ARTICLE / INVESTIGACIÓN

Parasitic contamination of some fresh and collected vegetables from Mosul City markets

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DOI. 10.21931/RB/2022.07.03.26

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Abstract: The current study specifies the rate of spreading the parasites in fresh vegetables sold in shops located on the left and right sides of the city of Mosul. 600 samples were collected, 300 for each side left and right, with 15 samples of each Lettuce, Celery, Pepper, Tomatoes, Onions and Carrots. Results showed significant differences in the rates of contaminating variables with intestinal parasites at probability level ($p<0.05$) on both sides, where it was noticed that the percentage of contamination on the right side (39%) was higher than the one on the left side(26%). The results also showed that fresh vegetables are contaminated with three types of intestinal parasites: *Entamoeba histolytica*, *Giardia Lamblia*, *Entamoeba coli*, and four types of intestinal worms as follows: *Ascaris lumbricoides*, *Trichuris trichura*, *Hymenolypis nana*, *Enterobius Vermiculoris*. The highest contamination percentage with intestinal protozoa was found with *Entamoeba histolytica* parasite (67%) on the left side. On the right side, the percentage of contamination was *Entamoeba histolytica* (50%) in each of the tomato plants and coriander., and the highest percentage of contamination with intestinal worms was by *Ascaris lumbricoides* worm on the left side (40%) and in the right side (29%). Also shown from the results, the percentage of single contamination in the fresh vegetables was higher than the double and triple contamination. The single contamination was found with a percentage of (82-95%) on both sides, respectively and also noticed in the current study, the leafy vegetables (lettuce and celery) and Tomato, which are the most vegetables contaminated with parasites in both sides in comparison with the rest types of vegetables.

Key words: Contamination, intestinal parasites, vegetables, left and right sides.

Introduction

Vegetables are essential to a healthy person's diet due to their nutritional value. Raw vegetables are an essential source of vitamins, fiber, and minerals. They contain vitamins necessary for the human body, such as vitamin C, E, and A, and other elements such as calcium, magnesium, potassium and iron. Regular consumption of vegetables is associated with a lower incidence of cardiovascular diseases because they do not contain cholesterol at all[1], but misusing them leads to significant damage. Reports in recent years pointed to frequent parasite contaminations resulting from eating fresh vegetables. Residents of many countries in the world eat raw vegetables or only expose them to the sun to keep their taste, which increases the possibility of parasites existing in them, and eventually, these parasites will easily reach humans[2,3].

Naturally, food is considered a source of contamination for humans if they are contaminated by collecting, producing or transporting. Also, using animal manure by farmers to fertilize the soil without exposing it to sunlight for some time may lead to the transport of parasites and infections in humans[4]. On the other hand, using drainage waters to irrigate plants is also considered essential for transporting all types of parasites to the soil, animals, and humans[5,6].

Parasites are widely spread in all countries of the world, including the developed ones; the percentage of contamination in these countries is estimated at 60%. The probability of the existence of parasites increases in societies that lack health awareness, and man is contaminated with those parasites through contaminated water, meat, fruit and contaminated vegetables. Some of these parasites are transported by insects, and some are transported from the mother to the fetus. Man is also considered a host for more than (100) types of parasites as forms of eelworms, cestode worms, trematoda, protozoa. Parasites also affect human tissues and organs, causing different symptoms such as diarrhea, bloating, malabsorption, dysentery and anemia, and some of them cause Asthma, arthritis, and skin ulceration[7,8].

Many survey studies have been made about parasites that associate fruit and vegetables in many countries of the world[9,10] among them a study by (11) in the Saudi Arabia Kingdom when the eggs of *Ancylostoma duadenale* and *Entamoeba coli* in cress, radish, lettuce and melon. In Tabriz in Iran, (1) could identify the *Ascaris lumbriocoides* and *Giardia lamblia* in parsley, lettuce, leek, and cress in Nigeria[1,2,4,5].

Because of the increase in consuming vegetables recently by man, and as far as these vegetables have dangerous disease effects if they are not well sterilized; then comes the current study aims to investigate the rate of the existence of worms, eggs and cysts of protozoa to avoid being affected by them because this may represent an environmental catastrophe.

