

*Full Length Research Paper*

# Cultural practices and pesticides contamination level of tomato in two gardening sites in the region of Boucle du Mouhoun, Burkina Faso

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The present study consisted of evaluation of cultural practices and pesticides contamination level of tomato in some gardening sites in the region of Boucle du Mouhoun (Burkina Faso). A survey of phytosanitary practices among 30 producers was carried out at the Di and Dedougou sites. The pesticide contamination level of tomatoes collected was determined by the QuEChERS method. The survey revealed a low level of literacy among producers (60%), an increased use of pesticides without adequate protection materials, non-compliance with prescribed doses, use of unregistered pesticides (28%) and poor management of packaging. Chromatographic analysis of the samples detected 16 active substances predominantly organophosphorus (62%). 62.5% of detected compounds (Omethoate, Parathion methyl, Diazinon, Methyldathion, Pyridaphethion, Pyrimiphos methyl, Alachlor, 2.4 DDT, lindane, permethrin and Imazalil) are not authorized by the CSP. Among authorized compounds, Dimethoate, Malathion, and Cypermethrin contamination levels higher than the MRLs have been observed. These results confirmed risks of environment contamination and sanitary of farmers and consumers linked to their exposure and consumption of tomatoes. Measures should be taken to raise awareness among market gardeners of good pesticide use practices and the adoption of alternative methods to pesticides to protect environment, gardeners and consumers health.

**Key words:** *Lycopersicon esculentum*, pesticides, contamination, MRLs, Burkina Faso.

## INTRODUCTION

Agriculture is the main occupation for 80% of the active population of Burkina Faso and contributes nearly 40% of

the Gross Domestic Product (GDP) (CAPES, 2007). The cultivated areas estimated at 3.6 million hectares are

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dominated by cereal crops, cash crops and vegetable crops. Among vegetable crops, the tomato is the second most important crop in terms of area and production. Its production is estimated to 289872 tons/year (Son, 2018). In many countries, the tomato (*Lycopersicon esculentum*, Mill.) is an important vegetable crop grown (Mutari and Debbie, 2011) and highly consumed because of its richness in nutrients especially carotenoids, vitamins and phenolic compounds. These nutrients are very beneficial for human health and intervene into prevention non-communicable diseases (Victoria et al., 2017; Oboulbiga et al., 2017).

In Burkina Faso, vegetables are mainly grown during the dry season (January-June) and the sector faces significant constraints with a high level of exposure to climatic risk, principally drought and high pests' pressure. These constraints can cause high losses in yield. Losses caused by insects and diseases in tomato production can exceed 30% (Toé, 2010), so pesticides are widely applied in agriculture to control pests and to improve yields (Kolia, 2015). However, pollution of water sources and the environment can occur due to several factors including run-off of pesticides applied to plants, the washing of clothes worn by those spraying crops in the vicinity and/or in surrounding watercourses, and cleaning sprayers (Naré et al., 2015). Unintended exposure to pesticides or ingestion of contaminated food can be extremely dangerous to humans, other living organisms and environment as they are designed to be poisonous (Sarwar, 2015).

The contamination pathways are multiple, including direct exposure (farmers for example), eating foods or liquids (water) containing pesticide residue, or inhalation (or contact) of pesticide-contaminated air. Even very low levels of exposure may have adverse health effects at early development (Damalas and Eleftherohorinos, 2011). In those situations, children are the more susceptible to pesticides than adults due to their physical makeup, behavior and physiology (Lehmann et al., 2017). Unfortunately, studies already carried out on certain market gardening sites in Burkina Faso reported the existence of poor phytosanitary practices: non-compliance with doses prescribed, non-compliance with the rules of protection and hygiene during treatments, poor management of the empty pesticide containers (Naré et al., 2015). In addition, the Burkina Faso, Ministry of Health also reported in 2019 the death of dozens of people due to contamination of pesticide residues. The region of *Boucle of Mouhoun* is a large tomato production area of which *Di* and *Dedougou* are major market gardening production sites, mainly for tomatoes. This production ensures local consumption and above all exports of tomatoes to various countries including Europe. Its annual tomato production is estimated at 29723 tons/year (MARHASA, 2014). Unfortunately, data on phytosanitary practices, the types of pesticides used and the risks to the health of consumers and the

environment are very limited. This study proposes a comprehensive assessment cultural practices and pesticides contamination level of tomato in these gardening sites.

