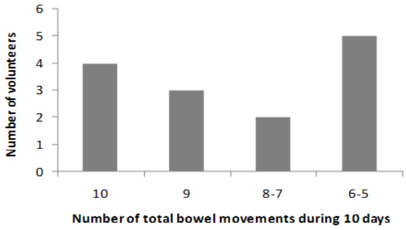

Figure 3. Number of bowel movements during the 10 days of daily consumption of the FVR flour

movement frequency (Dukas *et al.*, 2003). The dough produced mainly from insoluble fibre, or by increasing the microbial mass is required to provide a normal evacuation. Thereby, the increase in the daily intake of insoluble fibre can increase stool weight, promoting normal laxation (Marlett *et al.*, 2002; Slavin, 2005).

In this study, the variation of the age of the volunteers had no influence on the improvement in constipation observed during the FVR flour consumption (Figure 2). However, it was found that the average of body mass index (BMI) showed significant difference between the groups (Figure 2) and the group with higher mean BMI showed faster response (less than 3 days) in constipation symptoms after the consumption of FVR flour. Adults who are overweight have, generally, diets with high energy density and low in dietary fibre (Delgado-Aros *et al.*, 2004). The association between BMI and constipation is not yet clear, however, it can be suggested that the fibre inclusion, such as by the consumption of FVR based flour, in the diet of individuals with reduced consumption would benefit in a faster way than in individuals with adequate fibre intake.

Constipation is also attributed to abnormal consistency of stools, sensation of incomplete evacuation, sensation of obstruction or anorectal blockage and manual manoeuvres to facilitate defecation. Drawn up in 2006, the Rome III criteria include all these information in diagnosing constipation (Burgers *et al.*, 2012; Waitzberg *et al.*, 2013). When applying the Rome II criteria, the exclusion of such information may be considered too restrictive and the requirement that only two of the six symptoms also very permissive to accurately identify those with constipation (Pare *et al.*, 2001). Usually constipation is defined as less than 3 bowel movements per week. Generally, stool weight is significantly increased by adding sources of insoluble fibre to the diet, and thereby normalizes bowel function in patients with constipation (Chen *et al.*, 1998; ADA, 2008). Most part of volunteers (n = 10) presented between 5 to 9 bowel movements during the 10 days analyzed (Figure 3). This result is consistent with those recent reported in a meta-analysis study (Yang *et al.*, 2012). These authors related a significant increase in the number of stools per week in the group submitted to the fibre based diet. Even if positive trends in favour of dietary fibre group have been showed, the effect of dietary fibre on different grades of constipation can be different.

Conclusion

Fruit and vegetable residue flour, formulated in order to promote the use of residues from industrial processing, represents a rich source of dietary fibre with a suitable IDF to SDF ratio and can be used in the food products development of added nutritional value. The flour promoted a prompt increase in the number of bowel movements in adult women volunteers. A prominent antioxidant activity with similar to higher values than those reported in several plant residues were found in the FVR flour. Further studies are being conducted to identify the functional compounds involved in the radical scavenging activity and to establish their bioavailability.

References

Ajila, C. M. and Prasada Rao, U. J. S. 2013. Mango peel dietary fibre: Composition and associated bound phenolics. Journal of Functional Foods 5(1): 444-450.

American Diabetes Association (ADA) 2008. Standards of Medical Care in Diabetes – 2008. Diabetes Care 2008; 31: 12-54.

AOAC. 2000. Association of Official Analytical Chemistry. Official Methods of Analysis, 16th ed. AOAC International, Gaithersburg, MD, USA.

Babbar, N., Oberoi, H. S., Uppal, D. S. and Patil, R. T. 2011. Total phenolic content and antioxidant capacity of extracts obtained from six important fruit residues. Food Research International 44(1): 391–396.

Bijkerk, C. J., Muris, J. W. M., Knottnerus, J. A., Hoes, A. W. and De Wit, N. J. 2004. Systematic review: the role of different types of fibre in the treatment of irritable bowel syndrome. Alimentary Pharmacologyand Therapeutics 19(3): 245–251.

Brand-Williams, W., Cuvelier, M. E. and Berset, C. 1995. Use of a Free Radical method to evaluate antioxidant activity. Food Science and Technology-Lebensmittel-Wissenschaft and Technologie 28(1): 25–30.

