Parasitic Contamination in Raw Vegetables in Cities of the Sarawat Mountain Range of Saudi Arabia

Mohammed Abdullah Alqumber

Department of Laboratory Medicine, Faculty of Applied Medical Sciences, Albaha University, Saudi Arabia
dr.alqumber@gmail.com

Abstract: It is well known that foodborne infections can be transmitted to humans via vegetable consumption. The study reported here aimed to determine the prevalence of parasitic contamination on raw vegetables sourced from the mountainous southwestern region of the Kingdom of Saudi Arabia. The vegetables examined in this work included lettuce, green onions, cucumbers, carrots, spinach, tomatoes, parsley, ginger, radish and arugula. For each vegetable type, 20 samples were collected from the four markets included in the study, resulting in 800 samples used in subsequent analysis. More specifically, 200 samples were sourced from each main market of the main four cities located on the Sarawat mountain range of the Kingdom of Saudi Arabia, namely Altaif, Albaha, Baljurish and Abha. These samples were analyzed by a concentration method and examined by light microscopy. Helminth ova were detected in the examined vegetables. While the lowest contamination with helminth ova was detected in cucumbers, tomatoes and green onions, the highest contamination was observed in radishes, parsley, carrots, spinach and ginger. Moreover, the highest helminth ova contamination was seen in samples from Albaha (n = 38), followed by Baljurish (n = 30), Altaif (n = 25) and Abha (n = 22). *Trichuris trichiura* and *Trichostrongylus* were the most commonly detected infectious agents in the vegetables, while *Hemenolepis nana* was the least prevalent. The contamination of vegetables with infective ova emphasizes the need for adequate preventative measures that can assist in avoiding the transmission of diseases.

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1. Introduction

Vegetables are a very important source of various nutrients, including fiber, vitamins and minerals. Consuming them in raw and unprocessed form is recommended for maintaining good human health (Hjartaker et al., 2014). However, this increases the risk of foodborne infections, as during their growth, vegetables are highly susceptible to contamination from fertilizing manure, soil, water or animals (Park et al., 2012). In addition, it is known that, in developing countries and water-poor regions, the use of water-containing effluents, or those contaminated with human feces, for irrigation of crops can increase the rates of contamination with infective parasites (Guilherme et al., 1999; Habbari et al., 2000; Takayanagui et al., 2000). Contaminated vegetables are transmission vehicles for parasites unless they are cooked, washed or peeled. Among the diseases transmitted in this manner, most notable are *Entamoeba, Toxoplasma, Isospora, Cryptosporidium, Giardia, Hymenolepis* and hookworms (de Oliveira and Germano, 1992; Ogunba and Adedeji, 1986; Rude et al., 1984).

The Sarawart mountainous range of southwestern Saudi Arabia is known for the fertile lands, which are used for the production of may fruits and vegetables. The region is also home to several free-range animals, such as baboons, donkeys, dogs, cats, and many birds and rodents. Here, we collected samples of several vegetables from several southwestern cities of the kingdom of Saudi Arabia and examined them for the presence of different gastrointestinal parasites. All samples were analyzed by a concentration method and examined by light microscopy. The vegetables can be contaminated during their growth on the farmland, as well as during their transportation with other food products. It is not uncommon for contamination to occur during their processing or preparation. The main sources of contamination are soil or water contaminated with animal manure or feces. Thus, vegetables that are consumed raw, without prior peeling or washing, present a serious health risk. Parasites that can cause human infections via ingestion of contaminated foods include: *Giardia*, *Entamoeba*, *Toxoplasma*, *Isospora*, *Hymenolepis*, *Taenia*, *Ascaris, Fasciola*, *Trichuris*, *Trichostrongylus*, *strongyloides* and hookworms. It is known that infection with these parasites can cause malnourishment and stunted growth in humans due to either reduced food intake, or an increase in nutrient depletion due to the infection itself (Stephenson et al., 2000). Parasitic infection can also lead to vitamin (such as vitamin A, B6 and B12) and mineral (such as iron, calcium and magnesium) deficiencies due to reduced absorption. In addition, as the parasites consume these vital nutrients, they become unavailable to the host. Consequences of parasitic infection may also include weakened immunity and