Citation: Al-Niaeemi B. H., Ahmed N. M., Kharofa W. A. Parasitic contamination of some fresh and collected vegetables from Mosul City markets. Revis Bionatura 2022;7(3) 26. http://dx.doi.org/10.21931/RB/2022.07.03.26
Received: 19 March 2022 / **Accepted:** 7 April 2022 / **Published:** 15 Agoust 2022

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Materials and methods

Collecting of samples

In the current study (600) samples of fresh vegetables were collected (300 from the left side and 300 from the right side), (50) samples for each of these vegetables during the period of times (the 1st of March 2021, to 30th December 2021). The samples were collected randomly from the local markets on the right and left sides of the city of Mosul. Those vegetables included *Lactuca stavia* (Lettuce), *Apiumgraveolens* (Celery), *Capsicumannuum* (Papper), *Lycopersion esculentum* (Tomatoes), *Allium cepa* (Onion) and *Daucus carota* (Carrots). Then the samples were put in plastic bags, each alone in one bag; then, their titles were written on the bags and sent to the laboratory to search for cyst stages of protozoa and worms for six hours after collecting them.

Examination of samples

The vegetables were washed with a quantity of distilled water; after that, the water was refined with medical gauze to remove the big stuff, then the precipitate was allowed to be precipitated gradually where the refined water was poured, and (5) mm of the precipitate is taken and put in test tubes in the centrifuge for (5) minutes with a speed of (2000) cycle per minute. After that, the refined liquid will be poured, and a quantity of the precipitate is taken and put on a slide, then examined by microscope to investigate the protozoa cysts and worms eggs[12].

Statistical analysis

The data were analyzed using variance analysis and the famous analysis program SPSS v.17[13].

Results and discussion

Table (1) shows significant differences for the tested vegetables between the two sides, right and left, at probability level ($p<0.05$). Contamination on the right side was higher than on the left side; the percentage of celery contamination was (46%) on the right side, while on the left side, it was (34%). As for lettuce contamination, the percentage was (44%) on the right side, while on the left side, it was (38%). Also, carrot contamination was (34%) on the right side, while it was (18%) on the left side. Tomato contamination was (24%) on the right side compared to the left side, where it reached (20%). Onion contamination recorded high levels on the right side (42%), while on the left side, it was (22%). The same can be said about capsicum when it recorded (44%) of contamination on the right and (26%) on the left side.

These rates are higher than those which were recorded by (14) in Nigeria, which reached (4.6%) in a study for several vegetables and higher than the rate[11] reached in the Saudi Arabia Kingdom, which was (7.8%) where tap water was used for washing vegetables. The researcher pointed out that the percentage of contamination by worms, eggs and cysts stages reached (27.2%) in case of using the saline solution in washing vegetables.

The high contamination on the right side is due to sewage waters and human stools near markets. In addition, vegetables are irrigated or fertilized by animals and human stools instead of nitrogen fertilizer. Also, the existence of lonely animals in markets, considered middle hosts, works on transporting parasites to vegetables[15,16].

Table (1) the highest percentage of contamination shows in leafy vegetables (celery and lettuce), and this is due to the unorganized form of the leafs of such vegetables; also, the surface of their leafs contain big pores that let cysts and eggs of parasites to stick on it[15,17,18]. Using animal dung in developing countries has a great role in transporting the parasite infection. Farmers' ignorance in correct fertilizing methods for planted vegetables is considered among the main reasons for parasite contamination, and eventually, they transport these fertilizing methods to the plants[19]. In addition, insects play a role in transporting parasites mechanically to the green parts of the plants[11].

It is noticed from the table (2) that there are significant differences in vegetable contamination with intestinal protozoa on the left side at probability ($P<0.05$). The rate of contamination by *Entamoeba histolytica* of celery (41%). As for contamination by *Giardia lamblia* in celery, the rate reached at (29%), also contamination by Entamoeba coli parasites recorded a percentage of (0%).

The contamination by *E. histolytica* in carrots reached at (67%) and *G. lamblia* (22%), while the percentage by *E. coli* was (11%). Also, in tomatoes, the percentage of contamination by *E. histolytica* reached (40%), while by *G. lamblia*, it reached (36%). As for *E. coli*, the contamination rate was (0%). The contamination in onion by *E.histolytica* reached (64%), *G. lamblia* (36%) and *E. coli* (8%).

Vegetables	Left side			Right side		
	Number of examined samples	Number of contaminated samples	Percentage of contamination	Number of examined samples	Number of contaminated samples	Percentage of contamination
Celery	50	17	34%	50	32	46%
Lettuce	50	19	38%	50	22	44%
Carrot	50	09	18%	50	17	34%
Tomato	50	10	20%	50	12	24%
Onion	50	11	22%	50	21	42%
Capsicums	50	13	26%	50	22	44%
Percentage of contamination	In the left side		*26%	In the right side		*39%

*Refers to presence of significant differences at probability level P<0.05

Table 1. Percentage of vegetable contamination on the two sides (Left and Right).

