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Research Article

Assessment of Pesticide Residues in Tomatoes from the Marketgardening Area of Mountougoula, Mali

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Abstract

In Mali, the excessive and uncontrolled use of pesticides in agriculture poses a threat to public health and the environment. Marketgarden crops, particularly tomatoes, are particularly affected. This work aims to assess the impact of pesticide use in tomato production in the Mountougoula marketgarden area bygeolocating the site's sampling points and determining the concentration of pesticide residues in the tomatoes produced. Thirty (30) tomato samples were randomly collected from different points in the marketgarden area. The residue extraction was carried out using the QuEChERS method (NF EN 15662: 2009), followed by analysis bygas chromatography coupled with an electron capture detector (GC-µECD). A total of 5 different pesticides were detected in the tested tomato samples belonging to classes of insecticides: an organochlorine (Acetamiprid), an organophosphate (Chlorpyrifos) and three pyrethroids (Lambda-Cyhalothrin, Cypermethrin and Deltamethrin). Pesticide residues were detected in 11 (36.66%) samples and 19 (63.33%) samples showed no pesticides quantification. Regarding pesticide residues level, it was found that out of 11 samples contaminated, 8 (26.6%) samples showed pesticide residues higher than MRLs. The absence of quantifiable residues in the majority of samples is encouraging. However, the presence of residues above the tolerated limits in more than a third of the samples highlights the need for better supervision of producers in order to prevent health risks linked to chronic exposure to pesticides.

Keywords

Pesticide Residues, Tomatoes, QuEChERS, Mountougoula, Mali

1. Introduction

Marketgardening is increasingly developing in Mountougoula through the establishment and operation of several marketgardening areas, both community and private. Marketgarden produce from this area supplies fruits and vegetables to the peripheral markets of Dialakorobougou and Yirimadio, located in Commune IV of the Bamako District. Tomatoes (*Solanum lycopersicum L.*) are one of the most widely cultivated and consumed vegetables in the world,

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with global production estimated at over 180 million tonnes in 2022 (FAO, 2023) [1]. Rich in vitamins, antioxidants, and minerals, they occupy an essential place in the human diet, both fresh and processed (Chayma & Bessioud, 2021) [2]. In West Africa, particularly in Mali, tomato cultivation plays a key role in food security and constitutes an important source of income for small producers. However, this sector faces numerous phytosanitary challenges that lead to intensive use of pesticides to control insect pests, fungal diseases, and weeds (Adou et al., 2022) [3]. The frequent use of these phytosanitary products, often without compliance with Good Agricultural Practices (GAP), results in the presence of pesticide residues in agricultural products, sometimes exceeding authorized maximum residue limits (MRLs).

It also exposes consumers to the risks associated with consuming foods containing pesticide residues. These substances can have harmful effects on human health, ranging from simple digestive disorders to more serious pathologies such as cancer or endocrine disorders (WHO, 2021; EFSA, 2022) [4, 5]. In Mali, pesticide-related poisonings represent a serious public health issue, with the country recording a case fatality rate of 9.5% among reported poisonings (DNSP, 2020) [6].

In this context, the assessment of pesticide residues in marketgarden produce, particularly tomatoes, is essential to prevent health risks and raise awareness among producers.

2. Materials and Methods

2.1. Study Area and Sampling Points

Mountougoula is a rural commune located 30 km southeast of Bamako, in the Koulikoro region (Mali). It covers 368 km ²and includes 16 villages. The climate is hot and dry (BWh climate type) with an average annual temperature of 27.6 ℃ and approximately 790 mm of rainfall. Agriculture, particularly marketgardening, is the main activity. Samples were taken at several tomato production points, geolocated in this area.