## MATERIALS AND METHODS

### Sites description

The study was conducted in March to May 2018 in two gardening sites of the region of *Boucle du Mouhoun* which is one of the 13 regions of the administrative division of Burkina Faso. Located in the northwest of the country, the *Boucle du Mouhoun* region, which capital is Dedougou, occupies about 12% of the national territory, an area of 34,497 km<sup>2</sup>. The region is located in the Sudano-Sahelian zone and has two seasons: a long dry season (between 6 and 8 months) and a rainy season (3 to 5 months). The region's economy is essentially based on agriculture and animal husbandry, which occupy about 90% of the population. Market gardening is one of the main counter-season activities in the region. The first collecting site is the market garden site of Di, located in the department of Di and the second site is located in the town of Dedougou (Figure 1). The main crops of the two sites are onion, pepper, green bean, potato, maize, tomato, cabbage and aubergines. Thirty (30) samples of fresh tomatoes were collected from two production sites including *Di* and *Dedougou*.

### Field investigations

A survey of 15 tomato producers selected randomly in each site was carried out. The choice of these sites was motivated by the geographical position near the border, to determine whether fraudulent introduction of pesticides had occurred.

### Sample collection

For each site, 1 kg of ripe tomato fruit was randomly collected from 15 plots. Tomato samples from the same plot constituted one sample. The tomato samples were labeled and then transported to the laboratory where they were kept at -20°C for the different analyses.

### Pesticides extraction and chemical analysis

Pesticides residues in tomatoes were extracted using a modified AOAC 2007.01 QuEChERS (Quick Easy Cheap Rugged and Safe) extraction method. For chromatographic analysis, the samples were washed with distilled water and then crushed and 5 g of each sample was taken from the 50 ml falcon tubes. 5 g of sample were homogenized with 10 mL acetonitrile and vortexed for 1 min. The extraction of samples was realized by centrifugation (3000 tr/min for 5 min) with 1 g of sodium chloride (NaCl), 1 g of sodium citrate (Na Citrate), 0.5 g of Na citrate anhydrous and 4 g of magnesium sulfate (MgSO<sub>4</sub>). The purification of the extracts was carried out by centrifugation with salts (sulphate of anhydrous sodium) and carbon black graphitized (GCB) to mobilize the coloured substances (chlorophyll and carotene) that are non-active by precipitation. The supernatant obtained from the frozen extract after centrifugation was recovered in a vial using a Pasteur pipette. The analysis of the extracts was carried out using a chromatograph in gas phase (Agilent Technologies) that has a micro-detector that captures electron (GC- $\mu$ ECD/GC-FPD, Hewlett Packard). A capillary