Vegetables	*Entamoeba histolytica*			*Giardia lamblia*			*Entamoeba coli*		
	Total number of contaminated samples	Number of contaminated samples	Percentage of contamination	Total number of contaminated samples	Number of contaminated samples	Percentage of contamination	Total number of contaminated samples	Number of contaminated samples	Percentage of contamination
Celery	17	07	41%	17	05	29%	17	0	0%
Lettuce	19	08	42%	19	03	16%	19	01	5%
Carrots	09	06	67%	09	02	22%	09	01	11%
Tomato	10	04	40%	11	04	36%	11	0	0%
Onion	11	07	64%	11	04	36%	13	01	8%
Capsicum	13	02	15%	13	05	38%	13	01	8%
Percentage of contamination	*45%			*29%			*6%		

*refers to presence of significant differences at probability level P<0.05

Table 2. Percentage of vegetable contamination with intestinal protozoa on the left side.

Table (3) reveals the percentage of contamination by intestinal protozoa on the right side. Significant differences in vegetable contamination by intestinal protozoa were noticed (P<0.05). Results showed significant contamination by *Entamoeba histolytica* in all vegetable samples under study, when the contamination percentage in capsicum and Tomato reached (50%) both of them, respectively. As for celery; the percentage of contamination reached (43%), while the contamination in lettuce by *E. histolytica* reached (41%). The researcher[1] mentioned in his study that lettuce is one of the vegetables that is contaminated by eggs and cysts of parasites; when significant differences were found between lettuce on the one side and the rest types of vegetables, these rates were higher than those which were recorded by (11) in the Saudi Arabia Kingdom which reached (17%), and followed by wild cress plant with a percentage of (16%), these rates are less than those which are recorded by (11) in the Saudi Arabia Kingdom which reached (17%). As for Tomato, it reached (25%) and lettuce (23%). In celery, the rate of contamination by *Giardia lamblia* (22%). *Entamoeba coli* recorded the highest percentage of contamination in capsicum when it reached (9%) and celery also (9%).

It is noticed in the table (2 and 3) that the rate of contamination in both sides was high by *G. lamblia* and *E. histolytica*, this may be due to the appropriate environmental conditions for developing these phases and this type of parasites which transports by water and food and by the mechanical transporter (flies), or due to shitting near vegetable farms in addition to using stools for fertilizing beside washing vegetables by water contaminated with parasites cysts[20-24].

The reason behind the high rate of contamination on the left side is the existence of sewage water and human wastes near markets. Also, many vegetables are irritated by sewage waters or fertilized by human and animal stools instead of nitrogen fertilizer. Gatherings of stray animals in vegetable markets transport the parasites to the vegetables; accordingly, they are considered transporters for parasite phases[17,25].

In table (4), significant differences in the contamination of vegetables by intestinal worms were found on the left side at a level (P<0.05). The highest percentage of contamination in Tomato by *Ascaris lumbrcoides*, when it reached (40%). Also, the contamination of lettuce by *A. lumbrcoides* recorded a high percentage (37%). A high contamination rate also by *A. lumbrcoides* was found in each capsicum, onion and carrot (31%, 11%, 22%), respectively.

The current study's findings differed from the study of (26) in Jordan regarding the percentage of contamination in tomatoes and cucumbers by parasites when they were estimated (24%) and (13%) respectively. It also does not agree with the study of (15) in Egypt, where the percentage of contamination in onion was estimated (13%).

Vegetables	*Entamoeba histolytica*			*Giardia lamblia*			*Entamoeba coli*		
	Total number of contaminated samples	Number of contaminated samples	Percentage of contamination	Total number of contaminated samples	Number of contaminated samples	Percentage of contamination	Total number of contaminated samples	Number of contaminated samples	Percentage of contamination
Celery	23	10	43%	23	05	22%	23	02	9%
Lettuce	22	09	41%	22	05	23%	22	05	0%
Carrots	17	06	35%	17	02	12%	17	01	6%
Tomato	12	06	50%	12	03	25%	12	0	0%
Onion	21	05	24%	21	04	19%	21	01	5%
Capsicum	22	11	50%	22	07	32%	22	02	9%
The rate of contamination	*41%			*22%			*5%		

*refers to presence of significant differences at probability level P<0.05

Table 3. Percentage of vegetable contamination with intestinal protozoa on the right side.

