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Incidence of pesticides on the quality of *Solanum Lycopersicum* tomato in the supply of retail markets in the city of Lima, Peru

Incidência de agrotóxicos na qualidade do tomate *Solanum Lycopersicum* no abastecimento de mercados varejistas na cidade de Lima, Peru

Incidencia de los plaguicidas en la calidad del tomate *Solanum Lycopersicum* en la oferta de los mercados minoristas de la ciudad de Lima Perú

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The results presented can serve as a guide for the design of future public policies involving combating or promoting the use of pesticides in tomato cultivation.
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The article addresses in detail a subject that has been little explored by natural sciences research in the Ecuadorian context.

ABSTRACT

The objective of this research article was to describe the incidence of pesticides on the quality of Solanum Lycopersicum tomatoes in the supply of retail markets in the city of Lima, Peru, by consulting updated bibliographic sources related to the subject under study. The methodology used was documentary analysis, with a general descriptive and descriptive approach. The search for information was carried out by means of an initial selection based on the abstracts and titles of the available information, identifying potentially eligible articles in the different Google Scholar and SciELO databases. The population consisted of 25 documents registered under the format of articles/books consulted, selected through criteria, being conformed by a total of six (06) documents. It has been found in the bibliographic review that the use of pesticides in tomato, not only affects its quality, but also that of traders and the ecosystem itself; however, it was found that the expenses produced by the investment lead the farmer to look for mechanisms to increase his profit, such as the use of substances that can reduce the pests that naturally affect this type of vegetable. It was discovered that growers lack techniques for spraying, and that spraying is carried out profusely, as well as inadequate post-harvest vegetable handling techniques. Finally, it was determined that there are factors that are considered as determinants of tomato quality such as characteristics; firmness, durability, uniformity and area of origin; however, in most retail markets this denomination is identified more with commercial aspects.

Keywords: Tomato, pesticides, trade.

RESUMO

O objetivo deste artigo de pesquisa foi descrever a incidência de agrotóxicos na qualidade do Tomate Solanum Lycopersicum no abastecimento de mercados varejistas da cidade de Lima, Peru, para o qual foi realizada a consulta de fontes bibliográficas atualizadas inerentes ao assunto. em estudo. A metodologia utilizada foi a análise documental, com descrição geral e abordagem descritiva. A busca das informações foi realizada por meio de uma seleção inicial feita com base nos resumos e títulos das informações disponíveis, identificando artigos potencialmente elegíveis nas diferentes bases de dados Google Acadêmico e SciELO. A população foi composta por 25 documentos cadastrados no formato de artigos/livros consultados, dos quais foram selecionados através de critérios, sendo composta por um total de 06 (seis) documentos. Constatou-se na revisão bibliográfica que se identifica claramente que o uso de agrotóxicos no tomate não afeta apenas a sua qualidade, mas também a dos comerciantes e do próprio ecossistema; porém, constatou-se que os gastos gerados pelo investimento levam o agricultor a buscar mecanismos que aumentem seu lucro, como a utilização de substâncias que possam reduzir as pragas que afetam naturalmente esse tipo de hortaliça. Descobriu-se a falta de técnicas nos produtores para realizar fumigações; bem como que esta é realizada de forma profusa e as técnicas inadequadas de manejo da hortaliça pós-colheita. Por fim, constatou-se que existem fatores que são considerados determinantes da qualidade do tomate como características; firmeza, durabilidade, uniformidade e área de origem; no entanto, na maioria dos mercados retalhistas esta denominação é mais identificada com aspectos comerciais.

Palabras clave: Tomate, pesticidas agrotóxicos, comércio.

