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Nutritional value and antioxidant capacity of lunch meals consumed by elderly people of Sharpeville, South Africa

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ABSTRACT

The main objective of this study was to determine the nutritional value and the total dietary antioxidant capacity (TDAC) of lunch meals consumed by elderly people attending a day-care centre in Sharpeville, South Africa. Meals were monitored and collected for a two-week period. The menus were analysed for water, ash, fat, protein, carbohydrates, polyphenols and antioxidant capacity. Eighteen food items, grouped in seven different menus, were identified. Energy provided by the menus covered 32% of the daily reference intakes for females and 25% for males, and the distribution of macronutrients in the menus was 10%, 34% and 56% for protein, fat and carbohydrates, respectively. This is close to the prescribed acceptable macronutrient distribution ranges of 10–35% protein, 20–35% fat and 45–65% carbohydrates. TDAC available from the menus was estimated at 332 μmol Trolox equivalents by DPPH (2,2′-diphenyl-1-picrylhydrazyl) and represented about 9% of the recommended daily allowance. Fruit, which represented only 2.8% of the amount of foods composing the menus, supplied 75.3% of TDAC, whilst contributions from vegetables and legumes were low. With 269 mg gallic acid equivalent in the menus, total phenolics appeared to be quantitatively the main dietary antioxidant, and were significantly correlated ($r = 0.443$ and $p = 0.007$) with antioxidant capacity. Fruit portions of the meals served by the day-care centre to the elderly of Sharpeville, need to be increased and diversified in order to reinforce their intake of antioxidants and thus reduce the incidence of non-communicable diseases.

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1. Introduction

Some of the most exciting research in the last decade has been the discovery of a group of nutrients which have protective effects against cell oxidation. Furthermore, certain food items have been classified as "functional foods", as these provide additional physiological benefits, such as preventing or delaying the onset of chronic diseases as well as meeting basic nutritional requirements. Oxidative and free radical-mediated reactions are implicated in numerous pathological conditions, such as inflammation, metabolic disorders, cellular ageing, reperfusion damage, atherosclerosis, and carcinogenesis (Ames, Shigenaga, & Hagen, 1993; Robak, Shahidi, Wolbis, & Krolikowska, 1988). There is growing scientific evidence that dietary antioxidants play a critical role in the maintenance of human health (Liu, 2003). Several epidemiological studies suggest that diets rich in phytochemicals and antioxidants execute a protective role in health and disease, and frequent consumption of fruits and vegetables has been associated with a lowered risk of cancer, heart disease, hypertension and stroke (Marco, Joseph, & John 1997; Vinson, Su, Zubik, & Bose, 2001; Wolfe & Liu, 2003). The major groups of chemicals that contribute to the total antioxidant capacity of foods include polyphenols, carotenoids and vitamins C and E. There are several studies reporting the antioxidant capacities of individual foods and isolated food antioxidants (Lako et al., 2007; Podsędek, 2007; Tsai, Wua, & Cheng, 2008; Wojdyło, Oszmiański, & Czemerys, 2007). However, to the best of our knowledge, there is a lack of studies on the antioxidant capacity of whole meals. Therefore, we believe that a more appropriate way to access and then address the needs of people will be by examining the antioxidant capacity of meals, in addition to that of single nutrients or foods.

The Vaal region is an industrial area situated approximately 70 km south of Johannesburg, South Africa, with a population of 794,599 people; 46.1% of households in this area live in poverty (McIlrath & Slabbert, 2003). Given the importance to health of dietary habits and food components, it is vital to provide information regarding the antioxidant capacity of meals consumed by a vulnerable population in the Vaal region, in order to support future work in assessing its protective effects against chronic degenerative disorders.

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The main objective of this study was to determine the nutritional value and the total dietary antioxidant capacity (TDAC) of meals, as provided by the day-care centre and consumed by elderly people of Sharpeville in the Vaal region.

2. Materials and methods

2.1. Meal samples

Meals consumed by the elderly in the day-care centre in Sharpeville were monitored and collected for a two-week period. This centre receives about 450 elderly people (aged $\geqslant$ 60 years) from Monday to Friday. Eighteen different food items, being part of seven different menus, were identified and allocated to one of the nine nutritional food groups recommended by FAO, depending on the major component (Table 1). The serving portion represented the average intake per person.