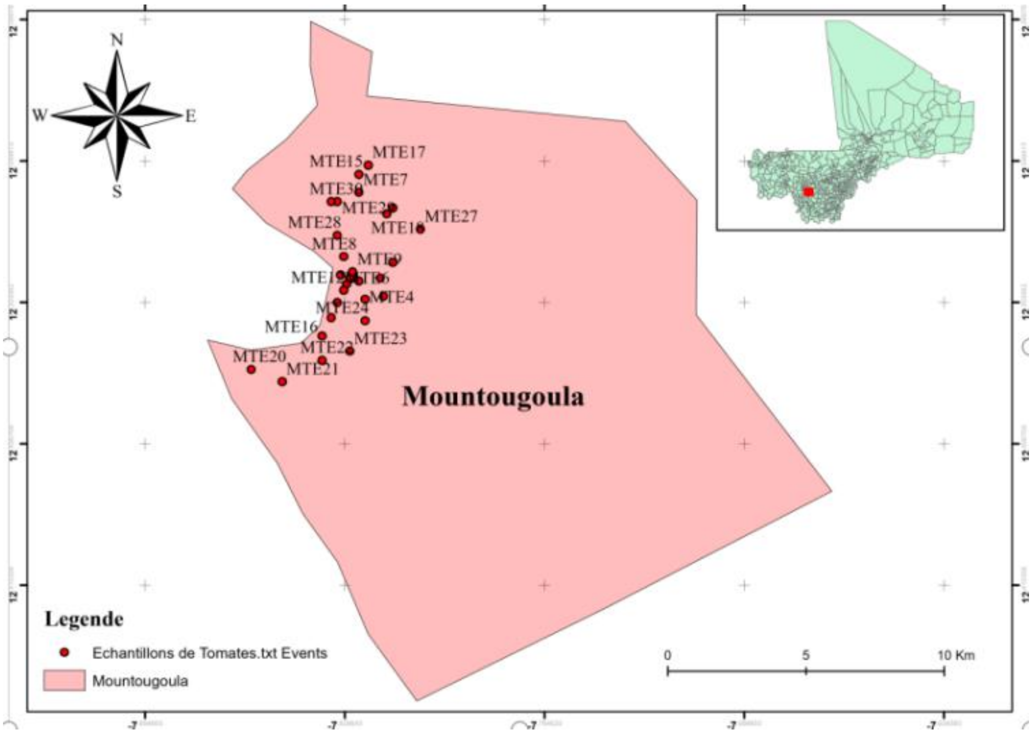

Figure 1. Study area map showing location of sampling points.

2.2. Sample Collection

The biological material consisted of 30 composite tomato samples collected from different plants at the Mountougoula marketgarden site. Each sample, weighting a total of 500g, was packaged in aluminum foil, labeled, placed in a cooler, and transported at +4 ℃.

2.3. Extraction and Laboratory Analysis

Pesticides extraction from tomato samples was done by QuEChERS method, in the laboratory, the tomatoes were ground and from the ground material, 300g were homogenized, then 10g were transferred into 50mL tubes containing 4g of $mgSO_4$ and 1g of NaCl. 10mL of acetonitrile were added to the contents of the tube, then shake vigorously for 1 minute, followed by vortexing for 3 minutes. The tubes were then centrifuged at 3,000rpm for 2 minutes. After decanting, 1.5mL of the upper phase were transferred into 2mL tubes containing 150mg of $mgSO_4$, 50mg of APS and 50mg of C18. These tubes were shaken for 30 seconds and then centrifuged at 3,000rpm for 2 minutes. Finally, 0.5mL of the purified extract is transferred into a vial for analysis by gas chromatography coupled with an electron capture detector (GC-µECD).

2.4. Analytical Standards Preparation

The analytical reference standards of ten pesticides of purity between 95.8 and 98.7% were acquired from the manufacturer (EhrenstorfergmbH Reference Augsburg-Germany). An individual solution of each standard required for identification and quantification was prepared by diluting the stock solution in hexane "for residues". The solution of the mixture of five concentration standards 5µg/mL was prepared by dilution in hexane. Then an assay range of five different levels at concentrations (0.0125, 0.25, 0.5, 0.1 and 0.125µg/mL) was prepared and used for GC calibration.

3. Results

The general situation of the samples after the analyses as well as the summary of the pesticide contents quantified per sample are respectively presented in Table 1 and Table 2.