increased predisposition to other serious diseases (Stephenson, 1994). Understanding the level of contamination of different vegetables can provide valuable information to regulatory bodies and consumers, helping reduce the risk of infection. The Sarawart regions of Saudi Arabia are important agricultural and livestock production areas located in the temperate mountainous areas of southwestern Saudi Arabia. Vegetables are grown throughout the year and are consumed by the local residents of the Kingdom of Saudi Arabia. The determination of the level of contamination of vegetables available for sale in the Sarawat mountainous range markets is possible using the currently available methods. This work present a survey of several gastrointestinal parasites of human importance in the vegetables produced and sold in the Sarawat mountainous range markets of the Kingdom of Saudi Arabia. The analyses performed as a part of this study included lettuce, green onions, cucumbers, carrots, spinach, tomatoes, parsley, ginger, radish and arugula. The collected samples were tested for the presence of the following parasites: *Hemenolepis nana, Taenia* species, *Trichuris trichiura, Ascaris lumbricoides, Toxocara canis, Enterobius vermicularis* and *Trichostrongylus* species. Cucumbers, tomatoes and green onions were found to be less contaminated than radishes, parsley, carrots, spinach and ginger. The results obtained emphasize the need for adequate preventative measures to avoid disease transmission.

2. Materials and Methods

Samples. Vegetable samples were obtained from the four main vegetable markets of the cities of Altaif, Albaha, Baljurish and Abha. For each vegetable (lettuce, green onions, cucumbers, carrots, spinach, tomatoes, parsley, ginger, radish and arugula) 20 samples were collected from the four markets included in the study, resulting in 800 samples available for analysis. More specifically, 200 samples from each main market of the main four cities located on the Sarawat mountain range of Saudi Arabia were examined. The collection was performed by simple random selection. First, each market vendor was assigned a number, which enabled us to randomly select 20 numbers using a jar containing numbered and folded yellow sticky notes. If a selected vendor did not provide some of the vegetables included in the survey, another number was selected randomly from the jar to provide the missing vegetable(s). Finally, the randomly selected vendors were asked to provide one sample each of lettuce, green onions, cucumbers, carrots, spinach, tomatoes, parsley, ginger, radish and arugula. These samples were transported to the laboratory at 4 °C within five hours and were subsequently used, as described below.

Detection of gastrointestinal pathogens. The method used by the United States Food and Drug Administration for the identification of parasitic contamination of raw fruits and vegetables was used as described previously (Bier, 1991). First, 200 g of each specimen was randomly obtained from each sample and then submerged in 1.5 l of a 1% (w/v) sodium dodecyl sulfate and 1% (v/v) tween 80 (Sigma-aldrich Chemie GmbH, Steinheim, Germany). Next, the sample was sonicated for 10 minutes, after which, 50 mL aliquots from the miscible were centrifuged for 15 minutes at 1500 g. The resulting sediments were examined microscopically at 10× and 40× magnifications using a light microscope (LABOMED®, Labo America Inc., USA).

3. Results

The random number assignment performed on generated 77 vendors from Altaif, 78 from Albaha, 67 from Baljurish and 81 from Abha. Helminth ova were detected in 277 cases, obtained from 115 samples (samples where usually contaminated with two or more types of ova). In other words, 14.4% of the total 800 samples tested were contaminated. The ova were identified as those of *Hemenolepis nana, Taenia* species, *Trichuris trichiura, A. lumbricoides, Toxocara canis, Enterobius vermicularis* and *Trichostrongylus* species. The highest contamination was observed in radishes, parsley, carrots, spinach and ginger, with the lowest contamination in samples of tomatoes, cucumbers and green onions. The highest helminth ova contamination was seen in samples from Albha (n = 38), followed by Baljurish (n = 30), Altaif (n = 25) and Abha (n = 22). *A. lumbricoides*, *Trichostrongylus* species, *Enterobius vermicularis, Trichuris trichiura*, and *Taenia* species were the most commonly detected infectious agents in this study, while *Hemenolepis nana* was the least common. Figure 1 presents the occurrence rates of different pathogens detected in the surveyed samples, while the occurrence rates of the different pathogens are depicted in Figure 2.