Freshly prepared food samples were used for the determination of moisture, total phenolics and antioxidant capacity, and these were air-dried at 40 °C, ground and stored at −21 °C, until analyses of ash, fat, protein and carbohydrates were carried out.

2.2. Proximate analysis

Protein content ($N \times 6.25$) was determined by Kjeldahl digestion technique followed by spectrophotometric determination of the resulting ammonia, using the method of Devani, Shishoo, Shah, and Suhgka (1989). Total carbohydrates were evaluated by the phenol–sulphuric acid method (Dubois, Gilles, Hamilton, Rebers, & Smith, 1956), after hot digestion with 1.5 M sulphuric acid. Fat content was determined by exhaustively extracting samples in a Soxhlet apparatus with petroleum ether (AOAC, 1980). The energy value was calculated using average conversion factors for protein, fat and carbohydrates.

2.3. Sample extraction

Samples for total antioxidant capacity and total polyphenols were treated according to the method of Pérez-Jiménez et al. (2008). Ten grams of food sample were extracted with 40 ml of methanol:water (50:50, v/v; pH 2.0) at room temperature, using an ultra-speed homogeniser for 5 min. The homogenates were kept at 4 °C for 1 h and then centrifuged at 2500*g* for 10 min. The supernatants were recovered and the residue was further washed with 40 ml of acetone:water (70:30, v/v) and centrifuged. The resulting supernatants were combined and stored at −20 °C.

Table 1
Intake of food items in menus for elderly people of Sharpeville.

Food items	Menu	Serving edible portion (g/person)
Starchy foods		
Cake	2	55
Maltabella (sorghum porridge)	1	223
Pap (maize meal porridge)	3, 4, 6	233
Rice, white, cooked	2, 5	200
Sandwich 1 (brown bread + salami + tomato)	1, 3	93
Sandwich 2 (brown bread + peanut butter)	2, 4	87
Sandwich 3 (brown bread + margarine)	6	90
Sandwich 4 (brown bread + jam)	5, 7	90
Sweet potato, boiled	5	70
Vegetables		
Cabbage, sautéed in vegetable oil with onion	1, 5	99
Green beans, cooked with potato, onion and oil	3	51
Green beans in Vienna soup	2, 7	287
Pumpkin, boiled and mashed with margarine	1, 3	123
Spinach, cooked with potato, onion and margarine	6	99
Fruit		
Orange	4, 6	69
Flesh products		
Chicken, fried in vegetable oil	3, 5, 6	20
Legumes		
Sugar bean soup	4	155
Umcushu (cooked samp and sugar beans)	7	102

2.4. Estimation of total antioxidant capacity

The antioxidant capacity of sample extracts was evaluated using the DPPH assay, according to the method of Brand-Williams, Cuvelier, and Berset (1995), as modified by Thaipong, Boonprakob, Crosby, Cisneros-Zevallos, and Byrne (2006). The stock solution was prepared by dissolving 24 mg DPPH in 100 ml methanol and then stored at −20 °C until needed. The working solution was obtained by mixing 10 ml stock solution with methanol to obtain an absorbance of 1.1 ± 0.02 units at 515 nm, using a spectrophotometer. Sample extracts (150 µl) were allowed to react with 2850 µl of the DPPH solution in the dark for 24 h. Then the absorbance was measured at 515 nm. Results were expressed in Trolox equivalents (µmol TE/g fresh matter), using a Trolox (25–800 µM) standard curve.

2.5. Determination of total phenolics

Total phenolics were determined by the Swain and Hillis (1959) method, using Folin–Ciocalteu reagent. In a test tube, 150 µl of the methanol–acetone extract, 2400 µl of nanopure water, and 150 µl of 0.25 N Folin–Ciocalteu reagent were combined and then mixed well, using a vortex. The mixture was allowed to react for 3 min after which 300 µl of 1 N Na_2CO_3 solution was added and mixed well. The solution was incubated at room temperature for 2 h and absorbance was measured at 725 nm against a blank. Results were expressed in gallic acid equivalents (GAE; mg/100 g of fresh matter), using a gallic acid (0–0.1 mg/ml) standard curve.