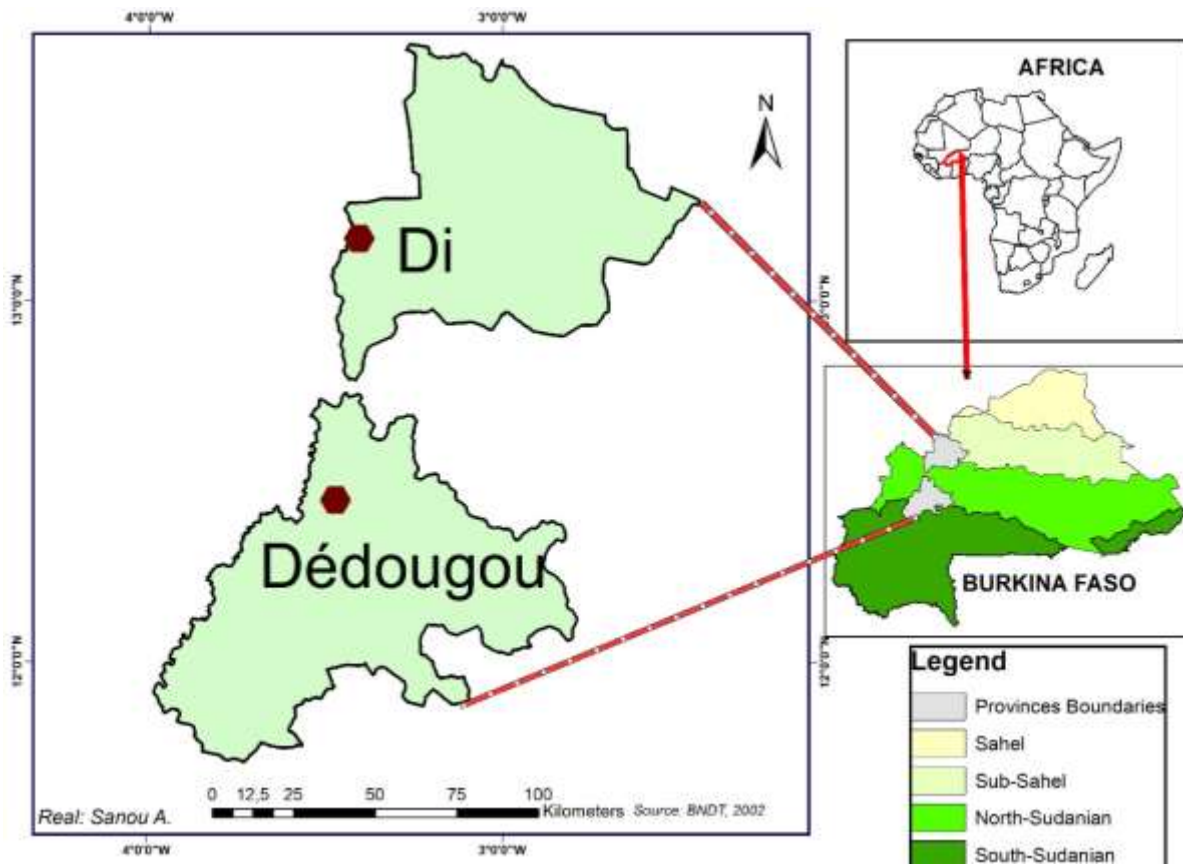


Figure 1. Location of collection sites.

chromatographic column of type dB-17 MS. It had a length of 30 cm, an internal diameter of 250  $\mu\text{m}$  and a thickness of 0.25  $\mu\text{m}$ . Nitrogen of high purity was used as the carrier gas. The injection was carried out using Split/Splitless injection technique with an injection volume of 2  $\mu\text{l}$ . The temperatures of the apparatus were as follows: Room of injector programmed at 275°C with a pressure of 20.72 psi; Column (75°C during 0.5 mn, 75-300°C with a flow of 10°C/mn and 300°C during 7 mn); Detector (325°C).

#### Statistical analysis

The Tukey's test, the descriptive statistics and the creation of the various graphs were established using Excel and XLSAT software version 2016.

## RESULTS

### Socio-demographic characteristics

The socio-demographic characteristics of the farmers taken into account in this study are shown in Table 1. The results showed that in the two gardening sites, the met producers were mostly men (93.33%) and their age ranged from 26 to 51 years. 60% of the producers are not educated and only half belong to an agricultural group

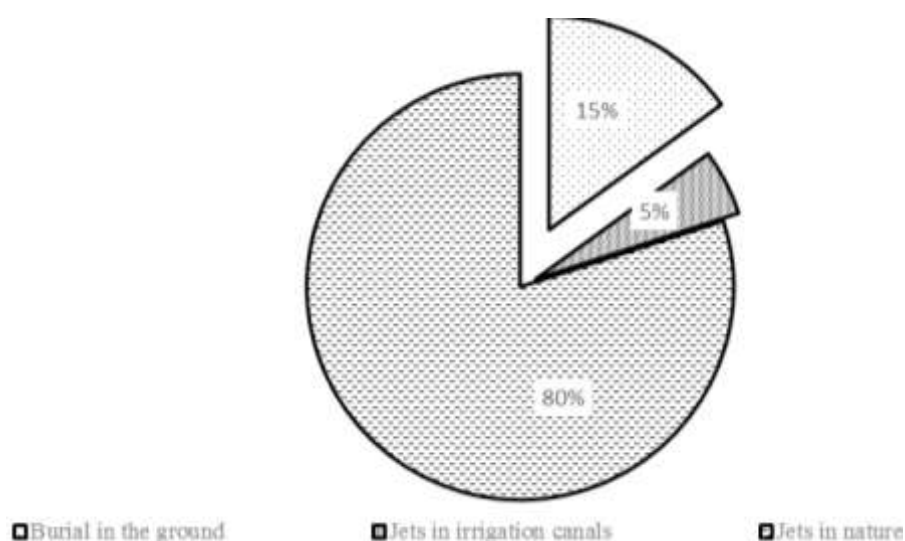
and therefore did not receive any technical supervision or advisory support from market gardening technicians.