Table 1. *General situation of samples after analysis.*

	Pesticides Residues		
	Absent	Present	Total
Number of samples	19	11	30

Thegeneral situation of the samples after the analyses is presented in this Table shows that 11 (36.66%) samples were contaminated by pesticide residues and 19 (63.33%) samples did not present any pesticide residues.

The limits of quantification of the different pesticides quantified are presented in the figure.

Table 2. *Tomato samples with pesticides residues.*

Sample Code	Results in mg/Kg					
	Deltamethrin	Chlorpyrifos	Acetamiprid	Lambda-cyhalothrin	Cypermethrin	Total Residus
ETM3	-	-	-	0,008	-	0,008
ETM5	0,008	-	-	-	-	0,008
ETM6	0,010	-	-	-	-	0,010
ETM7	-	-	0,007	-	-	0,007
ETM9	0,006	-	-	-	-	0,006
ETM10	0,031	-	-	-	0,043	0,074
ETM11	-	-	0,005	-	-	0,005
ETM17	-	0,010	-	-	-	0,010
ETM18	-	-	-	0,012	-	0,012
ETM19	0,020	-	-	-	-	0,020
ETM23	0,009	-	-	-	-	0,009

In most contaminated samples, only one pesticide was quantified. A combination of two pesticides (Deltamethrin and Cypermethrin) was found in one sample, each with high levels. The total residues of these two pesticides were found at a level of 0.074mg/kg of tomatoes. Individual pesticide levels in tomato samples ranged from 0.005mg/kg to 0.045mg/kg, most of which exceeded the maximum tolerated residue limits.

Table 3. Pesticides LOQ with their detection frequence.

Pesticides	Deltamethrin	Chlorpyrifos	Lambda-cyhalothrin	Acetamiprid	Cypermethrin
Limit of Quantification (LOQ)	0,004	0,003	0,004	0,004	0,003
Number of times detected in samples	6	2	2	1	1

Deltamethrin was the most encountered pesticide with six (6) samples, followed by Lambda-cyhalothrin and Acetaprimid each quantified in two (2) samples while Chlorpyrifos and Cypermethrin were each encountered in one (1) sample.

The Figure 2 shows the cumulative total pesticide residues encountered per tomato sample.

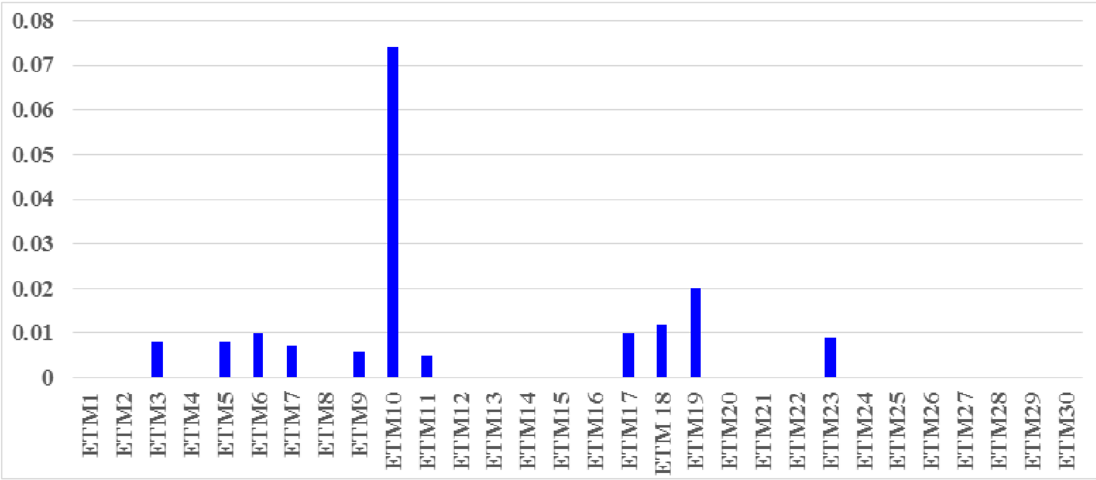

Figure 2. Total pesticide residues per sample.