Burgers, R., Levin, A. D., Di Lorenzo, C., Dijkgraaf, M. G. W. and Benninga, M. A. 2012. Functional defecation disorders in children: Comparing the Rome II with the Rome III criteria. Journal of Pediatrics 161(4): 615-620.

Chao, E. S. M., Kakis, G., Chen, S., Bryson, W. L. and Fulgoni III, V. L. 1993. Dose response to soluble fibre from psyllium in cholesterol lowering in the hamster. Nutrition Research 13(6): 677-689.

Chen, H. L., Haack, V. S., Janecky, C. W., Vollendorf, N. W. and Marlett, J. A. 1998. Mechanisms by which wheat bran and oat bran increase stool weight in humans. American Journal of Clinical Nutrition 68(3): 711-719.

Chong M. F., Macdonald R. and Lovegrove J. A. 2010. Fruit polyphenols and CVD risk: A review of human intervention studies. The British Journal of Nutrition 104(3): 28-39.

CODEX 2009. Report of the 30th session of the codex committee on nutrition and foods for special dietary uses. ALINORM 09/32/26.

Delgado-Aros, S., Locke, G. R., Camilleri, M., Talley, N. J., Fett, S., Zinsmeister, A. R., and Melton, L. J. 2004. Obesity is associated with increased risk of gastrointestinal symptoms: a population-based study. The American Journal of Gastroenterology 99(9): 1801-1806.

Deman, J. M. 1999. Principles of Food Chemistry. 3th ed. Aspen Publishers.

Drossman A. D., Corazziari E., Talley N. J., Thompsom W. G. and Whitehead W. E. editors. (2000). Rome II: the functional gastrointestinal disorders. 2a ed. p. 351-432. McLean (VA): Degnon Associate.

Dukas, L., Willett, W. and Giovannucci, E. 2003. Association between physical activity, fibre intake, and other lifestyle variables and constipation in a study of women. The American Journal of Gastroenterology 98(8): 1790-1796.

Ferreira M. S. L., Santos M. C. P., Moro T. M. A., Basto G. J., Andrade R. M. S. and Gonçalves, E. C. B. A. 2013. Formulation and characterization of functional foods based on fruit and vegetable residue flour. Journal of Food Science and Technology, DOI: 10.1007/s13197-013-1061-4.

Figuerola, F., Hurtado, M. L., Estévez, A. M., Chiffelle, I. and Asenjo, F. 2005. Fibre concentrates from apple pomace and citrus peel as potential fibre sources for food enrichment. Food Chemistry 91(3): 395-401.

Food and Agriculture Organization of the United Nations 2011. Global food losses and food waste. Study conducted for the International Congress Save Food at Interpack 2011. Düsseldorf, Germany.

Grigelmo-Miguel N. G, Gorisnstein S. and Belloso O. M. 1999. Characterization of peach dietary fibre concentrates as food ingredient. Food Chemistry 65(2): 175-181.

Guo C., Yang J., Wei J., Li Y., Xu J. and Jiang Y. 2003. Antioxidant activities of peel, pulp and seed fractions of common fruits as determined by FRAP assay. Nutrition Research 23(12): 1719-1726.

Institute Of Medicine 2002. Energy. In: Dietary Reference Intakes for energy, carbohydrate, fibre, fatty acids, cholesterol, protein, and amino acids. Washington, D.C.: The National Academy Press.

Li, B. W., Andrews, K. W. and Pehrsson, P. R. 2002. Individual sugars, soluble and insoluble dietary fibre contents of 70 high consumption foods. Journal of Food Composition and Analysis 15(6): 715-723.

Makris, D. P., Boskou, G. and Andrikopoulos, N. K. 2007. Polyphenolic content and *in vitro* antioxidant characteristics of wine industry and other agri-food solid waste extracts. Journal of Food Composition and Analysis 20(6): 125-132.

Marlett, J. A. 1992. Content and composition of dietary fibre in 117 frequently consumed foods. Journal of American Diet Association 92(2): 175-186.

Marlett, J. A., Mcburney, M. I. and Slavin, J. L. 2002. Position of the American Dietetic Association: Health implications of dietary fibre. Journal of the American Dietetic Association 102(7): 993-1000.

Martins R. C., Chiapetta S. C., Paula F. D. and Gonçalves E. C. B. A. 2011. Evaluation isotonic drink fruit and vegetables shelf life in 30 days. Brazilian Journal of Food and Nutrition 22(4): 623-629.