RESUMEN

El objetivo de este artículo de investigación fue describir la incidencia de los plaguicidas en la calidad del Tomate Solanum Lycopersicum en la oferta de los mercados minoristas de la ciudad de Lima Perú, para lo cual se realizó la consulta a fuentes bibliográficas actualizadas inherentes a la temática en estudio. La metodología empleada fue análisis documental, con enfoque de descripción general y de carácter descriptivo. La búsqueda de la información se llevó a cabo mediante una selección inicial que se realizó con base en los resúmenes y títulos de la información disponible, identificándolos artículos potencialmente elegibles en las distintas bases de datos Google Académico y SciELO. La población estuvo conformada por 25 documentos registrados bajo el formato de artículos/libros consultados, de los cuales se seleccionaron a través de criterios, quedando conformados por un total de seis (06) documentos. Se ha encontrado en la revisión bibliografía, que está claramente identificado que la utilización de plaguicidas en el tomate, no solo afecta su calidad, sino la de los comerciantes y el propio ecosistema; sin embargo, se encontró que los gastos producidos por la inversión llevan al agricultor a buscar mecanismos que incrementen su ganancia, tal como es el caso del empleo de sustancias que puedan disminuir las plagas que afectan naturalmente este tipo de hortaliza. Se descubrió la falta de técnicas en los productores para la realización de fumigaciones; así como que ésta se realiza de forma profusa y las técnicas inadecuadas de manejo de la hortaliza poscosecha. Por último, se determinó que existen factores que se consideran como determinantes de la calidad de los tomates como características; firmeza, durabilidad, uniformidad y zona de origen; sin embargo, en la mayoría de los mercados minoristas se identifica esta denominación más con aspectos comerciales.

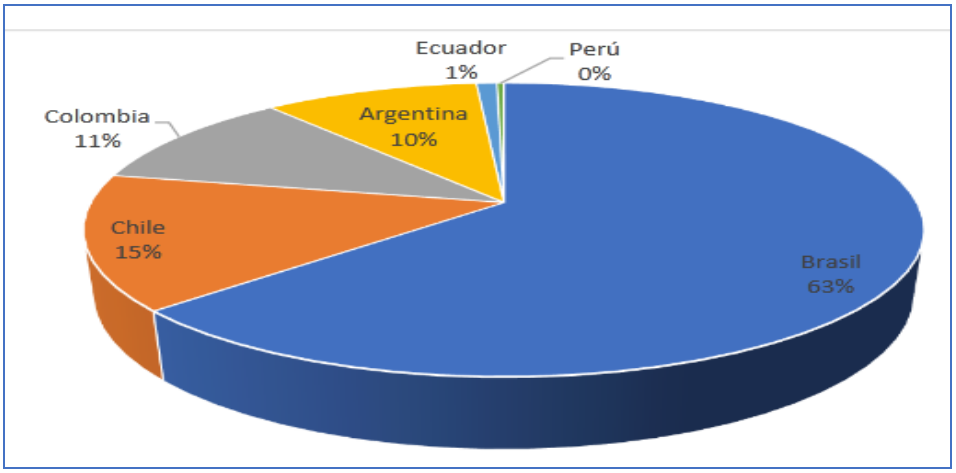
Palavras-chave: Tomate, plaguicidas, comercio.

INTRODUCTION

Chonto tomato (*Solanum lycopersicum*) is one of the most cultivated vegetables in the world (Engindeniz, 2006). (Engindeniz, 2006) registering in 2017 a production of 181 million tons of which 60% was concentrated in Asia, being, in addition, the continent that allocates more area to the crop. It is established as a transitory crop and is the sixth most consumed food product worldwide, after wheat, potatoes, sugar, dairy products and apples.

The volume of tomato production at the South American level in 2017 reached 7.2 million tons (FAOSTAT, 2017), with Brazil being the first producer with 4.23 million tons (63% of the South American total). It is followed by Chile with 993 thousand tons (15%), Colombia with 714 thousand tons (11%), Argentina with 660 thousand tons (10%), Ecuador with 62 thousand tons (1%) and Peru reports 22 thousand tons (0.33%).

