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Main Sources of Antioxidant Vitamins in the Jordanian Diet

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Abstract: This research evaluates the intakes of the antioxidant vitamins A (retinol), C (ascorbic acid) and E (tocopherols) as obtained from food consumption calculations based on the most recent food budget survey in Jordan (JHEIS, 2010). The estimated antioxidants intakes were analyzed using a nutrition analysis software program (Food Processor, 2008). The results showed that the means of daily per capita intakes of vitamin A, C and E were 781 µg, 123.3 and 8.4 mg/day, respectively. Amongst the Jordanian household intakes tomato was the best source of vitamins A and C. Beside tomatoes, carrots, fresh spinach and melon were at the top of vitamin A food sources. In addition, corn and olive oils and Jordanian bread were at the top of vitamin E sources. Tomatoes, citrus, green peppers and cucumber were the best sources of vitamin C. It is concluded that the Jordanian diet meets the recommendations of vitamin A and that vitamin C intake was higher than the recommendations whereas vitamin E intake was below the recommendations.

Key words: Jordan, antioxidant vitamins, vitamin A, vitamin E, vitamin C

INTRODUCTION

Food intake pattern has changed widely in different parts of the world including the Middle Eastern (ME) countries (Popkin, 2002; Alwan and Kharabsheh, 2006). In Jordan, the changes in life style and socioeconomic status led to nutrition transition (Musaiger *et al*., 2012; Madanat *et al*., 2008; Takruri and Alkurd, 2014). Consumption of fast foods and meals away from home increased. Although the poverty line increased after lifting the subsidization of basic food commodities since 2007, the health indicators improved (AlKurd, 2011).

Although the major causes of death and disability in ME have shifted from nutritional deficiencies and infectious diseases to chronic diseases (Stovall *et al*., 2013; Musaiger and Al-Hazzaa, 2012), there is still worry about the status of micronutrient intake particularly the antioxidant vitamins. Free radicals and low consumption of antioxidant nutrients are associated with prevalence of some of the chronic diseases such as cancer, cardiovascular diseases and arthritis (Takruri and Alkurd, 2014).

Oxidative stress diseases such as cancer and cardiovascular diseases (CVD) are multifactorial in etiology and are linked with the imbalance between the production and the elimination of the reactive free radicals generated during normal metabolic process. The presence of polyunsaturated fatty acids (PUFA) in the cell membrane make them prone to oxidation by free radicals leading to cell, protein, DNA and tissue damage (Mente *et al*., 2009).

Free radicals are highly unstable toxic molecules. Their instability is due to the presence of unpaired electrons in their outermost orbital. In the normal cell state, the mitochondria are able to balance the oxidative stress by consumption of the free radicals and reducing them. The neutralization of such electrons is one mechanism by which antioxidants can reduce the reactivity of free radicals (Bouayed and Bohn, 2010; Miller *et al*., 2012).

The antioxidant has been defined as a substance that combines the free radical ion to neutralize the oxidative damage to body cells and tissues. Cell membrane structure and function can be damaged by the free radicals (Insel, 2014). Reducing reactive oxygen species (ROS) can be simply done by adding more foods rich in antioxidants to the daily diet intake. ROS were connected to lipid oxidation in cell membranes causing damage to them and to the protein and DNA (Weikel *et al*., 2012).

The three vitamins A, C and E are known to be essential antioxidants that are obtained from food intake. However, the oxidation-reduction mechanisms differ from one vitamin to another. Vitamin E prevents lipid oxidation in organs especially the cell membranes, while vitamin C offers an electron to prevent the free radical overproduction (Miller *et al*., 2012).

The Dietary Reference Intakes (DRIs) of vitamin A for adult males is 900 µg retinol activity equivalent (RAEs) while for adult females it is 700 µg RAEs. However, this requirement increases during pregnancy and lactation to 770 and 1300 µg respectively. Such recommendations are important to fill the vitamin A liver stores (Insel, 2014).

