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Biochemical exploration of pancreatic function in market gardeners exposed to pesticides in Bobo-Dioulasso, Burkina Faso

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Market gardeners use pesticides that could contain disruptors affecting pancreatic function. The objective was to explore exocrine and endocrine pancreatic functions in market gardeners exposed to pesticides. This prospective study was conducted on a cohort of 50 market garden producer participants. Sociodemographic and clinical variables, as well as information on pesticides used, were collected alongside blood samples. Quantitative determination of total insulinemia in serum was conducted using a chemiluminescence microparticle immunoassay. Lipasemia, pancreatic amylasemia, triglyceridemia, and glycemia were measured through colorimetric or enzymatic methods. Reference intervals for glycemia (4.11-6.50 mmol/L), lipasemia (13-60 U/L), pancreatic amylasemia (13-53 U/L), triglyceridemia (<1.70 mmol/L), and insulinemia (2.60-24.90 µU/L) were considered. Fisher's exact test was employed to examine the significance of associations, with a p-value set at 0.05. The market garden producers included in the study were males with a median age of 38 years. They were most frequently exposed to active substances such as glyphosate (89.47%), paraquat chloride (36.84%), and 2,4-D dimethylamine salt (15.79%). Hyperinsulinemia (21.05%), hypoglycemia (44.00%), and hypertriglyceridemia (10.53%) were noted. An increase in catalytic activity of pancreatic enzymes was observed, including hyperlipasemia (2.63%) and hyperamylasemia (13.16%). Through insulinemia, a disorder in the endocrine secretion of the pancreas was noted, which may not be solely attributed to the pesticides used. Further comparative studies are needed.

Key words: Pancreas, market gardeners, pesticides.

INTRODUCTION

In Burkina Faso, as in other West African countries, cities are undergoing rapid population growth accompanied by accelerated urbanization (Yemadji et al., 2017). This trend has driven the expansion of urban and peri-urban agriculture due to increased food needs, rising living standards, and the necessity to diversify sources of income (Kêdowidé et al., 2010). Vegetable production remains the predominant agricultural activity in the larger cities of Burkina Faso (Robert et al., 2018). Nevertheless, crop losses (approximately 30%) resulting from damage caused by pests, nematodes, and weeds constitute a significant agricultural challenge for producers (Grunder et al., 2018).

In fact, a considerable proportion (about 59 to 100%) of market garden producers in major production centers such as Bobo-Dioulasso, Ouagadougou, and Ouahigouya resort to periodic pesticide application without adhering to the recommended dosage (Naré et al., 2015; Son et al., 2017). Additionally, a substantial number of synthetic pesticides employed by market gardeners lack registration by the Sahelian Pesticides Committee (CSP) and are consequently unauthorized for use in Burkina Faso (Toé et al., 2013). This widespread improper utilization of highly toxic chemical pesticides has adverse implications for human health (Son et al., 2018).

Pesticide exposure presents a significant public health concern, with over 200,000 cases of accidental poisoning reported annually (Liang et al., 2018). Furthermore, the contribution of pesticide exposure to pancreatic dysfunction remains unexplored in this region. The objective of this study is to assess the pancreatic function of market gardeners exposed to pesticides.

MATERIALS AND METHODS

Site and type of study

This is a prospective study that was conducted from July 10 to September 15, 2019. The study took place in the region of "Hauts-Bassins" precisely in periurban district 3 (Dogona) and 5 (Kuinima) (Figure 1).

Population and sampling

The study focused on a cohort of 50 market garden producers. The inclusion criteria were: being male or female of any age; owning a farm in the study area; using pesticides on the farm during the study period; and agreeing to participate in the study. This study was authorized by the Ethics Committee for Health Research of Burkina Faso, deliberation n ° 2018-7-083. Written informed consent was obtained from all market garden producers included in this study.

They were alerted about the high morbidity rate observed in persons using pesticides, including hormonal disorders. Their participation was completely voluntary. Biological samples were well labeled and all data were processed in anonymity.

Collection and processing of blood samples

A venepuncture was carried out using a needle with a vacutainer support. Three (03) ml of blood was taken under strict aseptic conditions. The blood was then packaged in a dry tube and transported directly to the laboratory in coolers containing the tube racks. At the laboratory, the blood samples were centrifuged, aliquoted and stored at a temperature of -20°C prior to analysis.