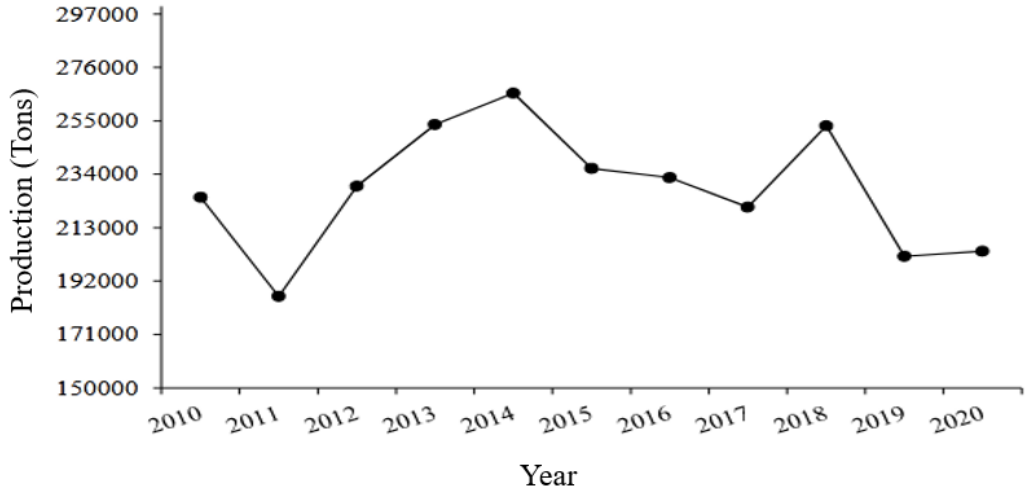
Figure 1. Distribution of tomato production volume in the main South American countries in 2017



Note. source: (FAOSTAT, 2017)

However, in Peru, tomatoes can be grown all year round, but variations in environmental conditions in the different In Peru, tomatoes for fresh consumption are produced intensively throughout the year by small and medium-sized farmers, concentrated in the department of Lima. In 2020 (Figure 2), about 4 837 ha of tomato were harvested (in Ica 1 031.50 ha, in Lima 929.50 ha and in Arequipa 714.00 ha), obtaining a production of 203 780 t, with an average yield of 42.13 t/ha, with Ica having the highest average yield (103.52 t/ha), followed by Arequipa (49.48 t/ha) and Lima (28.42 t/ha) agroecological zones restrict its cultivation (MINAM, 2020).

Figure 2. National tomato production



Note: Source: (Midagri, 2021)

This fruit commonly appears in the lists of vegetables with the highest concentration and variation of pesticide residues; indispensable inputs in the agricultural sector. For the commercialization of tomatoes in Peru, there are different

markets, mainly the large wholesale market of Lima, located in the district of Santa Anita, in the department of Lima. The wholesale markets "Andres Avelino Caceres", located in Arequipa, and "Moshoqueque" located in Lambayeque, are other places where large volumes of tomatoes are also traded. In these markets, as in others, the price is defined according to supply and demand.

The demand for fruit quality is more rigorous when there is an oversupply than when there is a shortage. The buyer is interested in having fruits with high firmness to avoid losses, so it excludes fruits of cultivars with lower firmness, even if they have flavor and quality characteristics accepted by consumers. The availability of tomato fruit throughout the year is possible due to the diversity of growing environments, which allows the product to reach the markets throughout the year.

The marketing chain starts with the producer, who sells the harvested product to the wholesaler, who sells it to the retailer, and finally the product reaches the final consumer. It can also happen that the producer can sell the product directly to the retailer and the retailer to the final consumer. This can happen in cases where the tomato harvest is in its final stage (last bales) and the farmer does not get enough volume to be sold in the wholesale market.

The nutritional value can be considered as the minimum content of food contaminants due to the use of pesticides which produces a residue of these, the content of nitrates and heavy metals; and on the other hand it can be considered with the content of important ingredients such as vitamins, minerals, proteins, among others (Torres, Valero, & Osuna, 2014).

Tomato quality can be affected by several factors such as genetic background, development conditions, inputs used and aging during storage, as well as by certain characteristics such as appearance, texture, safety, flavor and nutritional value. Other authors point out that the attributes of greatest importance in determining the organoleptic quality of tomatoes are texture, color, and flavor (Quinet, et al., 2019). The nutritional quality of this food then depends on the amount and source of nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, among others, provided by the soil of the production plot (Ramos, 2015).