### Phytosanitary practices on market gardening sites and risks to health and the environment

To control the main pests of tomatoes, producers generally use synthetic chemical pesticides. In order to characterize the main families of used pesticides and their origin with a view to assessing the health and environmental risks associated with their use, field investigations were initiated. The results showed that all the producers surveyed at both sites used pesticides to control tomato pests' control. The used pesticides were purchased directly from the surrounding markets without any guarantee of conformity and quality or provided by the Society of Fibres and Textile (SOFITEX), for the control of cotton pathogens. The dosage, formulation and application of pesticides are generally done by growers, often their children or their employees, but in some plots the phytosanitary treatment is carried out by women. The amounts of pesticides applied by market gardeners are variable in the two study sites. Surveys revealed that the rates applied ranged from 16 to 48 L per 0.25 ha. Only

**Table 1.** socio-demographic characteristics of the farmers.

Characteristic	Social status of producers	Proportion (%)
Sex	Man	93.33
	Woman	6.67
Education's level	Uneducated	60
	Primary	33
	Secondary	7
Agricultural group	Associated	50
	Unassociated	50

**Figure 2.** Management of pesticide packaging after use.

26% of producers revealed that they respected the doses prescribed by the manufacturers. The spraying frequencies recorded were 45, 25 and 30% for respectively less than a week, a week and more than a week. The study also revealed that producers observed on average week between the last spray and the harvest. In addition, the study revealed no investigated producer had complete protective equipment and only 33% use rudimentary materials of protection (masks, gloves, etc). As for the management of packaging after treatment, the recorded data (Figure 2) revealed that 80% of the market gardeners threw their packaging into the irrigation canals, 15% buried it in the ground after use and 5% threw it directly into the nature.

The Table 2 presents the main pesticides inventoried on the 2 sites of tomato production. The results showed that all the used pesticides were mostly insecticide. According to target and toxicity, these pesticides belong to categories 2 and 3. 28% of pesticides marketed in these areas are strictly prohibited by the Sahelian

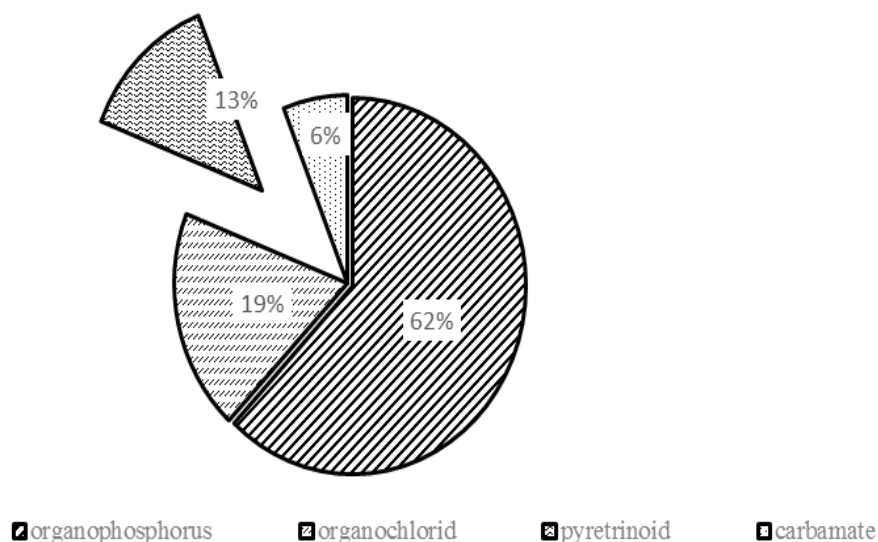
Committee of Pesticides (CSP).

### Pesticides residues in collected tomatoes and risk of contamination

The analysis of the chromatographic profile of the collected sample permitted the detection and the quantification of 16 target pesticides: Diazinon, dimethoate, Fenitrothion, Malathion, Methyldathion, Omeothoate, Parathion methyl, pyridaphenthion, Pirimifos methyl, profenofos, alachlor, 2.4 DDT, lindane, Cypermetrin, permethrin and imazalil. Among the detected pesticides (Figure 3), the organophosphorus pesticides are the most important (62%), followed by organochlorine (19%), pyrethrinoids (13%) and carbamates (6%). The quantification of the detected pesticides revealed that only the levels of methyl parathion, 2.4 DDT, Alachor and Imazalil varied according to the samples collected sites. Also, it is noteworthy that for some samples, threshold

