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Estimation of the Risk of Chronic Exposure of the Brazilian Population to Pesticide Residues by Eating Table Tomatoes

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HIGHLIGHTS

- Pesticide residues in foods can result in extremely harmful impacts on human health.
- Pesticide residues its have been identified in tomatoes.
- There was no of chronic dietary exposure risk to pesticides through of tomatoes.
- The tomatoes were safe for human consumption.

Abstract: This study estimated the risk of chronic exposure of the Brazilian population to pesticide residues by eating table tomatoes. This risk was evaluated taking into consideration 46 pesticides that were quantified in tomato samples by the Programa de Análise de Resíduos de Agrotóxicos em Alimentos (PARA) from 2013-2015. To identify those who were most susceptible to this risk, estimates were made considering the following population variables: gender (male and female); stage of life (adolescence, adult and old age); and place of residence (Brazilian zones and regions). The estimated daily intake (EDI) and the percentage of acceptable daily intake (%ADI) were determined to estimate the risk of chronic exposure. A risk of chronic exposure was considered when the %ADI was greater than 100%. The exposure of the total Brazilian population, men, women, adolescents, adults, the elderly, residents in urban and rural areas, and those living in the north, northeast, midwest, southeast and south regions to pesticides through the ingestion of tomatoes was safe because all the calculated %ADI were less than 100%. Thus, the Brazilian population was not exposed to chronic dietary risk when consuming tomatoes contaminated with pesticides.

Keywords: *Lycopersicon esculentum* Mill.; pesticides; chronic exposure; Brazil.

INTRODUCTION

The use of pesticides has been, until now, one of the main strategies used in agriculture for the control and prevention of pests and diseases and, consequently, the guarantee of a high production yield. According to the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) [1], more than 620,000 tons of active ingredients were sold in Brazil in 2019.

Although pesticides can help to generate economic benefits for the farming industry they can also remain in food in residual forms. When ingested through food, there is a possibility of pesticide residues result in extremely harmful impacts on human health.

According to the Pesquisa de Orçamentos Familiares (POF) [2], tomatoes were the most consumed vegetables by the Brazilian population compared to other vegetables mentioned in the survey. While the average per capita consumption of tomatoes was 6.5 g day^{-1}, the respective figures for cucumber, lettuce, kale and cabbage were 0.6, 3.6, 3.8 and 1 g day^{-1} [2].

The daily consumption of tomatoes promotes several benefits for human health. Their antioxidant constituints, and content of lycopene, β-carotene, vitamins A, C and E, selenium, zinc and phenolic compounds, promote functional properties which are responsible for the prevention of cancers and cardiovascular and circulatory diseases, for example [3].

In addition to their nutritional constituents, pesticides residues has been found in tomatoes [4-10]. Depending on the concentration and toxicological characteristics of pesticides, the harmful effects to health caused by these substances can outweigh the potential health benefits of the antioxidant constituents of tomatoes.

For this reason, the evaluation of dietary exposure to pesticides, and their association with the toxicity of these substances, not only makes it possible to identify possible risks to human health [11] but also aids the planning of public policies aimed at safe food production and risk management.

Thus, the aim of this study was to estimate the risk of chronic exposure of the Brazilian population to pesticide residues by eating table tomatoes.

MATERIAL AND METHODS

Study design

The study quantitative and documentary with deterministic methodology, consisted of the estimation of the risk of chronic exposure of the Brazilian population to pesticide residues by eating table tomatoes.

Estimation of the risk of chronic exposure of the population to pesticides

The estimation of the risk of chronic exposure of the population to pesticides was performed using the EDI (Formula 1) and the %ADI (Formula 2) [12]. The calculation of the EDI incorporated the concentration of a pesticide, the average per capita daily consumption of tomatoes, and the body weight of Brazilian population groups. The following population variables: the total Brazilian population; gender (male and female); stage of life (adolescence, adult and elderly); and place of residence (urban and rural areas, and the north, northeast, midwest, southeast and south regions) presented in different values for tomato consumption and body weight.