In this sense, one of the elements is the use of pesticides, also called pesticides, which are substances used to combat pests or pests in agriculture. They are chemical substances, organic, inorganic or microbiological, liquid or solid, that produce toxic effects on certain living organisms (Bedmar, 2011).

The objective of this research article is to describe the incidence of pesticides on the quality of the *Solanum Lycopersicum* tomato in the supply of retail markets in the city of Lima, Peru, by consulting updated bibliographic sources related to the subject under study

METHODOLOGY

This study was framed in a documentary research, with a qualitative and descriptive approach. According to Hernández, Fernández, & Baptista, (2014) "a descriptive design aims to investigate the incidence and values in which one or more variables are manifested and provides their description" (p.193). Likewise, the aforementioned authors point out that a study is qualitative because it seeks to understand a complex social phenomenon and, beyond measuring the variables involved, it seeks to understand it (p.190).

On the other hand, a documentary research, according to Tamayo & Tamayo, (2007) "is carried out based on the review of documents, manuals, magazines, newspapers, scientific proceedings, conclusions and seminars and/or any type of publication considered as a source of information" (p.130), which will allow establishing the incidence of pesticides on the quality of the *Solanum Lycopersicum* tomato in the supply of retail markets in the city of Lima, Peru.

The method used is the inductive method, since it allows making generalizations with a view to expanding knowledge on the subject of interest of this inquiry Hernández, Fernández, & Baptista, (2014), expose "it is applied in the principles discovered to particular cases, from a link of judgments" (p. 107). The search for information was carried out online through the search engines Google Scholar and SciELO, among other digital repositories of national and international universities and electronic databases of national and international organizations related to the subject. The criteria for the selection of studies included: master's works, books on the variable under study, doctoral theses, research articles, presented in full manuscript and in Spanish.

Thus, the population consisted of 15 documents registered under the format of theses/articles/books consulted to obtain the relevant information for this study. In this sense, Hernández, Fernández, & Baptista, (2014), point out that "the population in a research is the set of units from which it is desired to obtain information and about which conclusions are to be generated" (p. 105). Of which a non-probabilistic purposive sample was defined by Hernández, Fernández, & Baptista, (2014) as: "a subgroup of the population in which the choice of the elements does not depend on probability but on the characteristics of the research" (p. 241), which is directed to specific subjects selected by the particularities of the study, information available. For this purpose, the research sample consisted of 06 documents whose contribution and importance

were considered the most relevant and valuable in providing information for this research.

Inclusion criteria: articles related to agronomic or food engineering, published in the last 05 years, Spanish language and available in full text.

Exclusion criteria: duplicate articles, other language than Spanish, more than 05 years of publication.

As **search strategies**, the following actions were carried out after establishing the characteristics of the studies to include or exclude, the chain of terms or descriptors were selected in the database to carry out the bibliographic search. In addition, a manual search was carried out on the tables of contents of journals and repository portals, proceedings of conferences and congresses whose thematic axes are linked to the topic of pesticides, quality of *Solanum Lycopersicum* tomato, and supply of retail markets. The search was performed on the fields title, abstract, and key words, or any combination of them. With the exception of the SciELO portal where a search was performed on the full text in Spanish.

Once the search strategy described above was defined, the **evaluation and selection of documents** proceeded; that is, the **selection of evidence** and extraction of data through the identification of documents from the implementation of the search strategy; application of a screening technique that includes the elimination of duplicate documents and the evaluation of the remaining ones by reading the title and abstract; selection based on the reading of the complete documents resulting from the screening; and the inclusion of articles for review and synthesis. The application of the search strategy made it possible to recover a total of 20 documents from which a total of 05 related to the subject under study were selected.