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alpha-Tocopherol is the lipid-soluble antioxidant that conquers the formation of free radicals arising from the oxidation of unsaturated fat. Vitamin E prevents the damage that occurs from oxidation of the biological membranes by donating its hydroxyl hydrogen to the lipid peroxyl radical (Ulatowski and Manor, 2013). alpha-Tocopherol is one of the eight chemical forms of vitamin E that has the greatest bioavailability. Foods such as nuts, seeds and vegetable oils are considered to be rich in alpha-tocopherol (Litinjua, 2012). The recommendations of vitamin E are related to the body size and the consumption of PUFA. The DRI of alpha-tocopherol is 15 mg/day for adults and pregnant woman while lactating mother requires 19 mg/day.

Vitamin C minimizes free radical damage in cells by acting as a reducing agent. In addition, Vitamin C helps in recycling oxidized Vitamin E to be reused in the cells (Lykkesfeldt and Poulsend, 2010). Vitamin C is essential in many body functions such as activation of enzymes, collagen synthesize, enhancing non-heme iron absorption and enhancing immune cell functions (Douglas *et al*., 2007).

The DRI of vitamin C vary according to gender, age and smoking status. Adult males are recommended to consume 90 mg/day while adult females in same age are recommended to consume 75 mg/day. Pregnant and lactating women are recommended to consume 85, 120 mg/day, respectively. Smokers are advised to consume additional 35 mg to slow the metabolic turnover and prevent the damage that is caused by smoking (Insel, 2014).

Unlike vitamin A and E, vitamin C is water soluble. Hence, it doesn't show any toxicity signs because it is not stored in the body and the kidneys excrete the excess amount of the vitamin. However, vitamin C is very sensitive to heat and oxygen thus fresh fruits and raw vegetable are major sources of the vitamin (Bender, 2003).

This research aimed to identify the main sources of the antioxidant vitamins A, C and E and estimate their daily intake based on the Jordanian household and income survey.

MATERIALS AND METHODS

Data were based on the Jordanian Household Expenditure and Income Survey (JHEIS), 2010. Data collection extended from April 2010 to April 2011 (DOS, 2012). The survey aimed at collecting detailed information about the household income and expenditure and correlating these data with the demographic, social and economic changes in Jordan. The annual per capita food consumption data of a representative sample of all households in Jordan was calculated from the survey. The sample included 13866 households which were proportionally distributed among the different governorates of the country using two-stage cluster stratified sampling method. These households included 73490 individuals, by an average of 5.3 capita/household. Males constituted 51.26% of the sample, 40.2% were children younger than 18 years and 3.8% were elderly (older than 65 years).

Each participating household received a questionnaire that contained data of the expenditure on different food and nonfood categories. The data on food items were analyzed using a nutrition analysis software program (Food Processor, 2008) which included details on the contents of energy and nutrients for each food items. The composition of local food items that are not included in the database was obtained from references such as Food Composition Tables for Use in the Middle East (Pellett and Shadarevian, 1970) and Food Composition Tables of the Gulf Region (Musaiger, 2006). Such foods and their analyses were introduced to the food processor database. Then the daily intake of vitamins A, C and E were calculated and expressed as/capita. The nutrient intake values were then compared with the highest DRI values to assure that needs were met for all age groups (IOM, 2002/2005).

RESULTS

Table 1 presents the total daily intake of the antioxidant vitamins A, C and E and their comparison to the Dietary Reference Intakes (DRI) of the Food and Nutrition Board (IOM and FNB, 2000; IOM, 2002/2005). It is clear from the table that vitamin A intake is relatively acceptable but the estimated intake of vitamin E is below the recommendation. The recommendations of these vitamins are 700-900 µg retinol equivalent (RE), 75-90 mg vitamin C and 15 mg alpha-tocopherol/day. Jordanians eat 781 µg RE, 123.3 mg vitamin C and 8.4 mg of alpha-tocopherol.

Table 2 shows the richest food sources of vitamin A expressed as total vitamin A content (international unit, IU) in the Jordanian diet and the contribution of these sources as percentage of the total intake. For comparison purpose the values of vitamin A content in the Jordanian diet (IU/day) were expressed as RAE by dividing the value by 5 as shown in Table 2. The top food sources of the vitamin are: tomato (all types), fresh carrots, cantaloupe, watermelon and eggs.