2.6. Statistical analysis

All measurements were carried out in triplicate. Statistical analyses of data were performed using SPSS 15.0 software (SPSS Inc., Chicago, IL). Comparisons between dependent variables were determined, using analysis of variance, Duncan's multiple range test and correlation analysis. Statistical significance was defined at $p \leqslant 0.05$.

3. Results

Analysis of meals consumed by the elderly of Sharpeville showed that they were mainly composed of five food groups, with a predominance of starchy foods, followed by vegetables and flesh products (Fig. 1). Fat and oil were also well represented since they were used as ingredients in the preparation of several food items (Table 1). Energy and proximate composition of food items of the menus are summarised in Table 2. Carbohydrates supplied between 53% and 90% of energy for 10 food items, representing 56% of foods composing the menus, whilst fat supplied between 53% and 61% for five food items; proteins supplied between 3% and 35% of the energy. Energy and macronutrient intakes during the meal are summarised in Table 3. Energy provided by the meals covered about 32% of daily reference intakes for females, and 25% for males. With 10%, 34% and 56% of energy supplied by proteins, fat and carbohydrates, respectively, lunch meals consumed by the elderly of Sharpeville closely matched the acceptable macronutrient distribution range (Institute of Medicine, 2002).

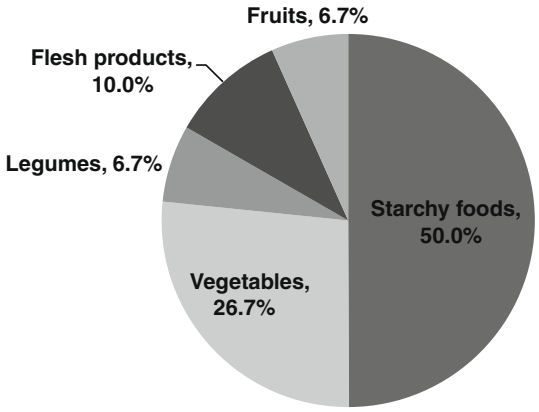

Fig. 1. Consumption frequency of food items composing the menus served by the care centre to the elderly in Sharpeville.

The antioxidant capacity and total phenolics content of food items composing the menus are shown in Table 4. The highest value for antioxidant capacity was registered for oranges, and no significant difference was noted for the rest of food items, according to Duncan's multiple range test. A significant correlation ($r = 0.443$ and $p = 0.007$) was observed between the antioxidant capacity of foods and their total polyphenol content, suggesting that phenolic compounds play a significant role in the antioxidant capacity exhibited by the food items of the menus. Total dietary antioxidant capacity (TDAC) can be defined as the antioxidant capacity of all food items composing the menus consumed daily, and may represent the amount of antioxidant units (Trolox equivalents) present daily in the human gut. TDAC in the menus consumed by the elderly of Sharpeville was estimated to be 332 μmol Trolox equivalents (Table 5), and represented about 9.5% of the recommended daily allowance (RDA) (The USDA [United States Department of Agriculture] currently recommends an RDA of 3000–5000 μmol Trolox equivalent values of antioxidants). The contribution of each food group to the TDAC was dependent on both food intake and food antioxidant capacity. The largest contributor to the TDAC was fruit (about 75.3%), despite a very low consumption (2.8% of the amount of foods forming the menus), whilst the contribution of vegetables, flesh products and legumes to the TDAC was low. Starchy foods counted for only 19.6% of TDAC, despite the large consumption.

The major groups of chemicals that contributed to the total dietary antioxidant capacity included polyphenols, carotenoids and vitamins C and E. The total phenolics in the menus consumed by the elderly of Sharpeville was estimated to be 269 mg/person (Table 5), which is considerably higher than the daily intake of carotenoids (0.4 mg), and vitamins C (41 mg) and E (4 mg) measured during a previous study (Oldewage-Theron & Kruger, 2008) amongst the elderly of Sharpeville. It has been reported that phenolic compounds possess higher antioxidant activity than vitamins and carotenoids (Gardner, White, McPhail, & Duthie, 2000; Pulido, Bravo, & Saura-Calixto, 2000; Vinson et al., 2001). This observation, linked to the significant correlation observed between antioxidant capacity and polyphenol content, suggests that polyphenols are quantitatively the main dietary antioxidant in menus consumed by the elderly of Sharpeville.

