Effect of Washing on the Removal of Contaminated Heavy Metals from some Leafy Vegetables Collected from Three Different Markets

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ABSTRACT

In this study six leafy vegetables, lettuce, radish leaves, roqutte, spinach, grape leaves, and chard, were collected from three different common markets, Abeis and Manshea El-Nozha at Alexandria city and the west district of kafr El-dawar city, Egypt, to determine their contents of Pb, Cd, Zn, Cu and Mn. The influence of washing of such vegetables with tap water, 2% sodium chloride, and 2% acetic acid solutions on the removal of the determined heavy metal were evaluated. Data showed that the level of Pb, Cd, Zn, Cu and Mn in the fresh unwashed leafy from the three markets vegetables ranged from 0.31-0.61, 0.12-0.195, 3.13-6.96, 2.45-3.53 and 2.25-3.79 mg/kg, respectively. More than 50% of heavy metals pollutants except Mn, in lettuce were removed by washing especially with acetic acid. This percent of reduction reduced the level of such pollutants to less than their harmful values mentioned by FAO/WHO (1990) and also indicated that the main source of their presence was the superficial pollution especially for Pb and Cd.

Key Words: Heavy metals, Leafy vegetables, Washing process, Markets

INTRODUCTION

The quality of food is a key factor affecting morbidity and mortality. As the quality of life improves, more and more people have become aware that food quality affects their well being and their daily life. Metal pollution in agricultural production is one of the important factors affecting vegetable and other food. The primary heavy metals in the environment detrimental to people's health include mercury, cadmium, chromium, lead, nickel, copper, zinc, and nonmetallic arsenic. They enter the environment mainly as a result of industrial and agricultural practices. They are stable unlike some potentially toxic organic compounds. Once ingested, they are difficult to eliminate and accumulate in the body, Ze-Yizhou, et al, (2000) according to Yang, Y. (1996).

Heavy metals contamination of fresh vegetables and fruits has posed a serious problem for the consumers, manufacturers and health authorities. Intake of relatively low doses of these metals over a long period can lead to malfunction of organs and chronic toxicity. Their harmful effect on human body primary depends on their maximum recommended levels and acceptable daily intake (ADI) that reported by FAO/WHO (1998).

The major source of such pollutants in vegetables and fruits are soils, irrigation water, industrial vaporous, pesticide containing such metals, an emitted dusts from car's wheel and fumes of plastic burning. According to (Zurera et al,1991), vegetables absorb these metals from the soil as well as from the deposits on the parts of the vegetables exposed to air from the polluted environment. The use of sewage effluent and/or residual waters for the irrigation as well as the application of certain fertilizers constitute or sludge are considered one of the principal source of metal pollution especially cadmium in vegetables (Trimizi et al., 1996).

For most peoples the major source of exposure to the metals is from the diet (DHSS 1980). There is some difficulty in accurately assessing the average dietary intake of such elements due to the problems associated with the reliably quantifying of their low concentration present in most food (Boxter et al., 1989). Generally, several factors affecting the regulatory limits of heavy metals in the food: their toxicity extent, level of contamination, food consumption rate, individual physiological vulnerability, environmental persistence and alteration (El-saeid and Shahata, 2000).

Holubowiez (1998) showed that washing the fruits always reduced the heavy metal content. El-saeid and Shahat (2000) explained that washing removes the heavy metals found in free form and presence on the surface of aerial parts of plants. El-sharnouby and Abd El-All (2003), found that washing of salad vegetables caused reduction ranging from 34% to 90% in Pb, and from 7 to 45% in Cd.

In this study six leafy vegetables (lettuce, radish leaves, roqutte, spinach, grape leave and chard) were collected from three different common markets near and far from their production area's at Alexandria and Kafr El-Dawar cities, Egypt. In order to determine their concentration of Pb, Cd, Zn, Cu, and Mn. The effect of washing procedures of such vegetables with tap water, 2% sodium chloride and 2% acetic acid solutions on the removal of the heavy metals was also evaluated.