Analysis of biochemical parameters

The analysis of blood samples was done in the biochemistry department in "Centre Hospitalier Universitaire Sourô SANOU de Bobo-Dioulasso". Quantitative determination of total insulinemia in serum was carried out by a chemiluminescence microparticle immunoassay (CMIA) and lipasemia, pancreatic amylasemia, triglyceridemia, glycemia were measured either by the colorimetric and enzymatic methods on HITACHI Cobas® 6000.

Data analysis

Data were analyzed with XLSTAT 2016.02.27444 (Lumivero, Colorado, USA). Statistical parameters such as medians, minimum, maximum and frequencies were expressed for data. We have considered reference intervals for glycemia (4.11-6.50 mmol/L), lipasemia (13-60 U/L), pancreatic amylasemia (13-53 U/L), triglyceridemia (<1.70 mmol/L) and insulinemia (2.60-24.90 µU/L). Fisher's exact test was used to assess the significance of associations with a p value < 0.05.

RESULTS

Socio-demographic and clinical characteristics

Market garden producers included were male with a median age of 38 years (minimum-maximum: 22-69 years). Market gardeners with primary education had a proportion 30.77%, secondary education 13.46% and illiterate 55.77%. Clinical signs frequently reported were colds (29.31%), coughs (25.86%), headaches (22.41%), and dizziness (12.07%). No clinical signs were reported for 39.47%.

Pesticide used

Seventeen pesticides were cited and used by the market gardeners. From these pesticides, 64.70% were registered by CSP. According to World Health Organization (WHO), 5.88% and 47.05% were in toxicity class U, II and III respectively. Glyphader 75 (58.00%), Gramopat super (32.00%) and Kalache (22.00%) were the most used pesticides. Their active substance were glyphosate (89.47%), paraquat chloride (36.84%) and 2,4-D dimethylamine salt (15.79%), endosulfan (5.26%), thirame (5.26%), acetamipride (2.63%) and

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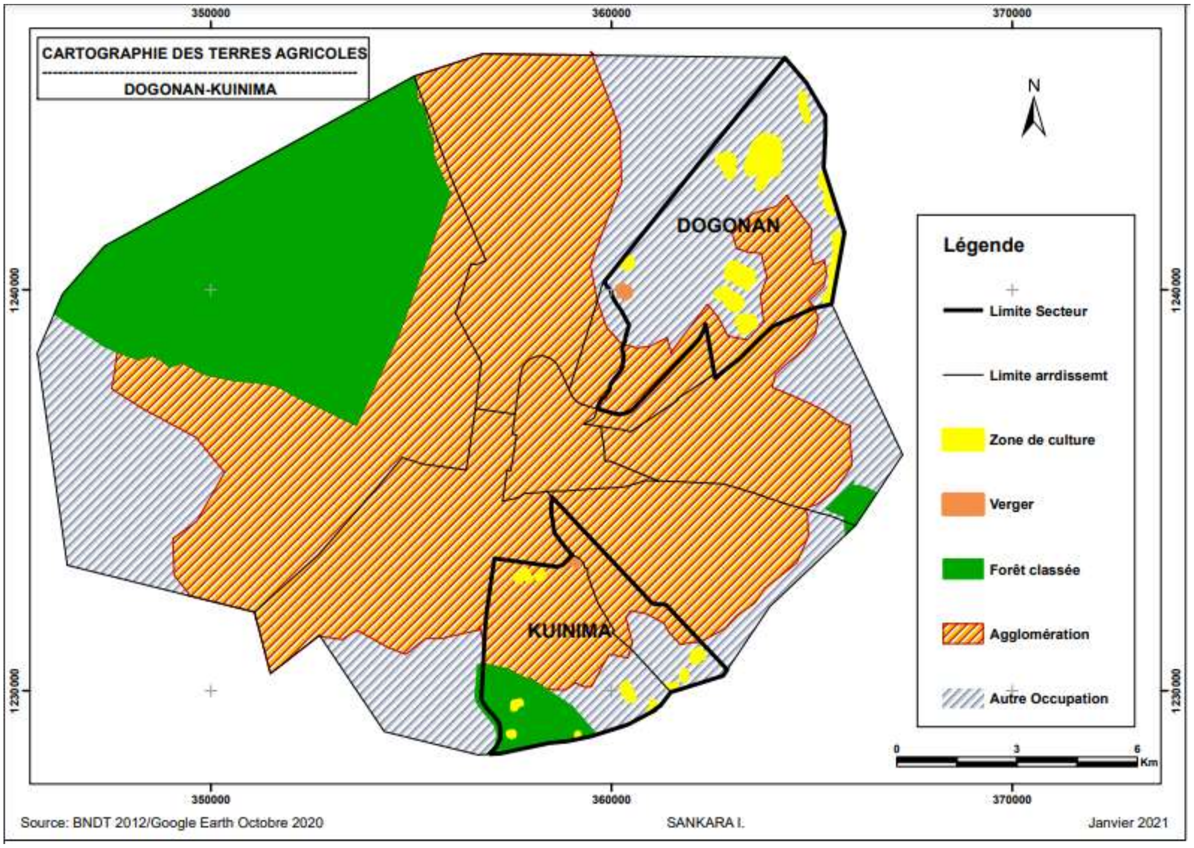

Figure 1. Agricultural land mapping.

lamda-cyalothrine (2.63%).