Table 3
Mean energy and macronutrient intakes provided by menus consumed by elderly of Sharpeville, as a function of food groups.

	Energy (kcal)	Protein (g)	Carbohydrate (g)	Fat (g)
Starchy foods	496.2 ± 165.9^{c}	10.7 ± 4.1^{c}	79.7 ± 19.2^{c}	14.9 ± 10.8^{b}
Vegetables	171.1 ± 133.2^{b}	4.2 ± 4.5^{b}	15.5 ± 9.4^{b}	10.3 ± 9.2^{b}
Fruits	9.2 ± 15.7^{a}	0.1 ± 0.2^{a}	2.1 ± 3.6^{a}	0.03 ± 0.05^{a}
Flesh products	23.7 ± 29.5^{a}	2.1 ± 2.6^{a,b}	0.4 ± 0.5^{a}	1.5 ± 1.9^{a}
Legumes	45.1 ± 78.6^{a}	1.4 ± 2.8^{a,b}	5.4 ± 9.2^{a,b}	2.0 ± 3.7^{a}
Total	745.9 ± 64.8	18.4 ± 1.7	103.0 ± 7.1	28.8 ± 4.7

$n = 7$ menus; mean ± SD.
Means in the same column with different superscripts are significantly different ($p \leqslant 0.05$) according to Duncan's multiple range test.

Table 2
Energy and macronutrient contents of food items served by the care centre to elderly in Sharpeville.