MATERIALS AND METHODS

A- Materials:

Six different types of fresh edible leafy vegetables, 3 Kg of each, including leafy lettuce (*Luctuca sativa),* radish leaves (Raphonus sativus L.), roqutte (*Eruca sativa)*, spinach (*Spinacia oleracea)*, grape leaves (*Vitis vinifera)* and chard (*Beta vulgaris var. cicla L.)* were purchased from three common markets namely, Abeis at the east district of Alexandria city, Manshea El-Nozha at the Middle district of Alexandria city and the west district of kafr El-dawar city, Egypt.

B- Methods:

1- Preparation of samples: - The edible parts f the fresh vegetables, as used for human consumption was blended by electric mixer and aliquot weights were taken for analysis. Washing treatment was accomplished by three treatments of soaking (tap water, 2% NaCl solution and 2% acetic acid solution) for 30 minutes followed by running tap water for two minutes. Then, the washed vegetables were blended by electric mixer and aliquot weights were taken for analysis.

2- Analytical methods: - Five heavy metals, Pb, Cd, Zn, Cu, and Mn in fresh and washed vegetables were extracted and dissolved in 100 ml 1N after ashing according to the AOAC (1990). The heavy metals content were determined by using Atomic Absorption Spectrophotometer (AAS), Prikin Elmer Model 2380, at the specific wavelength for each metal according to the AOAC (1990).

Statistical analysis:

Standard deviation was calculated for analytical results using methods described by Snedecor and Cochran, (1980).

RESULTS AND DISCUSSION

A-Level of heavy metals in fresh leafy vegetables:-

1- Lead (Pb): - Lead is a dangerous poison and accumulative when absorbed by human organisms. According to Mahadeviah and Gowramma (1980), minor amounts of lead may normally present in some foods. However, lead bearing spray and powders are employed as insecticides, the presence of Pb and Cd residues in foods is mainly due to the environmental pollution (Zurera et al., 1991). The source of Pb pollution of raw vegetables my include soil, irrigated water containing an industrial air which loaded with industrial wastes, and car's exhausts. As shown from the results in Table (1) except radish leaves, the other leafy vegetables contained higher Pb content than the potentially harmful level of toxicity, 0.3 mg/kg (Egyptian standard specification, ESC, 1993). The highest level of these metals was found in the vegetables of Manshea EL-Nozha market. This market lies on roadways. Therefore the originated pollutants from the traffic deposit on the leafy vegetable surfaces. As it is well known that, Pb is driven from the tetra allkyl lead, which used as antiknock additives in petrol (Boxter, 1989). Among the tested leafy vegetables Pb found in highest concentration in lettuce followed by spinach then grape leaves, roqutte, chard and radish leaves, respectively. These differences may be due to the variation in shape, surface area, and water content of leaves of such vegetables.

2- Cadmium (Cd): - The contamination sources of Cd include the emitted rubber dusts from car's wheel, fumes of plastic burning, and insecticide bearing Cd (Basovic and Cmelik, 1986). As seen from Table (1) the accumulation levels of such pollutant differed according to both types of leafy vegetables and selling markets. As mentioned in case of Pb, the vegetable obtained from Manshea EL-Nozha market is the highest in this pollutant. Except lettuce, and relatively both roqutte and chard, the average of Cd level in other tested vegetables exceeded the harmful value reported by(Egyptian standard specification, ESC, 1993) 0.1 mg/kg.

Table (1) Levels of some heavy metals (mg/kg) in some fresh leafy vegetables (on wet basis):