Market gardeners and pesticide used

Market gardeners who had received at least one training on good pesticide use represented 4.00% ; and those who had received no training at all were 96.00%. Among our market gardeners, 52.00% had less than ten years pesticide use experience; 36.00% had [10-20[years' experience and 12.00% had [20-30[years' experience. They were exposed to a single active substance (47.37% and 5.26% for glyphosate and paraquat chloride) or a combination of 2 (34.21%) or 3 (13.16%) active substances (Table 1).

Biochemical parameters analysis

We noted hypoinsulinemia (2.63%) and hyperinsulinemia (21.05%), but no significant association with glyphosate (p= 0.604), paraquat chloride (p=0.388) exposure. A significant association was observed with 2,4-D dimethylamin salt exposure and hyperinsulinemia (p=0.039). Hypoglycaemia (44.74%) and hyperglycaemia (2.63%) were observed in market gardeners but were not significantly associated with glyphosate (p= 0.650), paraquat chloride (p=0.579) or 2,4-D dimethylamin salt exposure (Table 1). No significant association was observed for 10.52% of market gardeners with both hyperinsulinemia and hypoglycemia (p= 0.793).

An increase in the catalytic activity of pancreatic enzymes was observed: hyperlipasemia (2.63%), hyperamylasemia (13.16%). Hypertriglyceridemia was 10.53% and was not significantly associated with any active substance exposure (p=0.372) or lipasemia level (p=0.826) (Table 2).

DISCUSSION

Biological studies on pancreatic function in response to pesticide exposure are scarce in Burkina Faso. Consequently, we were unable to locate any data on the prevalence of toxicity resulting from pesticide exposure, which could have enabled us to make comparisons with our findings. Moreover, we encountered a lack of biological crop promoters in these peri-urban environments that could have served as a control group.

Market gardening appears to be a predominantly male

Table 1. Single or combined active substances in pesticides used by market gardeners.

Active substances	Frequency (%)
Single active substance	52.63
Glyphosate	47.37
Paraquat chloride	5.26
Two active substances	34.21
Glyphosate+Paraquat chloride	23.68
Glyphosate+2,4-D dimethylamine	7.89
Endosulfan+Thirame	2.63
Three active substances	13.16
Glyphosate+2,4-D dimethylamine+Paraquat chloride	5.26
Glyphosate+2,4-D dimethylamine+Endosulfan	2.63
Glyphosate+Endosulfan+Thirame	2.63
Paraquat chloride+Lamda-cyhalothrine+Acetamipride	2.63

Table 2. Frequency of biochemical parameters level and active substance exposure.

Biochemical parameters level	Glyphosate		p-value	Paraquat chloride		p-value	2,4-D dimethylamin		p-value
	No	Yes		No	Yes		No	Yes	
Glycemia (mmol/L)			0.650			0.579			0.118
High	0.00	2.63		2.63	0.00		2.63	0.00	
Low	2.63	42.11		31.58	13.16		31.58	13.16	
Normal	7.89	44.74		28.95	23.68		50.00	2.63	
Insulinemia (µU/ml)			0.604			0.388			0.039
High	0.00	21.05		15.79	5.26		15.79	5.26	
Low	0.00	2.63		0.00	2.63		0.00	2.63	
Normal	10.53	65.79		47.37	28.95		68.42	7.89	
Triglyceridemia (mmol/L)			0.372			1.00			1.00
High	2.63	7.89		7.89	2.63		10.53	0.00	
Normal	7.89	81.58		55.26	34.21		73.68	15.79	
Amylasemia (U/L)			0.446			0.337			0.570
High	2.63	10.53		5.26	7.89		13.16	0.00	
Normal	7.89	78.95		57.89	28.95		71.05	15.79	
Lipasemia (U/L)			1.00			0.043			1.00
High	0.00	2.63		0.00	2.63		2.63	0.00	
Normal	10.53	81.58		63.16	28.95		76.32	15.79	
low	0.00	5.26		0.00	5.26		5.26	0.00	

activity. These results align with those of Sawadogo (2016), who reported a 100.00% male participation rate. In contrast, the Western Regional Directorate of the National Center for Scientific and Technological Research (DRO/CNRST, 2016) found male representation at 94.10% and females at 5.86%. This variation could potentially be attributed to differences in sample size.