Food items	Moisture (g/100 g FW)	Ash quantity (g/100 g FW)	Fat quantity (g/100 g FW)	Total carbohydrate (g/100 g FW)	Protein (g/100 g FW)	Energy (kcal/100 g FW)
Starchy foods						
Cake	19.5 ± 0.1^{a}	1.6 ± 0.104^{d}	32.1 ± 0.8^{l}	40.4 ± 0.5^{j}	5.2 ± 0.4^{f}	471.9 ± 6.9^{k}
Maltabella	86.7 ± 0.4^{k}	0.18 ± 0.02^{a}	0.7 ± 0.1^{a,b}	11.1 ± 0.3^{d,e}	1.1 ± 0.1^{a,b,c}	55.1 ± 1.3^{a,b}
Pap	75.8 ± 0.6^{g,h}	0.39 ± 0.01^{a}	1.2 ± 0.1^{b}	18.7 ± 0.4^{g}	1.7 ± 0.1^{c,d}	92.2 ± 2.5^{d}
Rice	71.7 ± 0.4^{f}	0.42 ± 0.01^{a}	1.3 ± 0.1^{b}	22.9 ± 0.2^{h}	1.8 ± 0.2^{d}	110.4 ± 1.1^{e}
Sandwich 1 (bread + salami + tomato)	34.8 ± 0.2^{d}	2.94 ± 0.09^{g}	10.7 ± 0.2^{i}	42.5 ± 0.1^{k}	7.4 ± 0.3^{h}	295.8 ± 1.1^{i}
Sandwich 2 (brown bread + peanut)	28.0 ± 0.8^{b}	2.97 ± 0.33^{g}	18.8 ± 0.6^{k}	37.5 ± 0.1^{i}	12.4 ± 0.5^{i}	368.5 ± 3.0^{j}
Sandwich 3 (brown bread + margerine)	36.7 ± 0.3^{d}	2.99 ± 0.06^{g}	13.1 ± 0.1^{j}	39.8 ± 0.5^{j}	6.0 ± 0.1^{g}	301.3 ± 2.5^{i}
Sandwich 4 (brown bread + jam)	32.8 ± 3.3^{c}	1.68 ± 0.05^{d}	3.8 ± 0.1^{d}	55.7 ± 2.5^{l}	5.3 ± 0.5^{f}	277.6 ± 12.9^{h}
Sweet potato	84.2 ± 0.2^{j}	1.36 ± 0.07^{c}	1.0 ± 0.1^{b}	12.6 ± 0.3^{f}	0.5 ± 0.1^{a}	61.8 ± 1.8^{b}
Vegetables						
Green bean + potato	77.1 ± 0.1^{h}	1.68 ± 0.01^{d}	6.9 ± 0.1^{g}	12.2 ± 0.5^{e,f}	1.8 ± 0.1^{d}	118.2 ± 0.6^{e,f}
Green bean + Vienna soup	77.5 ± 0.4^{h}	1.96 ± 0.06^{e}	8.1 ± 0.2^{h}	8.4 ± 0.1^{b}	3.7 ± 0.1^{e}	121.0 ± 1.3^{f,g}
Cabbage	80.4 ± 0.6^{i}	2.45 ± 0.11^{f}	6.1 ± 0.1^{f}	9.47 ± 0.4^{b,c}	1.5 ± 0.1^{b,c,d}	98.6 ± 2.5^{d}
Pumpkin	83.8 ± 0.1^{j}	1.00 ± 0.01^{b}	2.8 ± 0.1^{c}	10.58 ± 0.2^{c,d}	1.0 ± 0.1^{a,b}	71.3 ± 0.2^{c}
Spinach	83.4 ± 0.1^{j}	1.58 ± 0.07^{c,d}	3.5 ± 0.1^{d}	9.22 ± 0.1^{b,c}	1.8 ± 0.1^{d}	75.5 ± 1.0^{c}
Fruit						
Orange	89.4 ± 0.3^{l}	0.41 ± 0.01^{a}	0.2 ± 0.03^{a}	10.6 ± 0.4^{c,d}	0.8 ± 0.1^{a}	46.9 ± 0.9^{a}
Flesh products						
Chicken	49.9 ± 0.5^{e}	2.30 ± 0.25^{f}	18.3 ± 0.1^{k}	4.4 ± 0.1^{a}	24.1 ± 0.9^{j}	278.1 ± 3.1^{h}
Legumes						
Sugar bean soup	73.9 ± 1.1^{g}	1.56 ± 0.01^{c,d}	6.0 ± 0.1^{f}	11.6 ± 0.6^{d,e,f}	4.8 ± 0.2^{f}	119.3 ± 3.1^{f}
Umcushu (samp + sugar beans)	71.7 ± 0.3^{f}	0.81 ± 0.01^{b}	4.6 ± 0.4^{e}	19.5 ± 0.4^{g}	2.2 ± 0.1^{d}	128.2 ± 2.4^{g}

$n = 3$; mean ± SD.
Means in the same column with different superscripts are significantly different ($p \leqslant 0.05$), according to Duncan's multiple range test.

Table 4
Antioxidant capacity and total polyphenol content of food items composing the menus.

Food items	Antioxidant capacity (μmol TE/100 g FW)	Polyphenols (mg GAE/100 g FW)
Starchy foods		
Cake	46.9 ± 0.4[a]	30.8 ± 1.9[b]
Maltabella	8.3 ± 0.3[a]	18.8 ± 0.9[a]
Pap	16.1 ± 1.0[a]	18.8 ± 0.9[a]
Rice	18.6 ± 0.8[a]	27.9 ± 0.8[b]
Sandwich 1 (bread + salami + tomato)	34.7 ± 1.8[a]	64.3 ± 1.9[f]
Sandwich 2 (brown bread + peanut butter)	29.7 ± 7.8[a]	87.3 ± 3.8[h]
Sandwich 3 (brown bread + margerine)	35.3 ± 1.2[a]	94.0 ± 1.5[i,j]
Sandwich 4 (brown bread + jam)	39.8 ± 1.8[a]	82.3 ± 2.6[g]
Sweet potato	8.1 ± 0.6[a]	47.6 ± 0.6[d]
Vegetables		
Cabbage	6.4 ± 0.1[a]	65.6 ± 0.7[f]
Green bean + potato	6.0 ± 0.2[a]	61.8 ± 0.1[e]
Green bean + Vienna soup	6.6 ± 0.1[a]	60.1 ± 0.2[e,f]
Pumpkin	6.8 ± 0.4[a]	29.4 ± 0.1[b]
Spinach	5.7 ± 0.3[a]	91.3 ± 0.9[i]
Fruit		
Orange	1270 ± 183.2[b]	110 ± 3.7[k]
Flesh products		
Chicken	5.8 ± 1.6[a]	34.8 ± 0.9[c]
Legumes		
Sugar bean soup	13.2 ± 0.2[a]	96.3 ± 0.5[j]
Umcushu (samp + sugar beans)	20.2 ± 0.3[a]	48.6 ± 0.4[d]