Montella, R., Coïsson, J. D., Travaglia, F., Locatelli, M., Bordiga, M., Meyrand, M., Barile, D. and Arlorio, M. 2013. Identification and characterisation of water and alkali soluble oligosaccharides from hazelnut skin (*Corylus avellana* L.). Food Chemistry 140(4): 717-725.

Mugie S. M.; Benninga M. A. and Di Lorenzo C. 2011. Epidemiology of constipation in children and adults: a systematic review. Best Practice Research Clinical Gastroenterology 25(1): 3-18.

Nawirska A. and Uklańska C. 2008. Waste products from fruit and vegetable processing as potential sources for food enrichment in dietary fibre. Acta Scientiarum Polonorum, Technologia Alimentaria 7(2): 35-42.

Nawirska, A. and Kwaśniewska, M. 2005. Dietary fibre fractions from fruit and vegetable processing waste. Food Chemistry 91(2): 221-225.

Oliveira, A. C., Valentim, I. B., Silva, C. A., Bechara, E. J. H., Barros, M. P., Mano, C. M. and Goulart, M. O. F. 2009. Total phenolic content and free radical scavenging activities of methanolic extract powders of tropical fruit residues. Food Chemistry 115(2): 469-475.

Özvural, E. B. and Vural, H. 2011. Grape seed flour is a viable ingredient to improve the nutritional profile and reduce lipid oxidation of frankfurters. Meat Science 88(1): 179-183.

Papathanasopoulos, A. and Camilleri, M. 2010. Dietary Fiber Supplements: Effects in Obesity and Metabolic Syndrome and Relationship to Gastrointestinal Functions. Gastroenterology 138(1): 65-72.

Pare, P., Ferrazzi, S., Thompson W. G., Irvine E. J. and Rance L. 2001. An epidemiological survey of constipation in Canada: definitions, rates, demographics, and predictors of health care seeking. American Journal of Gastroenterology 96(11): 3130-3137.

Pellegrini N., Colombi B., Salvatore S., Brenna O. V., Galaverna G., Del Rio D., Bianchi M., Bennett R. N. and Brighenti F. 2007. Evaluation of antioxidant capacity of some fruit and vegetable foods: efficiency of extraction of a sequence of solvents. Journal of Science of Food and Agriculture 87(1): 103-111.

Prosky, L., Asp, N. G., Furda, I., Devries, J. W., Schweizer, T. and Marland, B. 1984. Determination of total dietary fibre in foods, food products, and total diets: Interlaboratory study. Journal of the Association of Official Analytical Chemists International 67(4): 1044–1052.

Saura-Calixto, F. and Goñi, I. 2006. Antioxidant capacity of the Spanish Mediterranean diet. Food Chemistry 94(3): 442-447.

Silva J. K., Cazarin C. B. B., Colomeu T. C., Batista A. G., Meletti L. M. M., Paschoal J. A. R., Júnior S. B., Furlan M. F., Reyes F. G. R., Augusto F., Júnior M. R. M. and Silva R. L. Z. 2013. Antioxidant activity of aqueous extract of passion fruit (Passiflora edulis) leaves: *In vitro* and *in vivo* study. Food Research International 53(2): 882–890.

Slavin, J. L. 2005. Dietary fibre and body weight. Nutrition 21(3): 411-418.

Suares, N. C. and Ford, A. C. 2011. Prevalence of, and risk factors for, chronic idiopathic constipation in the community: Systematic review and meta-analysis. American Journal of Gastroenterology 106(9): 1582-1591.

Sun-Waterhouse, D. 2011. The development of fruit-based functional foods targeting the health and wellness market: a review. International Journal of Food Science & Technology 46(5): 899-920.

Waitzberg, D. L., Logullo, L. C., Bittencourt, A. F., Torrinhas, R. S., Shiroma, G. M., Paulino, N. P. and Teixeira-da-Silva, M. L. 2013. Effect of symbiotic in constipated adult women - A randomized, double-blind, placebo-controlled study of clinical response. Clinical Nutrition 32(1): 27-33.

Yang, J., Wang, H., Zhou, Li. and Xu, C. 2012. Effect of dietary fibre on constipation: A meta analysis. World Journal of Gastroenterology 18(48): 7378–7383.