In relation to the data collection techniques and instruments, the technique of documentary or bibliographic observation was used for this research. Additionally, documentary analysis and content analysis were used, since they are an integral part of any research, in order to facilitate the development and understanding of the topic. According to Sierra Bravo (2007), the documentary analysis matrix is a research technique for the systematic and quantitative objective description of the content of publications, in order to interpret them (p. 287). The analysis of the data was summarized in a double-entry table including authors, year of publication, title of the research and main results and/or conclusions obtained after completion of the investigation.

RESULTS AND DISCUSSION

This section presents the documentary sources selected and organized to carry out the respective content analysis, which will eventually allow us to draw the necessary conclusions.

Table 1. Documentary sources selected for the content analysis

Author(s)/year	Title	Results and/or conclusions
(Mejía Olivas, 2022)	Production and marketing of tomato (*Solanum Lycopersicum L.*) in Peru.	There are several mechanisms for pest control, among which we can mention cultural, biological, phytogenetic and chemical control. In this sense, for the economic success of tomato production, it is important to minimize the presence of pests and diseases in this crop.
(Bravo & Zamora, 2020)	Diagnosis of pesticide use and impacts on tomato (*solanum lycopersicum* l.) cultivation in Riochico parish, Portoviejo canton, province of Manabí, Ecuador.	The results showed that pesticide applications are made without technical criteria, between 35 to 40 applications during the cycle of this crop and they are applied up to 8 days before placing the tomato on the market. Farmers in this sector incorrectly apply insecticides at doses higher than those recommended, affecting human health and the environment; in addition, some apply pesticides at the suggestion of another farmer, which affects the use and management of agrochemicals, without technical criteria.
(MINAM, 2020)	Baseline of Peruvian tomato diversity for biosafety purposes.	The heavy investments in tomato cultivation induce the producer, without planning, to use an excess of agrochemicals to control pests and diseases (these are the main limitations to achieve high yields), causing a high degree of contamination in the environment and in the fruit, with effects on the biological balance, the development of resistance and the deterioration of the health of workers and consumers. In addition to this fact, the lack of use of protective equipment by personnel when applying agrochemicals, as well as the inadequate handling of pesticide containers, are the main causes of contamination in the environment and in the fruit, with effects on the biological balance, the development of resistance and the deterioration of the health of workers and consumers.
(Hualgayoc Provincial Municipality, 2017.)	List of greenhouses and tomato production tables in the city of Bambamarca.	Government institutions (SENASA) have not yet approached small and medium producers to encourage a healthier and contaminant-free production, a factor that still needs a lot of work. Firmness, durability, uniformity and area of origin are the criteria chosen by wholesalers and retailers when buying the product, then the final consumers prefer tomatoes with healthy, fleshy and deep red fruit. In the market, fruit considered "quality" refers to a purely commercial term, since it is very likely that what is marketed is fruit with pesticide residues in quantities that could be harmful to the health of consumers.

(Gargurevich, 2018)	Reinventing tomato cultivation	He determined that the marketing of tomatoes, in general, does not take into account quality criteria, such as safety, and this is very worrying. Purchasing criteria are defined only in terms of price, size, firmness and physical appearance. In order to change this trend, support and education of consumers, buyers and farmers is definitely needed. It is very important that consumers know and demand quality at the time of purchase. Also, we have noticed that in wholesale markets there is a disproportionate agreement under which farmers deliver or sell 12 crates, but are paid for only 10; it is almost an imposition. The other case is at the level of some supermarkets that do not allow producers to differentiate themselves from their competitors.
(Garcia, Rodriguez, Restrepo, & Sanchez, 2017).	Pesticide residues in tomato (*Solanum lycopersicum)* marketed in armenia, Colombia	This fruit is attacked by pests that generate losses of more than 30%. The Colombian Agricultural Institute (ICA) restricts the use of agrochemicals; however, traces of endosulfan and 4,4'-DDDT, which are regulated and prohibited in most countries, including Colombia, have been found in tomatoes marketed. Tomato quality is established according to Codex Alimentarius recommendations on pesticides, which require sensitive, selective and approved methods of analysis. The methodology was shown to be robust in the analysis of pesticide residues. 4,4'-DDDT, endosulfan and methoxychlor, despite being restricted and/or banned in Colombia, were found in most of the samples analyzed.