vegetables	*Trichuris triclura*			*Ascaris lumbricoides*			*Enterobius vermicularis*		
	Total number of contaminated samples	Number of contaminated samples	Percentage of contamination	Total number of contaminated samples	Number of contaminated samples	Percentage of contamination	Total number of contaminated samples	Number of contaminated samples	Percentage of contamination
Celery	17	03	18%	17	05	29%	17	01	6%
Lettuce	19	05	26%	19	07	37%	19	0	0%
Carrots	09	01	11%	09	02	22%	09	0	0%
Tomato	10	03	30%	10	04	40%	10	0	0%
Onion	11	01	09%	11	02	11%	11	01	9%
Capsicum	13	03	23%	13	04	31%	13	0	0%
Rate of contamination	*20%			*30%			*2%		

* refers to presence of significant differences at probability level P<0.05

Table 4. Percentage of vegetable contamination with intestinal worms on the left side.

Tomato and lettuce are the most contaminated vegetables by *A. lumbrcoides*. Contamination by intestinal worms conforms a group of health problems, particularly in the developing and developing countries other than the rest areas of the world, and that is because of the high population in addition to little care of public health rules and the low health awareness and the spread of insects that work as intermedia host in transporting the diseases and worms very quickly in these areas[27].

They are also seen in areas where people suffer from insufficient nourishment. It is affirmed that there is a relation between contamination by intestinal worms and lousy nourishment, and it is a complicated relation and it is affected by many restrictions such as social, economic and biological circumstances and the type of life that an individual lives[28-30]. The spread of *Ascaris* worms and the rest of the intestinal parasites in societies is considered vital evidence that refers to the rate of environmental contamination by wastes and different levels of cleanliness[31].

It was noticed from the results that the percentage of contamination by *A. lumbricoides* worm was high in comparison with results of other studies when the percentage was very much higher than the results which were recorded by (32) in Baghdad governorate which reached (0.3%), and (33) in Karbala governorate when it reached (11%).

The closeness and difference in the percentage of contamination which is recorded in the current study in comparison with the above-mentioned studies are due to several reasons; amongst them the similar climate and environmental conditions of the country in general and the difference in the size of the sample and ages under study, in addition to using more than one different laboratory method in diagnosis. Also, the difference of duration of time that the study covered, and some other reasons such as shortage in municipality services, shortage of rain and the drought resulting from this shortage.

Table (5) showed no significant differences in contamination by intestinal worms on the right side. The contamination of carrots by eggs of *Ascaris* lumbricoides worm reached (18%.) As for onion, lettuce and celery, the contamination reached (14%, 0%, and 0%) respectively. Contamination by *Trichuris trichura*, the percentage of contamination reached at (14%) in lettuce and (0%) in Tomato, and (4%) in celery. Also, the contamination percentage in capsicum, onion, and carrots reached (5%, 10%, 12%) respectively. As for contamination by eggs of *Enterobius vermicularis* worm, it was recorded (29%) in carrots, and (19%) in onion, and (5%) in capsicum.

Contamination by intestinal worms eggs was observed on the right side because of bad social and economic circumstances and uncleanliness of markets of vegetables, and the wide spread of garbage and non-getting healthily rid of the garbage, in addition to the existence of hosts that bear many parasites such as mice and rats[34].

In the table (6), we can notice that there are significant differences in single, double and triple contamination in the examined vegetables on the left side at a level of (P<0.05). The rate of single contamination in tomatoes was high; it

The tested vegetables	*Hymenolypis nana*			*Enterobius vermicularis*			*Ascaris lumbricoides*			*Trichuris triclura*		
	Total number of contaminated samples	number of contaminated samples	Percentage of contamination	total number of contaminated samples	number of contaminated samples	Percentage of contamination	total number of contaminated samples	number of contaminated samples	Percentage of contamination	total number of contaminated samples	number of contaminated samples	Percentage of contamination
Celery	23	03	13%	23	04	17%	23	0	0%	23	01	4%
Lettuce	22	04	18%	22	04	18%	22	0	0%	22	03	14%
Carrots	17	01	6%	17	05	29%	17	03	18%	17	02	12%
Tomato		02	17%	12	02	17%	12	0	0%	12	01	0%
Onion	21	01	5%	21	04	19%	21	03	14	21	02	10
Capsicum	22	02	9%	22	01	5%	22	02	9%	22	01	5%
Rate of contamination	11%			18%			9%			9%		

Table 5. Percentage of vegetable contamination with intestinal worms on the right side.

reached (90%). Also, there was a high contamination rate in capsicum, and lettuce was recorded when they reached (85% and 84%) respectively. The rate of single contamination in onion was high too, it reached (82%), and in carrots, it reached at (78%), while in celery it reached (71%).