$$\text{EDI} = \frac{\text{Concentration of pesticide (mg kg}^{-1}\text{) x Consumption of food (kg)}}{\text{Body weight (kg)}} \quad (1)$$

$$\%\text{ADI} = \frac{\text{EDI}}{\text{ADI}} \text{ x } 100 \quad (2)$$

To determine the %ADI, the EDI calculated for each pesticide and population variable, and the ADI of the corresponding pesticide, were used. The ADI was extracted from monographs on pesticides whose use is authorized in Brazil [13]. The Codex Alimentarius [14] was used for pesticides that did not have an ADI in Brazil. A risk of chronic exposure was considered when the %ADI was greater than 100% [12].

Studied population

The estimation of the risk of chronic exposure was determined for the Brazilian population aged ten years and over, initially considering this as a whole (total). Subsequently, in order to identify Brazilians susceptible to risk, estimates were made according to the following population variables: gender (male and female); stage of life (adolescence, adult and elderly); and place of residence (zones and regions).

Population database

The population data were obtained from the POF 2008-2009 provided by the Instituto Brasileiro de Geografia e Estatística [2,15]. The daily average per capita consumption of tomatoes [2] and the body weight [15] of the population were extracted from the POF according to the evaluated group. The average body weight was calculated as the arithmetic mean of the medians [15].

Pesticides database

Information regarding the pesticides and their concentrations were derived from analyses of table tomato samples monitored by the PARA from 2013-2015. The concentrations of pesticides in tomato samples were requested from the Agência Nacional de Vigilância Sanitária (ANVISA) [16] and their use in this study was authorized by ANVISA.

Selection of pesticides

The pesticides quantified in the tomato samples by the PARA from 2013-2015 were selected for the present study. The PARA studied the potential presence of 202 pesticides in 730 samples of table tomatoes [9]. Residues of 63 pesticides were identified in the samples, 58 of which were quantified [9], as shown in Table 1.

Of the 58 pesticides quantified in the samples, it was found that four were prohibited in Brazil and eight were not permitted to be used in the production of table tomatoes, although they were allowed to be used in Brazil as a general rule [9]. Although they had been quantified, the EDIs and the %ADI of the pesticides banned in Brazil and the that were not authorized for use in the production of table tomatoes were not calculated. Thus, the EDI and the %ADI was calculated for 46 pesticides.

Table 1. Pesticides identified in table tomato samples by the Programa de Análise de Resíduos de Agrotóxicos em Alimentos (PARA) from 2013-2015 according to the chemical group to which they belong.

		Chemical group*	**Identified pesticides**[¥]
Unquantified pesticides	**Authorized in Brazil and in tomato production***	Imidazole	Cyazofamid
		Organophosphate	Malathion
	Authorized in Brazil but not in tomato production*	Benzoylureas	Flufenoxuron
		Strobilurin	Picoxystrobin
		Triazole	Epoxiconazole
Quantified pesticides	**Unauthorized in Brazil***	Benzofuranyl Methylcarbamate	Carbofuran
		Cyclodiene organochlorine	Endosulfan
		Organochlorine	Hexachlorocyclohexane
		Organophosphate	Methamidophos
	Unauthorized in tomato production*	Benzimidazole	Carbendazim
		Benzofuranyl Methylcarbamate	Carbosulfan
		Dicarboximides	Folpet
		Organophosphates	Acephate Chlorpyrifos
		Pyrethroid	Fenvalerate
		Pyrimidinyl carbinol	Fenarimol
		Triazole	Cyproconazole
	Authorized in Brazil and in tomato production*	Acylalaninate	Metalaxyl-m
		Alkyl sulfite	Propargite
		Anilides	Boscalid
		Benzimidazole	Thiabendazole
		Benzoylureas	Diflubenzuron Lufenuron Teflubenzuron
		Diacylhydrazine	Methoxyfenozide
		Dicarboximides	Iprodione Procymidone