$n = 3$; mean ± SD
Means in the same column with different superscripts are significantly different ($p \leqslant 0.05$) according to Duncan's multiple range test.

Table 5
Total antioxidant capacity and polyphenol intakes provided by menus consumed by elderly of Sharpeville as function of food groups.

	Intake (g)	Antioxidant capacity (μmol TE)	Polyphenols (mg GAE)
Starchy foods	296.7 ± 92.4[c]	65.2 ± 17.6[a,b]	120.0 ± 30.2[b]
Vegetable	166.9 ± 107.3[b]	10.9 ± 7.2[a]	95.5 ± 61.5[b]
Fruits	14.5 ± 26.9[a]	249.5 ± 426.0[b]	21.7 ± 37.1[a]
Flesh products	8.6 ± 10.7[a]	0.5 ± 0.6[a]	3.0 ± 3.7[a]
Legume	36.7 ± 64.5[a]	5.9 ± 10.0[a]	28.4 ± 56.4[a]
Total	523.3 ± 41.3	331.9 ± 186.7	268.7 ± 23.1

$n = 7$ menus; mean ± SD.
Means in the same column with different superscripts are significantly different ($p \leqslant 0.05$) according to Duncan's multiple range test.

4. Discussion

Whereas other studies have previously reported antioxidant capacities of individual foods (Lako et al., 2007; Podsędek, 2007; Tsai et al., 2008; Wojdyło et al., 2007), this study is amongst the few reporting the contribution of whole meals as prepared in the community. In spite of the relatively high number of food items composing the menus consumed by the elderly of Sharpeville, which were adequate in regard to the Acceptable Macronutrient Distribution Ranges, these food items possessed a low antioxidant capacity that could hardly achieve the RDA. Polyphenols, as already reported in previous studies (Gardner et al., 2000; Pulido et al., 2000; Vinson et al., 2001), appeared to be quantitatively the main dietary antioxidants in foods consumed by the elderly of Sharpeville. However, it has to be noted that the biological effects of these substances depend on their bioavailability (Manach, Scalbert, Morand, Rémésy, & Jiménez, 2004). The marginal contribution of vegetables to the antioxidant capacity of the menus observed in this study contrasted with previous studies reporting significant levels of antioxidant components in vegetables (Cao, Srfie, & Prior, 1996; Lako et al., 2007; Podsędek, 2007). This could be explained, as previously reported (Saura-Calixto & Goñi, 2006), by the hypothesis that studies on individual foods may overestimate their potential effects on a whole diet, a theory which was illustrated by the fact that tea and olive oil, known to have a higher antioxidant capacity, contributed very little to the antioxidant capacity of the Spanish diet. On the other hand, despite their very low consumption, fruit appeared to be the main contributor to the antioxidant capacity of menus consumed by the elderly of Sharpeville, which highlights the importance of fruit consumption for protection against cellular damage caused by exposure to high levels of free radicals. In this connection, Martínez-González et al. (2002) found an inverse association between the first acute myocardial infarction and the consumption of fruits in the Spanish Mediterranean diet, but not the consumption of vegetables or legumes, a result that is consistent with the results found with some fruits regarding overall survival in a cohort of elderly Italians (Fortes et al., 2000).

In summary, the total dietary antioxidant capacity may be a parameter to be considered in future nutritional studies. The fruit portion of the meals served at the day-care centre to the elderly of Sharpeville needs to be significantly increased and diversified in order to reinforce their intake of antioxidants and reduce the likelihood and incidence of non-communicable diseases.

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