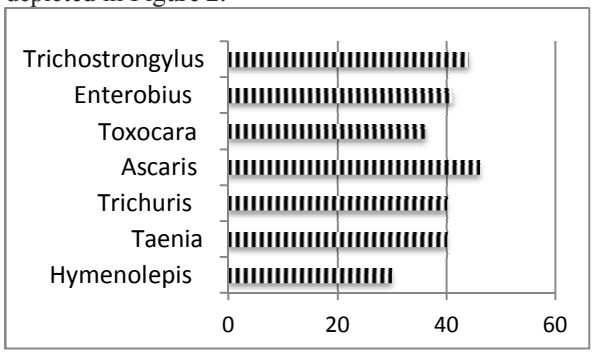

Figure 1: Occurrence of different intestinal parasites in all the surveyed vegetables.

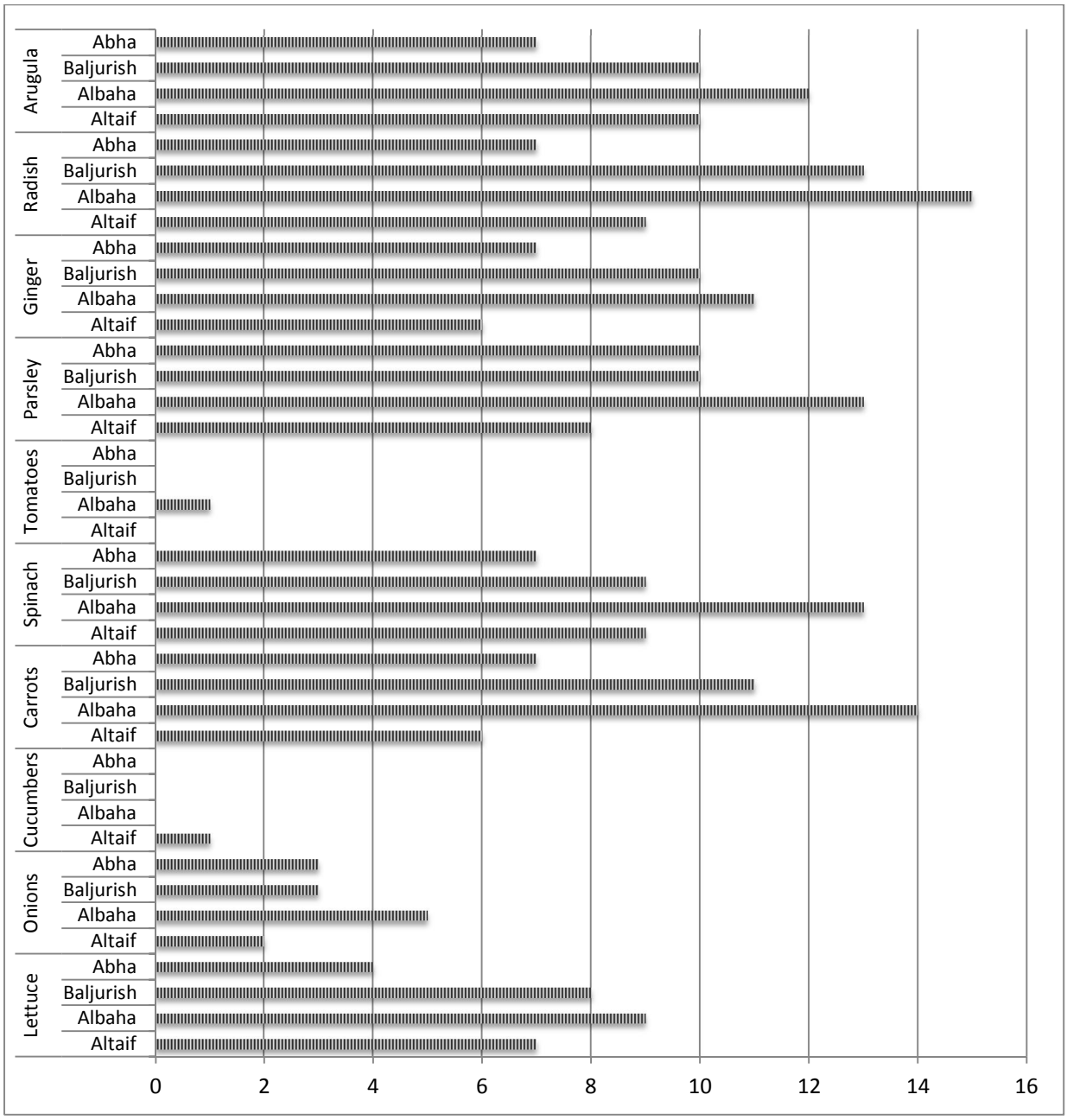

Figure 2: Frequency of all infectious agents per city and vegetable.

Figure 3 presents the occurrence of *Hemenolepis nana, Taenia* spp., *Trichuris trichiura, A. lumbricoides, Toxocara canis, Enterobius vermicularis* and *Trichostrongylus* species in the samples randomly selected from the four locations surveyed. Our observations also revealed that most vegetables are sold without being subjected to standard cleaning. Most of the packaging processes were carried out on the farms before transporting the vegetables to the vendors. Some products, such as tomatoes, were re-packaged into smaller cartons before sale by the vendors. Carrots and radishes were being sold inside sealed bags containing different quantities. The green leafy vegetables were tied in groups of 3-7 plants and sold as bundles. The bundles were stored by the vendors inside wet sackcloth and sold to the customers in plastic bags. Cucumbers were distributed to the vendors and sold to the consumers inside polystyrene boxes covered with a plastic sheet wrap. Ginger was stored by the vendors inside large carton boxes and sold to the consumers in kilogram portions placed inside plastic bags.