Cont. Table 1

	Dimethylcarbamate	Pirimicarb
	Diphenyl ether	Etofenprox
	Dithiocarbamate	Dithiocarbamate (CS_2)
	Imidazolinone	Fenamidone
	Isophthalonitrile	Chlorothalonil
	Ketoenol	Spiromesifen
	Morpholine	Dimethomorph
	Neonicotinoids	Acetamiprid Clothianidin Imidacloprid Thiamethoxam
	Organophosphates	Dimethoate Phenthoate Profenofos Triazophos
	Oxadiazine	Indoxacarb
	Oxazolidinedione	Famoxadone
	Oxime methyl carbamate	Methomyl
	Pyrethroids	Bifenthrin Cyfluthrin Cypermethrin Deltamethrin Esfenvalerate Fenpropathrin Lambda-cyhalothrin Permethrin
	Pyridyloxy propyl ether	Pyriproxyfen
	Strobilurins	Azoxystrobin Pyraclostrobin Trifloxystrobin
	Triazinamide	Cyromazine
	Triazoles	Difenoconazole Flutriafol Metconazole Tebuconazole Tetraconazole

Sources: ¥Agência Nacional de Vigilância Sanitária [9] and *Agência Nacional de Vigilância Sanitária [13].

Treatment of concentrations of pesticides

The data related to pesticides, which were provided by ANVISA, were set out using a Microsoft Excel® (version 2016) spreadsheet. The data were distributed in seven columns, in the following order: food; active ingredient; limit of detection (LOD); limit of quantification (LOQ); number of samples (n); minimum result (mg kg^{-1}) and maximum result (mg kg^{-1}).

The pesticides presented one or more n, with n being the number of samples in which the substance was identified. Each n had a range of concentrations formed by the minimum and maximum results. Using Pires [17] as a reference, when the pesticide had a minimum result lower than the LOQ, the LOQ value was adopted as the concentration. The average concentration of the pesticides was then calculated. For the pesticides that contained two or more n, the weighted arithmetic mean (WAM) was determined using Formula 3 [18], where x is the midpoint of the interval between the minimum and maximum results, and n represents the number of samples. A WAM with three decimal places was defined for each pesticide and was used to calculate the EDI.

$$\text{Weighted arithmetic mean} = \frac{\sum x \cdot n}{\sum n} \quad (3)$$

RESULTS

According to the POF 2008-2009 [2], the average daily per capita consumption of tomatoes for Brazilians was 6.5 g, with men being the greatest consumers (7.3 g day^{-1}). Women consumed, on average, 5.8 g of tomatoes per day [2]. Regarding age groups, the research identified that tomatoes were more consumed by adults (7.2 g day^{-1}) and the elderly (6.2 g day^{-1}) than by adolescents (4.4 g day^{-1}) [2]. When stratifying the population according to place of residence, there was higher consumption by people who lived in urban areas (6.6 g day^{-1}) than in rural areas (6.1 g day^{-1}) [2]. The average per capita consumption of tomatoes In the Brazilian midwest, south, southeast, northeast and north was 11, 8.5, 7.9, 3.3 and 2.6 g day^{-1}, respectively [2].

Between 2013 and 2015, pesticide residues were found in tomato samples analyzed by the PARA [9]. Of the 202 pesticides surveyed in the 730 samples, 63 were identified, 58 of which were quantified [9]. The most detected pesticides were acephate, imidacloprid and carbendazim, residues of which were found in 353, 333 and 272 samples, respectively [9]. The highest concentration quantified by the PARA in tomatoes was 1.8240 mg kg^{-1} of cypermethrin [16]. Of the minimum concentrations, values lower than 0.0100 mg kg^{-1} were found, i.e. below the LOQ, for several pesticides [16].

When estimating chronic exposure to pesticides through tomato consumption for the total Brazilian population, and the population variables of gender, stage of life (Table 2) and place of residence in Brazil (Table 3), it was found that the calculated %ADI were less than 100% for all pesticides assessed in this study.