Table 3 and 4 show the richest 10 food sources of vitamin C in the Jordanian diet and the contribution of these sources as a percentage of the total intake. The best food sources of the vitamin are: citrus fruits (including all types of orange, mandarine oranges, fresh clementine and lemon) and tomatoes. Jordanians consumed 22.4 and 16.8 mg vitamin C/day from citrus and tomatoes respectively. It is important to mention that our results show some of fresh food items that are considered as rich sources of the vitamin. However, some of them are not consumed fresh. Jordanian dishes do not contain fresh cauliflower, fresh jew's

Table 1: Comparison of the estimated Jordanian intakes of antioxidants vitamins A, C and E with DRI

Antioxidant vitamin	DRI	Our study
Vitamin A (RE)	700*-900	781 µg RE (3904 IU)
Vitamin C (mg)	75*-90	123.3
Vitamin E (mg)#	15	8.4

*For females #As alpha-tocopherol

Table 2: Top 10 food sources of vitamin A in the Jordanian diet

Food item	Consumption A-IU/day	Percentage of total intake (%)
Tomatoes all types	727.9	18.6
Fresh carrots	398	10.2
Fresh Spinach	385.4	9.9
Melon, cantaloupe	356.7	9.1
Fresh Watermelon	207.5	5.3
Eggs, whole raw	154.3	4
Mixed vegetables	130.8	3.4
Parsley, herb, springs	126.8	3.2
Cheese, goat, hard	124.8	3.2
Fresh squash, zucchini	105.4	2.7
Fresh Cucumber	89.4	2.3
Total of top 10	2807 IU/ 561.4 µg RE	
Total intake	3904 IU/ 781 µg RE	

Table 3: Top 10 food sources of vitamin C in the Jordanian diet according to the household budget

Food item	Consumption (mg/day)	Percentage of total intake (%)
Citrus[1]	22.4	18.2
Tomatoes [2]	16.8	13.6
Fresh Potatoes	12.6	10.2
Jew's mallow	9.5	7.7
Fresh cauliflower	9.3	7.5
Fresh squash, zucchini	7.3	5.9
Sweet green peppers	5.5	4.5
Melon, cantaloupe	3.9	3.2
Fresh cabbage	2.9	2.3
Fresh cucumber	2.7	2.2
Total of top 10	92.9 mg	
Total intake	123.3 mg	

[1]Citrus all types: oranges all types+Mandarin oranges clementine fresh+Mandarin orange fresh+lemon
[2]Tomatoes: tomatoes fresh plus tomato paste

Table 4: Top 10 food sources of vitamin C in the Jordanian diet that are eaten fresh

Food item	Consumption (mg/day)	Percentage of total intake (%)
Citrus[1]	22.4	18.2
Tomatoes[2]	16.8	13.6
Sweet green pepper	5.51	4.5
Melon, cantaloupe	3.87	3.2
Fresh cucumber	2.68	2.2
Fresh guava	2.44	2
Fresh onion	2.32	1.9
Fresh banana	2.15	1.7
Fresh watermelon	2.08	1.7
Parsley	2	1.6
Total of top 10	62.2 mg	
Total intake	123.3 mg	

[1]Citrus all types: oranges all types+Mandarin oranges clementine fresh+Mandarin orange fresh+lemon
[2]Tomatoes: tomatoes fresh plus tomato paste

mallow and fresh zucchini; they are eaten cooked, which significantly results in the losses of a good amount of their vitamin C content. Therefore this list is modified to represent the food sources of this vitamin traditionally consumed raw as presented in Table 4.