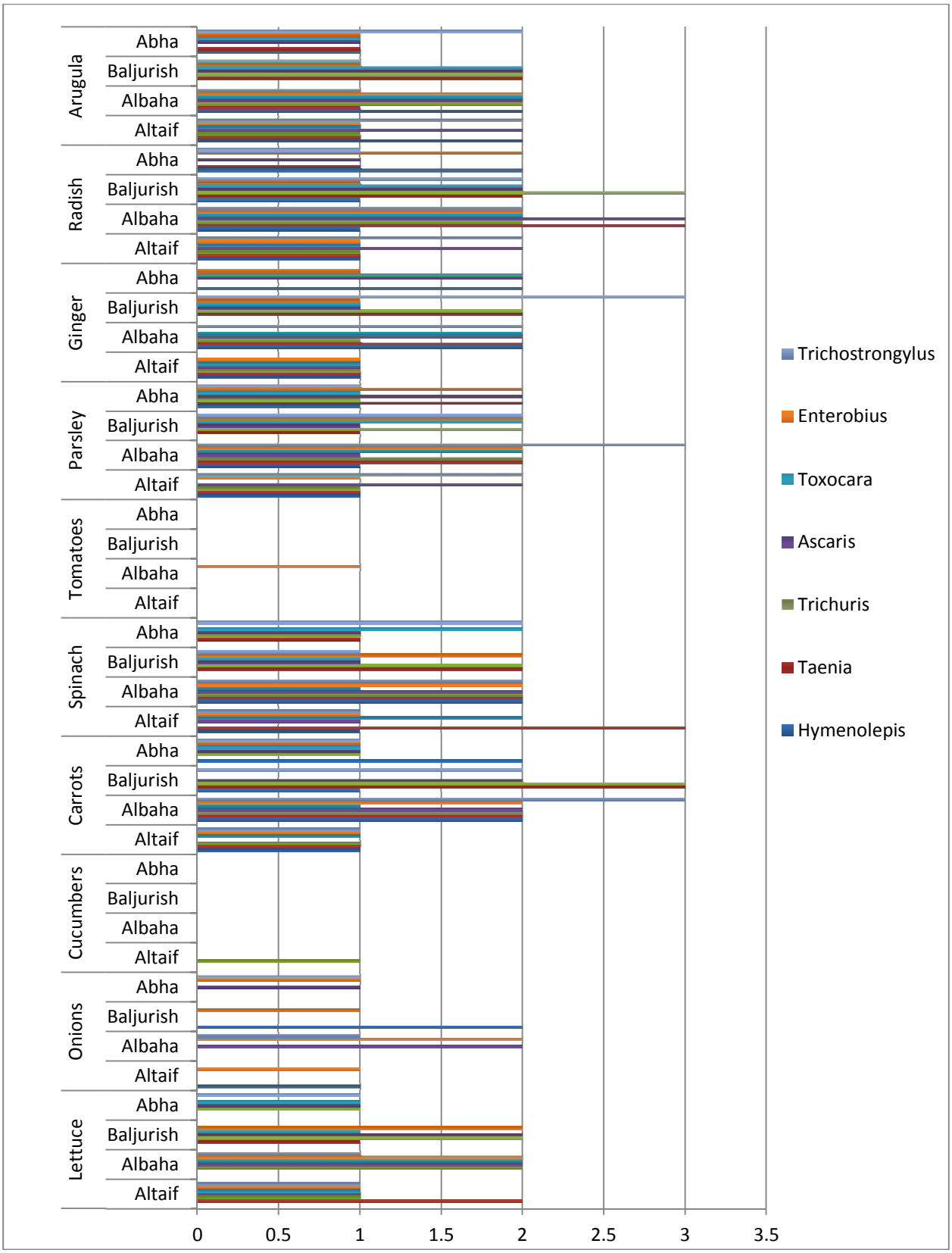

Figure 3: Distribution of the different infectious agents per city and vegetable.

4. Discussion

Intestinal parasites infect millions of individuals worldwide and consumption of contaminated vegetables has been implicated in the transmission of these parasites (Flint et al., 2005). Among the vegetables included in this study, radish, parsley, carrots, spinach and ginger were the most contaminated with helminth ova. Thus, these appear to pose the greatest risk to human health in the studied region. As 14.4% of the 800 samples tested were contaminated, this finding implies that failure to clean raw vegetables effectively can lead to infection. This may help explain the high rate of infection of gastrointestinal diseases in southwestern Saudi Arabia. In addition, most vegetables were found to be contaminated with more than one infective agent. In other words, the 14.4% contamination rate does not represent the risk of infection by a single pathogen, but rather multiple pathogens. The ova that were identified are those of *Hemenolepis nana, Taenia* - species, *Trichuris trichiura, A. lumbricoides, Toxocara canis, Enterobius vermicularis* and *Trichostrongylus* species. The lowest contamination was found in samples of tomatoes, cucumbers and green onions, which is not surprising as the last two usually grow on vines that are elevated from the soil surface, while green onions are