The age range of participants spanned from 22 to 69 years. These findings indicate that pesticide application is an activity involving individuals across different age categories. The educational attainment of surveyed market gardeners was generally low, with 55.77% being illiterate. A substantial number had not received any training in proper pesticide use techniques. The combination of limited education and lack of training constrains the safe application of pesticides. Furthermore, market gardeners with limited educational backgrounds might face challenges in comprehending label information, thereby increasing their exposure risk.

Similar observations were made by Toé (2010), who highlighted that the educational levels of producers do not facilitate the establishment of systems aimed at reducing health and environmental risks. Nonetheless, it is possible to educate gardeners in reading and writing in local languages such as Dioula, as suggested by Toé (2010). This could substantially enhance pesticide safety. The survey findings indicated that 52.00% of farmers had fewer than ten years of experience in pesticide use, while 12.00% possessed extensive experience exceeding twenty years. Long-standing experience in pesticide use could be a significant factor contributing to effective pesticide utilization.

However, extended experience could also serve as a toxicological risk factor. In the field, we have observed that some market gardeners who have been using pesticides for an extended period do not set the best example. This exposure to pesticide hazards might be further compounded by the utilization of unregistered pesticides as determined by the CSP. According to the WHO, 5.88% of the pesticides fell under class U, implying that they did not pose an acute hazard under proper usage conditions. Classes II and III accounted for 47.05% each, with Class II classified as moderately hazardous and Class III as slightly hazardous. Various pesticides contained one or more active substances, such as glyphosate and paraquat chloride, both of which have been shown to impact the pancreas. This aligns with the observations made by the Pesticide Action Network Updates Service (PANUPS, 2001) in 2001, which identified endosulfan as a hazardous substance restricted by the Sahelian Pesticide Committee (CSP), potentially causing disruptions in the human body's hormonal system and leading to increased birth defects, sexual abnormalities, and reproductive disabilities.

According to vegetable growers, unregistered pesticides, especially those originating from countries like Ghana and Nigeria, are more affordable than products offered by domestic distribution companies. Similar findings were reported by Ibrango (2014), who noted that these growers favored cheaper pesticides from Ghana. In terms of the assay of biological variables, our study found that 21.05% of pesticide users exhibited hyperinsulinemia, with 10.52% of them also experiencing hypoglycemia. This could potentially be attributed to a malfunction in the pancreatic endocrine function. Similar findings were observed by Jamshidi et al. (2009) and Bousquet (2016), who found increased insulin levels and pancreatic cancer in rats exposed to diazinon and glyphosate, respectively. Patients demonstrating both hyperinsulinemia and hypoglycemia could be explained by the natural role of insulin, an antihyperglycemic hormone, wherein elevated insulin levels lead to lower blood sugar.

The observed hypoglycemia in 44.74% of patients could be attributed to the 12-hour fasting period prior to collection, as well as the inactivity of pancreatic β cells, which stimulate antihypoglycemic hormone secretion. Hyperglycemia among our patients might be linked to a dysfunction of pancreatic α cells. Hyperlipasemia was detected in 2.63% of patients, and hyperamylasemia in 13.16% of patients. The escalation in catalytic activity of pancreatic enzymes could indicate acute pancreatitis, prompting a significant release of these enzymes. Bismuth et al. (1982) made similar observations during acute paraquat intoxication, reporting hyperlipasemia and hyperamylasemia in 26.00% of cases. Hypolipasemia in 5.26% of patients could point toward chronic pancreatitis, wherein lipase secretion diminishes over time. These biological disorders, whether acute or chronic in nature, could be attributed not only to the duration of exposure but also to the quantity used. Hypertriglyceridemia was noted in 8.00% of patients, which might be due to a deficiency in lipase secretion affecting the conversion of triglycerides into fatty acids.

Conclusion

This survey is characterized by poor control of pesticide use techniques and the choice of unregistered pesticides with lesser-known toxicity. Biochemical parameters showed biological disorders in lipasemia, amylasemia (pancreatic enzymes), insulinemia (pancreatic endocrine hormone), and hormonal regulation disorders of triglyceridemia and glycemia. However, the results obtained cannot be considered representative, as market gardeners have cited and used several types of pesticides, making it difficult to assign responsibility to each active substance.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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