For all the population groups, triazophos was the pesticide with the highest %ADI (between 0.1266% and 0.5066%), while the lowest percentages were observed for dimethomorph (between 0.0006% and 0.0026%). When considered the women, adults, elderly people, residents of urban areas, and residents of the northeast and midwest regions it was found that thiabendazole had the same %ADI as dimethomorph. Thus, in general, exposure to pesticides represented less than 0.6% of the safe toxicological value. Therefore, the total Brazilian population, men, women, adolescents, adults, the elderly, and residents in urban and rural areas, and those living in the north, northeast, midwest, southeast and south regions, were not exposed to chronic dietary risk through consuming tomatoes contaminated with pesticides.

Other studies carried out in Brazil also concluded that tomato consumption did not contribute to the risk of chronic exposure to pesticides. Conceição [19] identified %ADI between 3 and 6.40% when assessing the risk of chronic exposure to dithiocarbamate fungicides present in tomatoes sold in the Federal District.

Similarly to the results of a study by Conceição [19], tomatoes in natura consumed in Minas Gerais did not contribute to chronic exposure to dithiocarbamate pesticides [20]. Carvalho and Barbosa [20] considered tomato consumption in 2006, 2007 and 2008; they found %ADI equal to 0.61, 0.36 and 0.71%, respectively.

On the other hand, studies have concluded that tomatoes were among the main foods that favored the ingestion of pesticides. Caldas and Souza [21] evaluated the chronic risk of pesticide ingestion in the Brazilian diet and found that tomatoes were responsible for almost all (96%) of the theoretical maximum daily intake (TMDI) of prothiophos (national %ADI = 270%). Together with rice, tomatoes contributed to 67% of the TMDI of mancozeb (national %ADI = 850%), while with potatoes the contribution was 52% for methamidophos intake (national %ADI = 460%) [21].

In another study conducted by Caldas and Souza [22], tomatoes were responsible for 95, 76, 79 and 37% of the intake of the pesticides prothiophos (national %ADI = 270%), metam sodium (national %ADI = 120%), iminoctadine (national %ADI = 50%) and propineb (national %ADI = 50%), respectively.

A study by Enes and Silva [23] found that prothiophos intake was mostly derived from tomatoes. When considering consumption data for rice, beans, potatoes, tomatoes, onions and coffee, prothiophos presented %ADI equal to 284, 287 and 290.16% for the populations of Rio Grande do Sul, Paraná and Santa Catarina, respectively [23].

Similarly to the present study, the aforementioned authors used a deterministic methodology to assess the risk of chronic exposure to pesticides. It is noteworthy that Caldas and Souza [21,22] and Enes and Silva [23] used the maximum residue limit (MRL) to estimate the ingestion of pesticides. They simulated exposure to the maximum concentration of acceptable residue in the evaluated foods, ruling out the possibility of eliminating pesticides until the moment of consumption. It is important to stress that in the period in which these studies [21-23] were carried out, access to information regarding the concentrations of pesticides in food was limited, which explains the use of the MRL in the estimation of intake.

The results of the present study are considered satisfactory because they demonstrate that tomatoes were safe for consumption. However, the existence of evidence that tomatoes are an important contributor to chronic dietary exposure to pesticides justifies the need for such an assessment to be carried out periodically, taking into account data that reflect conditions closer to reality.

Table 2. Percentage of acceptable daily intake of pesticides for the total Brazilian population and according to the population variables of gender and stage of life.