peeled before sale. This could explain the low rate of contamination in these products. The highest helminth ova contamination was seen in samples from Albha (n = 38), followed by Baljurish (n = 30), Altaif (n = 25) and Abha (n = 22).

5. Conclusion

The survey revealed that 14.4% of the studied vegetable samples were contaminated with at least one of seven analyzed gastrointestinal parasites. Thus, vegetables sourced from the main vegetable markets in the mountainous southwestern region of the Kingdom Saudi Arabia need to be washed, peeled or cooked to avoid infection. This contamination—which was high in radishes, parsley, carrots, spinach and ginger, and low in samples of tomatoes, cucumbers and green onions—refers to the infective stages of *Hemenolepis nana, Taenia* spp., *Trichuris trichiura, A. lumbricoides, Toxocara canis, Enterobius vermicularis* and *Trichostrongylus* species. The highest helminth ova contamination was seen in samples from Albha (n = 38), followed by Baljurish (n = 30), Altaif (n = 25) and Abha (n = 22). Addressing safety procedures to avoid infection with these pathogens is therefore warranted.

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Corresponding Author:

Dr. Mohammed Abdullah Alqumber

Department of Laboratory Medicine, Faculty of Applied Medical Sciences, Albaha University, Saudi Arabia. E-mail: dr.alqumber@gmail.com

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