4. Discussion

The limits of quantification (LOQ) obtained in this study indicate a reliability of the analytical method used and agood sensitivity of GC-ECD widely recognized for their reliability in the detection of pesticide residues at low concentrations (Sharma et al., 2020) [7]. The predominance of pyrethroids (deltamethrin, lambda-cyhalothrin, cypermethrin) among the detected residues reflects their increasing use in marketgardening, due to their effectiveness and faster degradation profile compared to organochlorines (FAO & WHO, 2021; Youssef et al., 2021) [8, 9]. However, despite their low persistence, measurable traces remain frequent in vegetables such as tomatoes, highlighting the need for regular monitoring and rational use.

Of the 30 tomato samples analyzed in Mountougoula, 63.3% contained no detectable pesticide residues, while 36.7% had concentrations above the limits of quantification (LOQ), indicating occasional but actual use of plant protection products. One sample was found to be the most contaminated, with cumulative residues reaching 0.074mg/kg. These results are consistent with data reported in other African countries. For example, in Benin, Dovonou et al. (2020) [10] found pesticide residues in 30% of the vegetable samples analyzed, while in Nigeria, Akinneye et al. (2018) [11] observed contamination rates reaching 42% in market tomatoes. In Mali, Diallo et al. (2016) [12] had already reported the presence of pyrethroid residues in marketgarden produce, particularly in the peri-urban area of the Bamako District. These results confirm significant consumer exposure to chemical residues, justifying stricter regulation of pesticide use in marketgardening.

The results presented in Table 1 confirm a one-off but real use of pesticides in tomato cultivation in Mountougoula, with 36.7% of samples containing five detectable residues. The majority of which was deltamethrin (6 samples). This finding is consistent with several studies conducted in Africa, notably in Benin, Assogba-Komlan et al.(2020) [13] and Nigeria Olawale et al.(2022) [14], which reported a frequent presence of residues in vegetables, particularly pyrethroids and neonicotinoids. globally, work in Egypt [9] and India [7] also confirmed the regular detection of substances such as deltamethrin or chlorpyrifos in tomatoes. The co-presence of several residues in the same sample as observed in one sample, raises concerns in terms of cumulative risks [8, 9], even if the levels remain below the maximum limits authorized in some countries.

Among the pesticides tested, deltamethrin was the most frequently detected molecule, found in 20% of the samples analyzed. It was followed by acetamiprid and lambda-cyhalothrin, each present in 6.66% of the samples, while chlorpyrifos and cypermethrin were detected in only one sample each (3.33%). These results suggest a targeted, but not negligible, use of pyrethroids in tomato cultivation in Mountougoula, as has also been reported in other African agricultural contexts [10-12]. The dominance of pyrethroids could be explained by their efficacy against a broad spectrum of insects and their availability on the local market.

5. Conclusions

The study of pesticide residues in Mountougoula tomatoes reveals major issues for public health and the environment. Although 63.3% of samples were residue-free, 36.7% showed contamination, mainly by pyrethroids such as deltamethrin. This indicates actual pesticide use, often without compliance with Good Agricultural Practices, posing risks to consumer health, especially in a context of increasing poisoning in Mali. These results are in line with a trend observed in other African countries. It is therefore crucial to implement awareness-raising and training measures for producers, as well as strengthened regulatory oversight of pesticide use. Residue monitoring and control programs could also help mitigate the risks associated with their consumption.

Abbreviations

EFSA	European Food Safety Authority
FAO	Food and Agriculture Organization
GAP	Good Agricultural Practices
GC-µECD	Gas Chromatograph - Electron Capture Detector
INSP	Institut National de Santé Publique
LCV	Laboratoire Central Vétérinaire
LOQ	Limit of Quantification
MRL	Maximum Residues Limit
QuEChERS	Quick, Easy, Cheap, Effective, Rugged, Safe
WHO	World Health Organization

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Author Contributions

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Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the subject matter or materials discussed in this manuscript.

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