Chemical group*	Pesticide	ADI[¥]	%ADI[€]					
			Total	Gender		Stage of life		
				Male	Female	Adolescent	Adult	Elderly
Acylalaninate	Metalaxyl-m	0,0800*	0,0025	0,0026	0,0023	0,0019	0,0024	0,0021
Alkyl sulfite	Propargite	0,0100*	0,0390	0,0415	0,0368	0,0310	0,0375	0,0332
Anilides	Boscalid	0,0400*	0,0169	0,0180	0,0160	0,0134	0,0163	0,0144
Benzimidazole	Thiabendazole	0,1000*	0,0016	0,0017	0,0015	0,0013	0,0015	0,0013
Benzoylureas	Diflubenzuron	0,0200*	0,0056	0,0060	0,0053	0,0045	0,0054	0,0048
	Lufenuron	0,0200*	0,0112	0,0120	0,0106	0,0089	0,0108	0,0096
	Teflubenzuron	0,0100*	0,0281	0,0299	0,0265	0,0223	0,0269	0,0239
Diacylhydrazine	Methoxyfenozide	0,0100*	0,0168	0,0179	0,0159	0,0134	0,0162	0,0143
Dicarboximides	Iprodione	0,0600*	0,0045	0,0048	0,0042	0,0036	0,0043	0,0038
	Procymidone	0,1000*	0,0103	0,0110	0,0098	0,0082	0,0099	0,0088
Dimethylcarbamate	Pirimicarb	0,0200*	0,0101	0,0108	0,0095	0,0080	0,0097	0,0086
Diphenyl ether	Etofenprox	0,0300*	0,0767	0,0817	0,0725	0,0609	0,0737	0,0653
Dithiocarbamate	Dithiocarbamate	0,0300*	0,1406	0,1497	0,1327	0,1116	0,1349	0,1196
Imidazolinone	Fenamidone	0,0300*	0,0094	0,0100	0,0088	0,0074	0,0090	0,0080
Isophthalonitrile	Chlorothalonil	0,0300*	0,0259	0,0276	0,0244	0,0205	0,0249	0,0220
Ketoenol	Spiromesifen	0,0180*	0,0156	0,0166	0,0147	0,0124	0,0150	0,0133
Morpholine	Dimethomorph	0,2000**	0,0015	0,0016	0,0015	0,0012	0,0015	0,0013
Neonicotinoids	Acetamiprid	0,0240*	0,0273	0,0291	0,0258	0,0217	0,0262	0,0232
	Clothianidin	0,0900*	0,0023	0,0025	0,0022	0,0019	0,0022	0,0020
	Imidacloprid	0,0500*	0,0107	0,0114	0,0101	0,0085	0,0102	0,0091
	Thiamethoxam	0,0200*	0,0237	0,0253	0,0224	0,0188	0,0228	0,0202
Organophosphates	Dimethoate	0,0020**	0,1932	0,2057	0,1824	0,1533	0,1855	0,1643
	Phenthoate	0,0030**	0,1572	0,1674	0,1484	0,1248	0,1509	0,1337
	Profenofos	0,0100*	0,0275	0,0293	0,0260	0,0219	0,0264	0,0234
	Triazofos	0,0010*	0,3032	0,3228	0,2863	0,2406	0,2910	0,2579
Oxadiazine	Indoxacarb	0,0100*	0,0112	0,0120	0,0106	0,0089	0,0108	0,0096
Oxazolidinedione	Famoxadone	0,0060*	0,0842	0,0897	0,0795	0,0668	0,0808	0,0716
Oxime methyl carbamate	Methomyl	0,0200**	0,0067	0,0072	0,0064	0,0053	0,0065	0,0057
Pyrethroids	Bifenthrin	0,0200*	0,0188	0,0200	0,0177	0,0149	0,0180	0,0160
	Cyfluthrin	0,0200*	0,0171	0,0182	0,0162	0,0136	0,0164	0,0146
	Cypermethrin	0,0500*	0,2028	0,2159	0,1915	0,1610	0,1947	0,1725
	Deltamethrin	0,0100*	0,0281	0,0299	0,0265	0,0223	0,0269	0,0239
	Esfenvalerate	0,0200*	0,0542	0,0577	0,0512	0,0430	0,0520	0,0461
	Fenpropathrin	0,0300*	0,0464	0,0494	0,0438	0,0368	0,0445	0,0395
	Lambda-cyhalothrin	0,0500*	0,0317	0,0337	0,0299	0,0251	0,0304	0,0269
	Permethrin	0,0500*	0,0033	0,0035	0,0031	0,0026	0,0031	0,0028