Metal*	Market	Fresh leafy vegetables						
		Lettuce	Radish	Roqutte	Spinach	Grape	Chard	Mean
Pb	A	0.5±0.07	0.2±0.02	0.3±0.30	0.4±0.09	0.3±0.06	0.2±0.03	0.1 ±0.32
	B	0.6±0.15	0.2±0.07	0.5±0.70	0.3±0.40	0.4±0.39	0.3±0.21	0.32 ±0.38
	C	1.2±0.16	0.2±0.01	0.5±0.13	0.9±0.13	0.5±0.01	0.3±0.81	0.21 ±0.6
	Mean	0.5±0.07	0.2±0.02	0.3±0.30	0.4±0.09	0.3±0.06	0.2±0.03	
Cd	A	0.05±0.13	0.1±0.30	0.09±0.02	0.26±0.45	0.14±0.40	0.09±0.01	0.23 ±0.13
	B	0.07±0.19	0.11±0.12	0.09±0.09	0.31±0.31	0.15±0.15	0.01±0.31	0.2±0.12
	C	0.17±0.17	0.17±0.10	0.12±0.12	0.42±0.60	0.17±0.03	0.12±1.1	0.19 ±0.2
	Mean	0.09±0.67	0.13±0.17	0.1±0.75	0.33±0.51	0.15±0.17	0.1±0.13	
Zn	A	6.3 ±0.77	7.3±0.31	7.8±0.30	7.7±0.09	6.9±0.02	5.8±0.10	6.9±0.27
	B	3.2±0.26	4.1±0.18	3.5±0.15	7.3±0.13	3.3±0.11	3.7±0.30	4.18±0.19
	C	2.8±0.45	3.1±0.26	2.5±0.41	4.2±0.80	3.1±0.43	3.1±0.04	3.1±0.39
	Mean	4.1±0.49	4.8±0.25	4.6±0.36	6.4±0.31	6.4±0.18	4.4±0.15	
Cu	A	2.1±0.93	2.2±0.19	2.2±0.25	3.9±0.28	3.9±0.09	0.4±0.03	0.3±2.95
	B	2.8±0.23	2.4±0.45	2.4±0.11	4.1±0.01	4.7±0.25	6.0±0.53	0.26 ±3.7
	C	3.2±0.03	2.9±0.58	4.9±0.10	4.9±0.17	4.9±0.47	0.4±0.47	0.23 ±3.5
	Mean	2.7±0.39	2.5±0.30	3.2±0.15	4.3±0.42	4.3±0.27	0.6±0.33	
Mn	A	3.4±0.57	3.1±0.11	3.9±0.27	4.4±0.99	4.9±0.78	3.0±0.19	0.49±4.1
	B	1.0±0.16	4.0±0.11	1.6±0.17	3.4±0.03	3.7±0.19	2.9±1.10	0.25 ±2.8
	C	1.8±0.10	2.1±0.12	1.1±0.20	3.0±0.23	2.8±0.11	2.7±1.72	0.42 ±2.25
	Mean	2.1±0.58	3.1±0.13	2.2±0.62	3.6±0.22	3.8±0.43	2.9±2.20	

A = Abeis B = Kafr El-Dwar C = Manshia El-Nozha

*Values are means of three replicates ± standard deviation.

3-Zinc (Zn): - However Zn found naturally in foods and also in human organisms, and zinc salts sometimes used instead of copper salts to increase the green color of vegetables, vegetables did not consider as a Zn supplying product. Shahat and El-saeid (2000) stated that Zn content in vegetables was less than 3.8 mg/kg. Data in Table (1) showed that the level of Zn in the fresh-unwashed leafy vegetables ranged from 4.1 to 6.4 mg/kg. The highest level was

found in spinach followed by radish leaves, roqutte, grape leaves, chard, and lettuce, respectively. The mean of Zn content in spinach and grape leaves were only exceeded the maximum recommended levels of(Egyptian standard specification, ESC, 1993)., 5 mg/kg In other vegetables, the average of Zn content was near from Egyptian standard recommended level. This means that such vegetables were subjected to pollution during growing, harvesting and selling. Also data in the Table (1) showed that the vegetables obtained from Abeis contained the highest level of Zn follows by those obtained from Kafr El-Dawar and Manshea EL-Nozha, respectively. This may be due to the practices used during marketing of such vegetables during selling

4-Copper (Cu): - Naturally food products contain small quantity of Cu, 0.6-15 mg/kg, (Mahadeviah and Gowramma 1980). Copper salts can contaminate food either by the use of fungicide containing Cu and/or cooking in preparation in copper vessels. (Mitchell, et al., 1976). As seen from the results in Table (1) the average of Cu in the tested vegetables ranged from 0.39 - 3.9 mg/kg. Generally the levels of Cu in all tested vegetables from the three markets were less than this reported in the (Egyptian specification ESC, 1993)., 5 mg/kg Generally, the presence of Cu was higher in Manshea EL-Nozha leafy vegetables than those purchased from other two markets. Also, Cu was found in highest level in grape leaves followed by spinach, roqutte, radish leaves, lettuce and chard, respectively.