Table 5: Top 10 food sources of vitamin E (alpha-toco) in the Jordanian diet

Food item	Consumption (E-aTE) mg/day	Percentage of total intake (%)
Corn oil	3.7	44
Olive oil, extra virgin	1.2	14.3
Jordanian bread	1.0	12
Chicken	0.4	4.8
Whole eggs	0.3	3.6
Tomato paste	0.2	2.4
Falafel, patty	0.1	1.2
Fish	0.1	1.2
Thyme	0.09	1
Fresh spinach leaf	0.08	0.9
Total of top 10	7.2	
Total intake	8.4	

Table 5 shows the richest 10 food sources of vitamin E and the contribution of these food items as percentage of the total intake. The main food sources of tocopherol in the Jordanian diet are of plant origin (vegetable oils).

DISCUSSION

Vitamins A, C and E are important in the diet as antioxidants. This research aimed to evaluate their intakes in the Jordanian household daily intakes. The DRI for vitamin A lies between 700 to 900 µg/day while the daily intake of Jordanians is estimated to be 781 µg RE/day. This value is fairly good and is mainly due to the high intake of vegetables, particularly the leafy vegetables, which are abundant in the Jordanian diet. These include mallows, garden rocket, cress, water-cress, parsley, thyme, mint and many others (Takruri and Hamdan, 1989). In addition, vitamin A intake may be underestimated since many wild plants are rich in this vitamin. For example, vine leaves and other wild leafy vegetables, which are rich in this vitamin, are consumed as stuffed dishes (Tukan *et al*., 1998), though they do not appear in the household data. It is good to clarify that although liver is known to be one of the best sources of vitamin A (USDA, 2002; Ross and Harrison, 2007) but it is not mentioned in Table 2, because of its low consumption in the Jordanian diet.

Vitamin C consumption is 123.3 mg/day while the recommendation is 75 for females and 90 mg for males per day, which is considered higher than the recommendation (Table 1). Table 3 shows the top 10 richest sources of vitamin C according to the Jordanian household budget survey. It is clear that citrus fruits are the best source for this vitamin in the Jordanian diet as it contributes 18.2% of its total intake. Citrus fruits include oranges, mandarins and lemon, which are available throughout the year in Jordan. Tomatoes either fresh or paste are the second rich source of this vitamin. They contribute 13.6% of total intake (Table 3). Jordanian people eat tomato either fresh in salads or whole with

breakfast or dinner, or they use it as the base for of many stew dishes. It should be mentioned in this regard that although the vitamin C content of tomatoes is not very high but its high production in Jordan Valley makes it available and fairly in suitable price for most of the population.

Table 3 shows the top 10 food sources of vitamin C. However, some food items are not eaten fresh; for example, fresh potato contributes 10.2% of the daily consumption while potatoes are eaten either cooked or fried and not fresh. It is well established that cooking processes easily destroy vitamin C especially by heating or boiling (Douglas *et al*., 2007).

The top 10 food sources of vitamin C that are eaten fresh are shown in table 4 in which other food items such as guava, banana and watermelon appear. It is noteworthy that although Guava is one of the best vitamin C sources, it contributes only 2.2% of the vitamin intake because it is costly and not available in the market throughout the year.

The recommendation of vitamin E as alpha-tocopherol is 15 mg/day for both genders over 14 years old. Jordanian diet supplies only 8.4 mg/day, which is less than the recommendation.

It is clear that most of the vitamin E rich sources were plant based. That is explained by the fact that the consumption of vegetable oils is increasing in the Jordanian diet (Takruri *et al*., 2011). Corn oil consists 44% of the total intake in the Jordanian diet (Table 5). Corn oil is used in daily cooking either in making stews or in frying. Olive oil consumption is high in Jordan contributing 14.3% of the total intake (Table 5). Olive oil is consumed traditionally in the country and is used with many foods such as the thyme mix (Tukan *et al*., 1998) and in making the salad dressing. Chicken and eggs are less important as sources of this vitamin though they are more important than fish (Table 5). Fish dishes are expensive as fish is imported while poultry is the main meat consumed in Jordan (Tukan *et al*., 2011) and poultry farming is a successful agricultural business in Jordan.

Conclusion: Jordanian diet is rich in vitamin A and vitamin C and is expected to meet the recommendations of these vitamins while more attention should be paid to increase the intake of vitamin E in the Jordanian diet.

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