Cont. Table 2

Pyridyloxy propyl ether	Pyriproxyfen	0,1000*	0,0056	0,0060	0,0053	0,0045	0,0054	0,0048	
Strobilurins	Azoxystrobin	0,0200*	0,0091	0,0097	0,0086	0,0072	0,0087	0,0077	
	Pyraclostrobin	0,0400*	0,0083	0,0089	0,0079	0,0066	0,0080	0,0071	
	Trifloxystrobin	0,0300*	0,0054	0,0057	0,0051	0,0043	0,0051	0,0046	
Triazinamide	Cyromazine	0,0200*	0,0337	0,0359	0,0318	0,0267	0,0323	0,0287	
Triazoles	Difenoconazole	0,0600*	0,0089	0,0095	0,0084	0,0070	0,0085	0,0076	
	Flutriafol	0,0100*	0,0141	0,0151	0,0134	0,0112	0,0136	0,0120	
	Metconazole	0,0480*	0,0038	0,0040	0,0036	0,0030	0,0036	0,0032	
	Tebuconazole	0,0300*	0,0215	0,0229	0,0203	0,0170	0,0206	0,0183	
	Tetraconazole	0,0050*	0,0416	0,0442	0,0392	0,0330	0,0399	0,0353	

¥ADI - Acceptable daily intake (mg kg of body weight per day^{-1}).
€%ADI – Percentage of acceptable daily intake (%).
Sources: *Agência Nacional de Vigilância Sanitária [13] and **Codex Alimentarius [14].

Table 3. Percentage of acceptable daily intake of pesticides for the Brazilian population according to place of residence (zones and regions).

Chemical group*	Pesticide	ADI¥	%ADI€						
			Zone		Brazilian region				
			Urban	Rural	North	Northeast	Midwest	Southeast	South
Acylalaninate	Metalaxyl-m	0,0800*	0,0025	0,0024	0,0010	0,0013	0,0041	0,0029	0,0031
Alkyl sulfite	Propargite	0,0100*	0,0392	0,0384	0,0163	0,0207	0,0652	0,0464	0,0491
Anilides	Boscalid	0,0400*	0,0170	0,0167	0,0071	0,0090	0,0283	0,0201	0,0213
Benzimidazole	Thiabendazole	0,1000*	0,0016	0,0016	0,0007	0,0008	0,0026	0,0019	0,0020
Benzoylureas	Diflubenzuron	0,0200*	0,0056	0,0055	0,0023	0,0030	0,0094	0,0067	0,0071
	Lufenuron	0,0200*	0,0113	0,0110	0,0047	0,0060	0,0188	0,0134	0,0141
	Teflubenzuron	0,0100*	0,0282	0,0276	0,0117	0,0149	0,0469	0,0334	0,0353
Diacylhydrazine	Methoxyfenozide	0,0100*	0,0169	0,0166	0,0070	0,0089	0,0281	0,0200	0,0212
Dicarboximides	Iprodione	0,0600*	0,0045	0,0044	0,0019	0,0024	0,0075	0,0053	0,0057
	Procymidone	0,1000*	0,0104	0,0102	0,0043	0,0055	0,0173	0,0123	0,0130
Dimethylcarbamate	Pirimicarb	0,0200*	0,0102	0,0099	0,0042	0,0054	0,0169	0,0120	0,0127
Diphenyl ether	Etofenprox	0,0300*	0,0771	0,0755	0,0320	0,0407	0,1282	0,0913	0,0966
Dithiocarbamate	Dithiocarbamate	0,0300*	0,1413	0,1382	0,0587	0,0746	0,2349	0,1672	0,1769
Imidazolinone	Fenamidone	0,0300*	0,0094	0,0092	0,0039	0,0050	0,0156	0,0111	0,0118
Isophthalonitrile	Chlorothalonil	0,0300*	0,0260	0,0255	0,0108	0,0137	0,0433	0,0308	0,0326
Ketoenol	Spiromesifen	0,0180*	0,0157	0,0153	0,0065	0,0083	0,0261	0,0185	0,0196
Morpholine	Dimethomorph	0,2000**	0,0016	0,0015	0,0006	0,0008	0,0026	0,0018	0,0019
Neonicotinoids	Acetamiprid	0,0240*	0,0274	0,0268	0,0114	0,0145	0,0456	0,0325	0,0344
	Clothianidin	0,0900*	0,0024	0,0023	0,0010	0,0012	0,0039	0,0028	0,0029
	Imidacloprid	0,0500*	0,0107	0,0105	0,0045	0,0057	0,0178	0,0127	0,0134
	Thiamethoxam	0,0200*	0,0238	0,0233	0,0099	0,0126	0,0396	0,0282	0,0299