**Table 2.** The used pesticides on the 2 sites.

Commercial name	Nature of pesticides	Authorized by CSP	Category of toxicity
ACARIUS 80 EC	Insecticide	no	II
ADUMA WURA	Insecticide	no	II
ATTAKAN 344 EC	Insecticide+ herbicide	yes	II
CAIMAN ROUGE	Insecticide	yes	II
CONQUEST 88 EC	Insecticide	yes	II
COGA 80 WP	Insecticide	yes	III
CYPERCAL 50 EC	Insecticide	yes	III
EMACOT	Insecticide	yes	II
LAMBDA super 25EC	Insecticide	yes	III
PACHA 25EC	Insecticide	yes	II
RAMBO	Insecticide for mosquito/cockroach	no	II
ROUNDUP 360 SL	Insecticide	No	II
TANGO 500 EC46	Insecticide	yes	II
TITAN 25EC	Insecticide	yes	II

**Figure 3.** Main families of detected pesticides.

limits proposed by the European Directive 98/83/EC (1998) on the quality of vegetable intended for human consumption were exceeded. Indeed, the levels of 2.4 DDT in tomato samples from the site of Di and Alachore in tomato samples from both sites were above the maximum residue limits (Table 3).

Table 4 reveals that 78% of the active ingredients detected are prohibited by the CSP. Also, it is noteworthy that for some samples, threshold limits proposed by the European Directive 98/83/EC (1998) on the quality of vegetable intended for human consumption were exceeded. Indeed, only 37.5% of medium level of actives compounds detected in tomato samples was lower than the MRLs.

## DISCUSSION

The study revealed a low level of education among producers. In addition, the study revealed an insufficient level of training and monitoring of growers on the use of pesticides and dosages. As a result, pesticides are for the most part applied without appropriate means of protection at inappropriate doses. Such practices do not promote the proper use of plant protection products through ignorance and by using the appropriate product according to the target. Similar results were reported by Son et al. (2017) who also reported that the level of education is a determining factor for the mode of application, the persistence, the respect of the expiration

**Table 3.** Comparison of different active compounds per collection site.

Compound	Site	
	Dedougou	Di
Omethoate	2.01±0.52 <sup>a</sup>	2.3±0.01 <sup>a</sup>
Parathion methyl	0.05±0.01 <sup>a</sup>	0.6±0.02 <sup>b</sup>
Dimethoate	0.24±0.15 <sup>a</sup>	0.4±0.3 <sup>a</sup>
Diazinon	0.8±0.3 <sup>a</sup>	0.6±0.1 <sup>a</sup>
Fenitrothion	0.12±0.6 <sup>a</sup>	0.1±0.03 <sup>a</sup>
Malathion	0.07±0.02 <sup>a</sup>	0.7±0.02 <sup>a</sup>
Methyathion	0.09±0.05 <sup>a</sup>	0.13±0.02 <sup>a</sup>
Pyridaphenthion	0.45±0.02 <sup>a</sup>	0.41±0.26 <sup>a</sup>
Profenofos	0.2±0.1	0.23±0.4
Pyrimiphos methyl	0.17±0.21 <sup>a</sup>	0.19±0.01 <sup>a</sup>
Alachlor	0.06±0.02 <sup>a</sup>	0.15±0.03 <sup>b</sup>
2.4DDT	0.03±0.02 <sup>a</sup>	0.07±0.01 <sup>b</sup>
Lindane	0.05±0.01 <sup>a</sup>	0.04±0.02 <sup>a</sup>
Cypermethrin	0.14±0.03 <sup>a</sup>	0.11±0.01 <sup>a</sup>
Permethrin	0.1±0.02 <sup>a</sup>	0.14±0.03 <sup>a</sup>
Imazalil	0.129±0.01 <sup>a</sup>	0 <sup>b</sup>

**Table 4.** Authorization and contamination level of different active compounds.

Active compounds	Authorized by the CSP *	Median (ug/kg)	Maximum (ug/kg)	LMR (ug/kg)
Omethoate	No	1.32	2.7	0.01
Parathion methyl	No	0.03	0.32	0.5
Dimethoate	Yes	0.2	0.68	0.01
Diazinon	No	0.23	2.4	0.02
Fenitrothion	Yes	0.07	0.13	1
Malathion	Yes	0.14	0.79	0.02
Methyathion	No	0.08	0.18	0.1
Pyridaphenthion	No	0.18	0.68	0.05
Profenofos	Yes	0.23	0.86	1
Pyrimiphos methyl	No	0.016	0.24	0.01
Alachlor	No	0.15	1.74	0.5
2.4DDT	No	0.05	0.08	0.05
Lindane	No	0.02	0.03	0.01
Cypermethrin	Yes	0.08	1.12	0.05
Permethrin	No	0.11	3.46	0.05
Imazalil	No	0.04	1.01	0.05

\*CSP: Comité Sahélien des pesticides (2017).

times as well as the precautions to be taken before, during and after the application of pesticides. According to Kanda et al. (2013) and Wognin et al. (2014), pesticide use requires a minimum of theoretical and practical knowledge to avoid health and environmental risks. Indeed, in the context of the use of pesticides, the doses and instructions for use must be respected. In our case, the majority of growers cannot read or write, so cannot do the calculations to adjust the rates to be applied. They cannot understand the labels on the crop inputs, which

are usually written in English or French. This contributes to an increased risk of intoxication and environmental pollution (Son et al., 2017). According to Agnandji et al. (2018) overdosing pesticides during treatment, may cause contamination of vegetables as well as environmental compartments.