5-Manganese (Mn): - Generally there is no standard legislation for Mn limit in fresh vegetables or food. The level of Mn ranged from 2.07 to 3.8 mg/kg in examined vegetables. It was highest in grape leaves followed by spinach, radish leaves, chard, roqutte and lettuce, respectively. The vegetables also obtained from Manshea EL-Nozha markets had the lowest level of Mn followed by Kafr El-dawar then Abeis. The market near from production area of such crops had the highest level of such element. El-saeid and Shahat (2000) considered the presence of Mn in some fruits and vegetables at a level of 0.5 - 5.4 mg/kg was higher than it was natural occurrence in plant tissues. The pollution of our tested samples by this metal may be due to the growing soil, irrigation water and/or the handling under pollution with Mn rich chemical compounds.

B- Effect of washing treatment on the removal of heavy metals: -

The leafy vegetables were washed by soaking in three different washing solutions, tap water, 2% NaCl and 2% acetic acid, then rinsed with tap water. The influence of such washing system on the reduction percentage of the studied heavy metals (as shown in Fig1 to Fig 5) was differed. This variation could be due to the type of vegetables, structure of their leaf surface, type and concentration of the metal pollutants, distribution and form of accumulation of such elements in these vegetables. From this study it was found that: -

The Pb level was ranged from 53.1 – 68.1, 55.2 –71.4 and 59.6 to 77.7 of after washing the tested leafy vegetables with tap water, NaCl and acetic acid solutions, respectively. About 72, 68.5, 64.9, 62.7, 57.3 and 55.9% of Pb in lettuce, radish leaves, spinach, roqutte, grape leaves and chard respectively were removed after washing. This means that washing of such vegetables lowered the level of the contaminated Pb to less than harmful value of such element as recommended by Egyptian standard (1993).

Washing the tested leafy vegetables with tap water, NaCl and acetic acid caused a reduction of Cd ranged from 51.5 – 65.8, 55.6 – 68.2 and 58.3 – 72.8%, respectively. The highest reduction of Cd after washing was in lettuce (~68.9), then radish leaves (~67.9) and lastly chard (~55.1%).

The reduction percent of Zn varied from 56.4 to 68.6, 58.5 to 70.2, and 61.1 to 72.4% after washing the tested vegetables with tap water, 2% NaCl and 2% acetic acid solution, respectively. The average of the reduction percentage of Zn after washing was approximately 70% in requtte, 67.55% in spinach, 66% in chard, 63% in lettuce and 59% in both radish and grape leaves. This means that washing removed more than 60% of Zn in the leafy vegetables, which found in free form. Such reduction reduces the Zn level in such products to less than the legislation level.

The reduction percent of Cu from leafy vegetables was ranged from 48.3 – 68.1, 51.3 –68.6, and 53.8 – 73.9% after using tap water, NaCl and acetic acid as a washing solutions respectively. The highest reduction of this pollutant was noticed after washing radish leaves (70%) then spinach (~67.8%), roqutte (~64.9%), lettuce (63.9), grape leaves (~56.5%), and lastly chard (~53.45).

The reduction percent in Mn after washing the vegetables by the three suggested washing solutions was less than occurred with Zn. The reduction percent of Mn after washing with tap water, NaCl and acetic acid was varied from 31.5 to 65.2, 34.1 to 69.4, and 38.7 to 72.2%, respectively. The highest Zn reduction after washing was in chard (≈69.6%) followed by spinach (~68.5%), radish leaves (~54.9%) lettuce (53.4%), grape leaves (~46.6%) and roqutte (~34.8%), respectively.