Cont. Table 3

Organophosphates	Dimethoate	0,0020**	0,1942	0,1900	0,0807	0,1025	0,3228	0,2298	0,2432
	Phenthoate	0,0030**	0,1580	0,1546	0,0656	0,0834	0,2627	0,1870	0,1979
	Profenofos	0,0100*	0,0277	0,0271	0,0115	0,0146	0,0460	0,0327	0,0347
	Triazofos	0,0010*	0,3047	0,2982	0,1266	0,1608	0,5066	0,3606	0,3816
Oxadiazine	Indoxacarb	0,0100*	0,0113	0,0110	0,0047	0,0060	0,0188	0,0134	0,0141
Oxazolidinedione	Famoxadone	0,0060*	0,0846	0,0828	0,0352	0,0447	0,1407	0,1002	0,1060
Oxime methyl carbamate	Methomyl	0,0200**	0,0068	0,0066	0,0028	0,0036	0,0113	0,0080	0,0085
Pyrethroids	Bifenthrin	0,0200*	0,0189	0,0185	0,0078	0,0100	0,0314	0,0223	0,0236
	Cyfluthrin	0,0200*	0,0172	0,0168	0,0072	0,0091	0,0286	0,0204	0,0216
	Cypermethrin	0,0500*	0,2038	0,1994	0,0847	0,1076	0,3388	0,2412	0,2553
	Deltamethrin	0,0100*	0,0282	0,0276	0,0117	0,0149	0,0469	0,0334	0,0353
	Esfenvalerate	0,0200*	0,0545	0,0533	0,0226	0,0287	0,0905	0,0644	0,0682
	Fenpropathrin	0,0300*	0,0466	0,0456	0,0194	0,0246	0,0775	0,0552	0,0584
	Lambda-cyhalothrin	0,0500*	0,0318	0,0311	0,0132	0,0168	0,0529	0,0376	0,0398
	Permethrin	0,0500*	0,0033	0,0032	0,0014	0,0017	0,0054	0,0039	0,0041
Pyridyloxy propyl ether	Pyriproxyfen	0,1000*	0,0056	0,0055	0,0023	0,0030	0,0094	0,0067	0,0071
Strobilurins	Azoxystrobin	0,0200*	0,0091	0,0089	0,0038	0,0048	0,0152	0,0108	0,0114
	Pyraclostrobin	0,0400*	0,0084	0,0082	0,0035	0,0044	0,0139	0,0099	0,0105
	Trifloxystrobin	0,0300*	0,0054	0,0053	0,0022	0,0028	0,0090	0,0064	0,0068
Triazinamide	Cyromazine	0,0200*	0,0339	0,0331	0,0141	0,0179	0,0563	0,0401	0,0424
Triazoles	Difenoconazole	0,0600*	0,0089	0,0087	0,0037	0,0047	0,0148	0,0106	0,0112
	Flutriafol	0,0100*	0,0142	0,0139	0,0059	0,0075	0,0236	0,0168	0,0178
	Metconazole	0,0480*	0,0038	0,0037	0,0016	0,0020	0,0063	0,0045	0,0047
	Tebuconazole	0,0300*	0,0216	0,0211	0,0090	0,0114	0,0359	0,0255	0,0270
	Tetraconazole	0,0050*	0,0418	0,0409	0,0173	0,0220	0,0694	0,0494	0,0523

¥ADI - Acceptable daily intake (mg kg of body weight per day^{-1}).
€%ADI – Percentage of acceptable daily intake (%).
Sources: *Agência Nacional de Vigilância Sanitária [13] and **Codex Alimentarius [14].

CONCLUSION

The total Brazilian population, men, women, adolescents, adults, the elderly, and residents in urban and rural areas, and regions in the north, northeast, midwest, southeast and south were not exposed to chronic dietary risk when consuming tomatoes contaminated with pesticides. Thus, tomatoes were safe for human consumption.

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