As for the double contamination, the highest rate was in celery (29%), carrots (22%), capsicum (15%), Tomato and lettuce and onion (10%, 11%, 9%), respectively.

Last in triple contamination; in onion, it reached (9%) and lettuce (5%), while no triple contamination case was recorded for some of the vegetables under study (capsicum, Tomato, carrots and celery).

It was noticed in table (7) that the percentage of all types of total contamination in the examined vegetables on the right side is as follows: single contamination in capsicum and lettuce was (95%) and carrots (94%). The current study accords with the researcher[35] noticed, when the rate of contamination in carrots conformed (50%), while a low rate of contamination was found in onion coriander, only one case was recorded for each onion and coriander, the rate in coriander was higher (16.7%) according to the severity contamination, It was also found that the rate of single contamination in one type of parasite (95%) higher than the rate in two or more other types. The current study accords with the study which was made in Morocco by (36) when the rate of single contamination was estimated (72%) higher than the double and triple ones[35] in Ethiopia also explained that single contamination is more common than the double and triple one when it was estimated (32%). The results that were made by (16) in Egypt showed that the contamination rate in summer is generally higher than in other seasons because high temperature and warmth of the climate may be a reason for the increase of contamination of vegetables by parasites in comparison with cold climate. Single contamination in celery and Tomato was (87%, 83%) respectively. As for onion, the rate of single contamination was (86%).

It is evident from tables (6 and 7) that the rate of single contamination in vegetables was high on both the right and left sides. The reason is that using animal stools in developing countries as fertilizers has a significant role in transporting parasite infection, in addition to the unorganized form of the leafs of some vegetables such as lettuce and parsley has a role in making the cysts and eggs of some parasites stick easily to these vegetables[18]. Also, the lack of experience in the correct methods of fertilization for some farmers is considered one of the main reasons for transporting the parasite infection to the plants[19], in addition to the role that the insects play in transporting the parasites mechanically to the green parts of the plants[11]. Diseases that parasites cause are among the main reasons for the occurrence of disease and death, particularly in tropical developing countries, and consuming vegetables is one of the primary mediators to transport parasites to human beings[37].

Conclusions

The research results showed that the environmental decline has an essential role in the contamination of vegetables with parasites, as high pollution results were recorded on the right side compared to the left side. It was observed that fresh vegetables were contaminated with some primitives and intestinal worms, where the highest percentage of contamination was recorded with the parasite *Entamoeba histolytica* and *Ascaris lumbricoides*. The percentage of single contamination in fresh vegetables is higher than the percentage of double and triple pollution on both the left and right sides. Leafy vegetables (lettuce, celery), as well as tomatoes, are the most types of vegetables contaminated with parasites on both sides compared to the rest of the vegetables.

Funding

Self-funding.

Vegetables	Rate of single contamination			Rate of double contamination			Rate of triple contamination		
	total number of contaminated samples	Number	Percentage of contamination	total number of contaminated samples	Number	Percentage of contamination	total number of contaminated samples	Number	Percentage of contamination
Celery	17	12	71%	17	5	29%	17	0	0%
Lettuce	19	16	84%	17	05	11%	19	01	5%
Carrots	09	07	78%	09	02	22%	10	0	0%
Tomato	10	09	90%	10	01	10%	10	0	0%
Onion	11	09	82%	11	01	9%	11	01	9%
Capsicum	13	11	85%	13	02	15%	13	0	0%
Rate of contamination	*82%			*16%			*2%		

* refers to presence of significant differences at probability level P<0.05

Table 6. Percentage of total contamination of vegetables on the left side.

Vegetables	Rate of single contamination			Rate of double contamination			Rate of triple contamination		
	Total contaminated number	Number	Percentage of contamination	Total contaminated number	Number	Percentage of contamination	Total contaminated number	Number	Percentage of contamination
Celery	23	20	87%	23	02	9%	23	01	4%
Lettuce	22	21	95%	22	01	5%	23	01	0%
Carrots	17	16	94%	17	01	6%	17	0	0%
Tomato	12	10	83%	12	02	17%	12	0	0%
Onion	21	18	86%	21	02	10%	21	01	5%
Capsicum	22	21	95%	22	01	5%	22	0	0%
Rate of contamination	*95%			*8%			*2%		

* refers to presence of significant differences at probability level P<0.05

Table 7. Percentage of total contamination of vegetables in the right side.

Acknowledgments

Research team wanted to dedicate their appreciation to the University of Mosul presidency, and to both College of Nursing and the College of Medicine deanery, for their technical and moral efforts to complete the work.

Conflicts of Interest

There is no conflict.

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