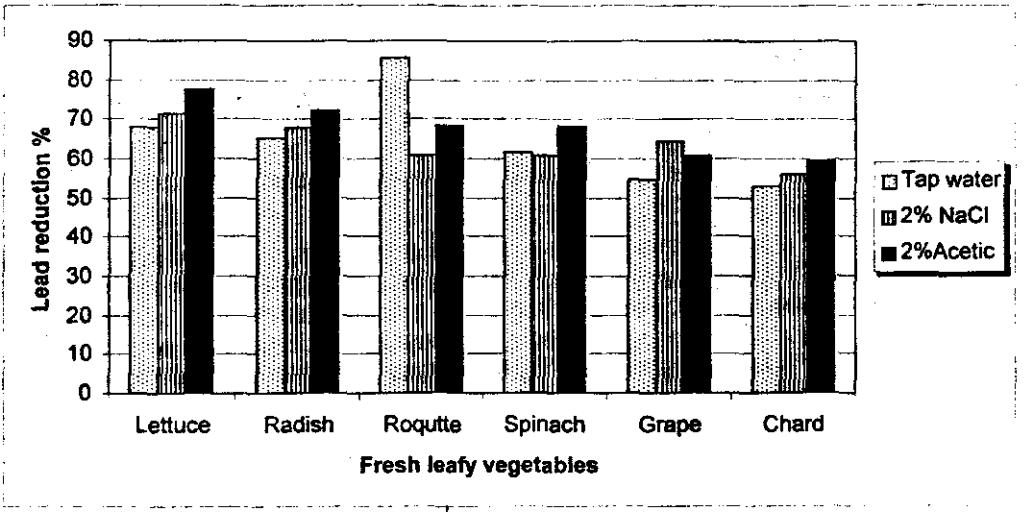

Fig. (1): Effect of washing some leafy vegetables on the reduction (%) of lead content.

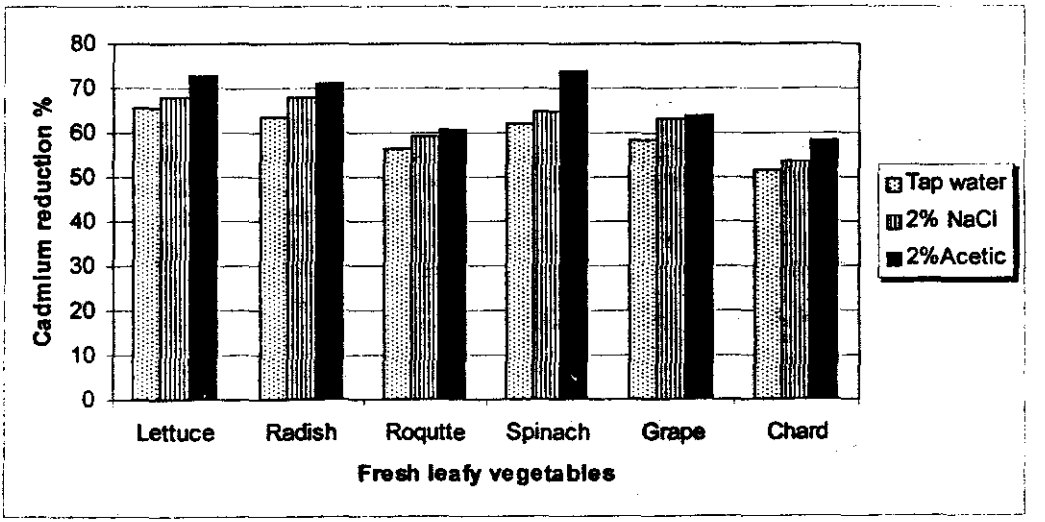

Fig. (2): Effect of washing some leafy vegetables on the reduction (%) of cadmium content