The results also showed treatments were carried out without adequate protective equipment. In addition, the packages are thrown into the irrigation canals. Our results corroborate those of Tyagi et al. (2015) in India,

Belhadi et al. (2016) in Algeria, Doumbia and Kwadjo (2009) in Côte d'Ivoire and Son et al. (2017) in Burkina Faso who reported that few producers used adequate protective equipment when treating crops with pesticides. Lack of protective equipment and poor management of pesticide wastes are at the root of acute poisoning cases in growers (Lehmann et al., 2017; Son et al., 2017). Lehmann et al. (2017) reported the pollution of certain rivers in Burkina Faso by pesticide residues in market gardening areas. Also, as some water reservoirs may be used for fish farming, there is a risk of contamination of humans through the transfer of pesticide residues as observed in Benin through tilapia under similar conditions (Agbohessi et al., 2012). Potential health effects are of particular concern because of the presence of children and women on pesticide application plots. Various studies have reported an increased risk of disease or malformation in humans, generally related to pesticides (Son et al., 2017). Among women, the possible consequences of exposure during pesticide use are spontaneous abortion and premature and malformed newborns (Multigner, 2005).

The marketing of pesticides is regulated by international and national laws. The source of acquisition of these products is an important parameter in the control of this legislation. The study shows that the local market and SOFITEX are the two sources of procurement of pesticides. Similar results have been reported by Ouédraogo et al. (2016) who reveal that in western Burkina Faso, 85.5% of the phytosanitary products are acquired on the market.

Acquisition of pesticides in market increases the health risks and risk fraud of unauthorized products. This is more worrying because unauthorized products and some pesticides for cotton crops are used in tomato cultivation and can induce health risks. These practices have been observed on several market gardening sites (Son et al., 2017) in Burkina Faso; Agnandji et al. (2018) in Togo and Muliele et al. (2017) in Congo.

Quantitative analysis revealed different active ingredients is not significantly different depending on the production areas with the exception of alachlor, Imazalil and DDT. The analysis revealed the presence of 16 active compounds with a dominance of organophosphorus. These results confirm these of Tarnagda et al. (2017) that has detected 13 active compounds on *Loumbila* areas. Our results are contrary to those of Son et al. (2017) who show a dominance of organochlorines in western and north region of Burkina Faso. These results could be explained by the diversity of pesticides used depending on the crop areas. The presence of organochlorine active ingredients on the production sites demonstrates the existence of fraud in the local pesticide trade. These organochlorines are strictly prohibited by the Sahelian committee of pesticides because of their toxicity. Among these prohibited products, we note the 2,4 DDT detected in our samples.

The particularity of these two organochlorines (alachlor, DDT) highly concentrated in *Di* compared to *Dedougou* could be justified by the proximity of this area of the Malian border. It thus constitutes an area susceptible to pesticide fraud. A comparison of the concentrations of active substances in relation to the maximum residue limits showed worrying levels for 62.5% of the active substances.

Similar results have been obtained by Kolia (2015) for other active ingredients. Bioaccumulation of these active compounds constitutes serious carcinogenic risks.

## Conclusion

In order to characterize the cultivation practices of tomato producers from market gardening sites in *Di* and *Dedougou* with a view to assessing their health risks to consumers, the present study was initiated. Investigations carried out on the two sites showed non-compliance with the conditions of use of pesticides, the use of unauthorized pesticides by some producers and poor management of pesticide packaging. These poor agricultural practices are linked to the low level of education and monitoring of producers and present numerous health and environmental risks. In addition, the quantification of pesticide residues in tomato samples from the two tomato sites detected 16 active compounds with a predominance of organophosphorus. These results confirm the health risks associated with the consumption of these tomatoes and raise the urgent need to train market gardeners on the judicious use of synthetic pesticides, manure and chemical fertilizers to guarantee the health of consumers.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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