Note: Source: Results of the literature review.

In analyzing the results of the review of selected documentary sources, the following aspects were found to be in agreement with several authors:

Regarding the control mechanisms of pests that commonly attack tomato (Solanum Lycopersicum L.), according to Mejías, (2022) there are: cultural, biological, phytogenetic and chemical control. In relation to the latter, they particularly refer to what is pointed out by García, Rodríguez, Restrepo, & Sánchez, (2017) who mention that pesticide residues have been found in this vegetable. 4,4'-DDDT, endosulfan and methoxychlor.

In relation to the use of these pesticides, it has been agreed in several articles that: pesticide applications are made without technical criteria, between 35 to 40 applications during the cycle of this crop and they are applied up to 8 days before placing the tomato on the market (Bravo & Zamora, 2020). This use is due to eminently economic aspects, such as the heavy investments in tomato cultivation that induce the producer, without planning, to use an excess of agrochemicals to control pests and diseases (MINAM, 2020); as well as government institutions (SENASA) still do not have an approach to small and medium producers that motivates a healthier production free of pollutants (Municipalidad Provincial Hualgayoc, 2017).

It is important to note that tomato quality has been defined to numerous indicators such as: Firmness, durability, uniformity and area of origin are the criteria chosen by wholesalers and retailers when purchasing the product, then, final consumers prefer tomatoes with healthy, fleshy fruit and intense red color (Municipalidad Provincial Hualgayoc, 2017). However, in this same research it has been pointed out that market, fruits considered "quality" refer to a purely commercial term. All the studies agrees on the harmful effects that pesticides possess (Bravo & Zamora, 2020) as a result of the incorrect application of insecticides at doses higher than recommended, affecting human health and the environment; in fruits, with effects on the biological balance, the development of resistance and in the deterioration of the health of workers and consumers (MINAM, 2020) (Provincial Municipality Hualgayoc, 2017) (García, Rodríguez, & Sánchez, 2017) (García, Rodríguez, & Sánchez, 2017).

CONCLUSIONS

Tomato (Solanum lycopersicum L.) has a high value in marketing and consumption, which is why we seek to encourage and improve the traditional cultivation in greenhouse cultivation. It is a crop of high commercial value and of enormous importance worldwide, due to the general acceptance of the fruit in food and its varied use, in addition to its excellent organoleptic qualities and high nutritional value.

Currently tomato crops have a great value in marketing and consumption, which is why they seek to minimize production costs, to subsequently improve the quality of products to change this trend requires the support and education of consumers, buyers and farmers. It is very important that consumers know and demand quality at the time of purchase.

It has been found in the literature review that it is clearly identified scientifically that the use of pesticides on tomatoes, not only affects their quality, but also that of traders and the ecosystem itself; however, it was found that the expenses produced by the investment lead the farmer to seek mechanisms to increase his profit, as in the case of the use of substances that can reduce the pests that naturally affect this type of vegetable. Some of the elements found in the research were the lack of techniques used by producers to carry out spraying, as well as the fact that spraying is carried out in a profuse manner and inadequate post-harvest vegetable handling techniques.

Finally, it was determined that there are factors that are considered as determinants of quality and marketing of tomatoes in retail markets: firmness, durability, uniformity and area of origin are the criteria chosen by wholesalers and retailers at the time of purchasing the product, then, final consumers prefer tomatoes with healthy, fleshy fruit and intense red color; however, in most retail markets this denomination is identified more with commercial aspects than the actual results of quality.

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Task	**A1**	**A2**	**A3**	**A4**
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B. data research and statistical analysis:	25%	25%	25%	25%
C. elaboration of figures and tables:	25%	25%	25%	25%
D. drafting, reviewing and writing of the text:	25%	25%	25%	25%
E. selection of bibliographical references	25%	25%	25%	25%
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