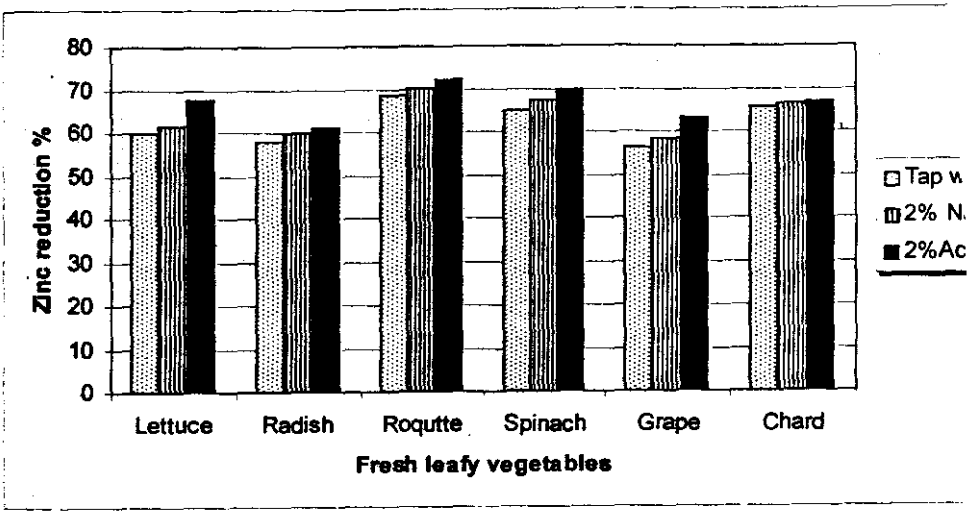

Fig. (3): Effect of washing some leafy vegetables on the reduction (%) of zinc content

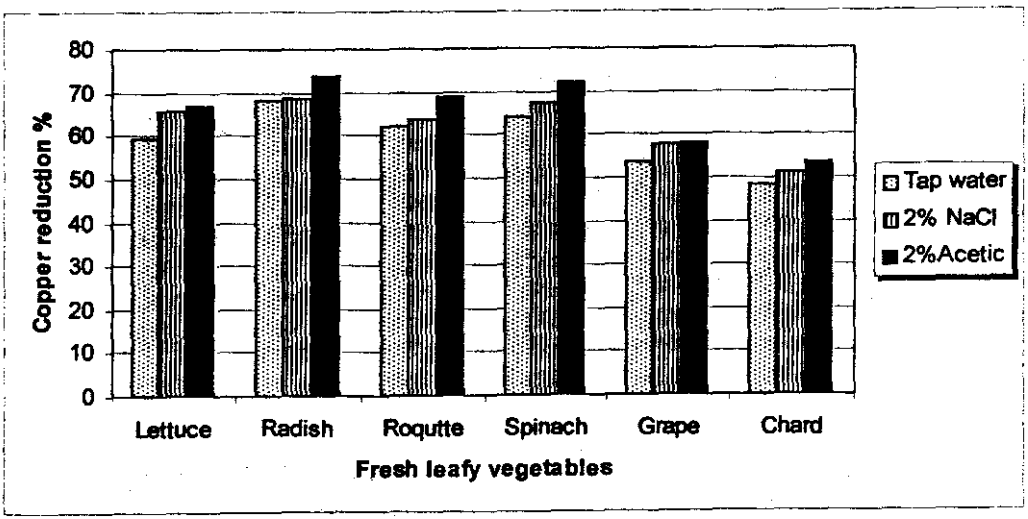

Fig. (4): Effect of washing some leafy vegetables on the reduction (%) of copper content

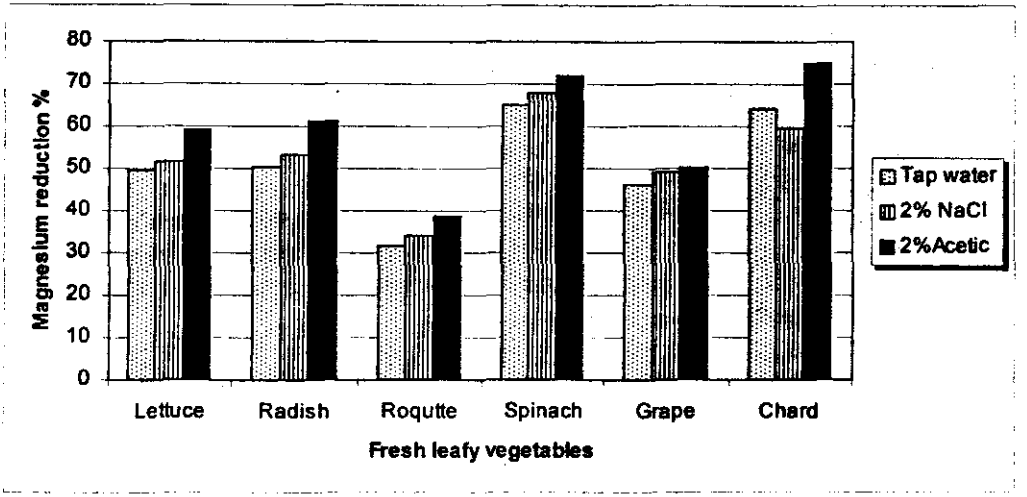

Fig. (5): Effect of washing some leafy vegetables on the reduction (%) of magnesium content.

The above results indicated that: -

washing.This percent of reduction reduced the level of such pollutants to less than their harmful values.

Removal of high percent of such pollutants indicated that most of these elements found in free form and also the main source of their presence in such vegetables was the superficial pollution especially Pb and Cd.

Generally high reduction in polluted elements was observed in vegetables containing high levels of such elements.

Due to the role of acetic acid as a weak acid, and the weak osmotic action of NaCl solution (2%), the reduction of polluted heavy metals was relatively higher when such solutions were used for washing comparing with tap water.

According to the results in this article, washing caused a reduction in the determined heavy metals of the tested vegetables ranging from 58.3 to 65.3% with an average of ~62.9%. These results in agreement with those obtained by El-saeid and Shahat, (2000), who postulated that washing of some raw vegetables and fruits caused a wide reduction (5- 55%) of heavy metals depending on type of metal and plant. Also, washing removes the heavy metals found in free form and presence on the surface of aerial parts of plants. Holubowiez (1998) showed that washing the fruits always reduced the heavy

metal content. Moreover, Basovic et al, (1986) showed that the reduction in Pb of lettuce after washing ranged from 27.45 to 76.1%. Furthermore, washing of salad vegetables caused reduction ranging from 34 to 90% in Pb, and from 7 to 45% in Cd (El-sharnouby and Abd El-All, 2003).

CONCLUSION

The above data confirmed: -

The importance of reducing the environmental pollution, utilization of pesticides bearing heavy metals, and the extension of farmer, sellers and consumers with the proper practices which must be practiced to avoid or minimize food pollution.

The importance of the selection of market position, and the changes in marketing and selling systems to avoid superficial pollution of food products with heavy metals.

The importance of washing process in the removal of pollutant residues.

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الملخص العربى

تأثير عملية الغسيل على التخلص من محتوى المعادن الثقيلة في بعض الخضراوات الورقية الطازجة والمجمعة من ثلاث أسواق مختلفة

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تم تقدير المحتوى من الرصاص و الكاد ميوم و الزنك والنحاس والمنجنيز في ست أنواع من الخضراوات الورقية الطازجة شملت الخس والفجل و الجرجير والسبانخ وورق العنب والسلق المشتراة من ثلاث أسواق للبيع وهـــى أبيس ومنشية النزهة فىمدينة الإسكندرية وشرق مدينة كفر الدوار وكذلك دراسة تأثير الغسيل بالنقع فى المـــاء و٢%كلوريد صوديوم و٢% حمض خليك لمدة نصف ساعة ثم الشطف بالماء الجاري لمدة دقيقتين على الـــتخلص مـــن هذه المعادن. أوضحت النتائج اختلاف تركيز كل من الرصاص و الكاد ميوم و الزنك والنحاس والمنجنيز ما بين ٠,٣١- ٠,٦١، ٠,١٢-٠,١٩٥، ٣,١٣-٦,٩٦، ٢,٤٥-٣,٥٣، ٢,٢٥-٣,٧٩ مجم /كجم على التوالـــي في الخضراوات الورقية قبل الغسيل وقد أدت عملية الغسيل إلى التخلص من اكثر من ٥٠%من هذه المعادن فيما عدا المنجنيز خاصة عند استخدام محلول حمض الخليك في الغسيل. وقد أدى هذا إلى خفض نسب المعـــادن إلـــى اقل من الحد الغير ضار بالصحة. و أكدت تلك النتائج أن المصدر الرئيسي لوجود هذه المعادن بالخضـــراوات الورقية هو التلوث الجوى وتؤكد الدراسة على أهمية خفض التلوث البيئي خاصة الجوى و تقليل اســـتخدام المبـــيدات المحتوية على المعادن السامة ودور الإرشاد لكل من المز ارع والمنتج والبائع والمستهلك لاتـــباع الطـــرق السليمة في نقل وتداول وتخزين الأغذية وكذلك إعادة النظر في اختيار مواقع الأسواق ونظام التسويق والبيع للمنتجات الغذائية وأهمية خطوة الغسيل خاصة للخضراوات الورقية الطازجة قبل الاستخدام.