Microbiological and toxicological qualities of *Solanum macrocarpum* Linn (Solanaceae) cultivated with chicken's manure and water of marsh in Cotonou (Benin)

Victorien Dougnon[1,2], Honoré Bankolé[2], Jean Robert Klotoé[2], Jacques Dougnon[2], Patrick Edorh[1], Michel Boko[1]

(1) Interfaculty Center of Formation and Research in Environment for the Sustainable Development, Laboratory of Toxicology and Environmental Health, University of Abomey-Calavi (UAC), 01 BP1463 Cotonou, Benin.

(2) Polytechnic School of Abomey-Calavi, Research Laboratory in Applied Biology, University of Abomey-Calavi, 01 BP 2009 Cotonou, Benin.

*Corresponding author: victorien88@hotmail.com

Abstract

Urban agriculture is one of the activities necessary to ensure the food security of urban dwellers. However, the modernization and intensification of production systems induce greater use of inputs. Producers meet this demand by recycling different types of waste. Thus, in Cotonou, the population developed a local strategy for vegetable production, which has resulted in the use of chicken manure and water swamps to amend and irrigate vegetables. Despite the nutrients in the manure of chickens, the probable presence of heavy metals and *E. coli* could permanently contaminate consumers. This work evaluated the impact of the use of chicken manure and irrigation water on the microbiological and toxicological quality of *S. macrocarpon*, a highly consumed vegetable in Cotonou.

Introduction

Urban agriculture became throughout the whole world and specifically in the developing countries, one of the activities necessary to ensure the food safety of the townsmen and to get financial resources with the unemployed persons of the cities. Its contribution with the food production on a world level which was at 15 % in 1993 can have exceeded 33 % as from the year 2005 [1]. Smit *et al*. [2] revealed that agriculture is practised in at least 90 towns of 31 countries of the Southeast Asia, Middle East, Europe, Subsaharian Africa, America and Antilles. In addition, 800 million people practise this activity on a worldwide scale [3]. The problems of urban agriculture in West Africa were the subject of several publications which show well its importance in cities [4]. Urban agriculture is thus socially significant. The activities of production, transformation and marketing offer employment opportunities for a mass of the urban population in situation of unemployment and the rural ones in seasonal migration. Benin, following the example of many African countries, experienced these last years a development of urban agriculture [5]. In Cotonou, the market-gardening production and more precisely of the vegetable-sheets is a reality. It contributes to the provisioning of the markets of the city of food products [6]. The systems of production are much diversified in terms of speculations (vegetables, fruits, flowers, meat, eggs, etc.) and of economic profile of the owners (young people, little qualified populations, contractors). The modernization and the intensification of the systems of production induce a stronger use of agricultural inputs. The producers answer this request by the recycling of various types of waste [4]. Thus, inside the city, the population developed a local strategy of market-gardening production which resulted in the use of the chicken's droppings to amend the market-gardening products. These poultry's droppings, as many waste used in agriculture, contains organic matter and biogenic salts which constitute a contribution interesting for the grounds of culture [7]. But the presence of elements traces in the droppings represents a major constraint with its use in agriculture because these elements can be brought in unstable and potentially biodisponibles forms [8]. Indeed, in the event of use of waste of animals on the market gardenings (whose sheets are consumed), certain metals, like lead, accumulate preferentially in the foliar parts [1]; which could be at the origin of food poisonings on the level of the fresh vegetable consumers. For that, we chose to study the lead which is one of the most toxic metals for the man. It involves more or less serious lesions and diseases [9].

Having thus noticed that an increasing number of market-gardeners prefer to use the chicken's droppings to amend their cultures, this study evaluated the microbiological and toxicological impacts of that practice on the quality of *S. macrocarpon*.

Material and Methods

Localization of the sites of study

Our survey took in account a witness site at Glo (6°56 ' Northern latitude and 2°30' Eastern longitude) and market-gardening sites of Houeyiho (6°21'20" Northern latitude and 2° 21' 35" Eastern longitude), of Fidjrosse (6°22' Northern latitude and 2° 24' Eastern longitude); of Agongbomey (6° 21' Northern latitude and 2°24'45" Eastern longitude). Two irrigation systems namely drilling and marsh water were observed on two sites. The other two study sites has a single sprinkler system: marsh water for Agongbomey and tap at Glo-Djigbé.On each site, in two different market-gardeners, some samples of droppings, soils, water and leaves were taken. 500 grams of chicken's droppings were collected on the sites and introduced into hermetically tied plastic sachets. All the samples were transported in a refrigerator towards the laboratory in a one hour interval after the taking away where they were preserved at once at a temperature of 4° C. The toxicological analyses were carried out in the 200 hours following the test sample selections.

Toxicological analyses

They were made at the Laboratory for Sciences Ground, Water and Environment of the National Institute of the Agronomic Research of Benin (INRAB) in Republic of the Benin. Lead and cadmium were required in the samples by reading with the Spectrophotometer of Atomic absorption (SAA) 110.

Microbiological analyses

The microbiological analyses were carried out in the Section Hygiene of Water and Food of the National Laboratory of Public Health at Benin. The purpose of the microbiological analyses were to highlight the presence or not of *Escherichia coli* and salmonella in the samples.

Statistical analyses

Averages and standard deviations were calculated. Multiple comparisons consisting in comparing the averages using the test of Student p (T>t) = 0.05 were made. The softwares used were Microsoft Excel 2010 and XL Stat 2011.

Results

Microbiological analyses

The irrigation water of control site (Glo-Djigbé) was not contaminated by fecal coliforms (0 CFU/100 mL) while those of Houéyiho, Fidjrossè and Agongbomey were it. *Escherichia coli* was absent in the control site of Glo-Djigbé unlike Houéyiho ($1.8.10^4$ ± 28.42 CFU/100 mL), Fidjrossè (70.10 ± $0.95.10^4$ CFU/100 mL) and Agongbomey (5545 ± 77.53 CFU/100 mL).

Contamination of leaves of *S. macrocarpum* by *E. coli* were of $35.65.10^4$ ± 457.08 CFU/g in the control site while it was respectively of 70.71 ± $0.95.10^3$ CFU/g, 1.10^3 ± 0 CFU/g and $0.9.10^3$ ± 0 CFU/g in Houéyiho, Fidjrossè and Agongbomey. Salmonella was not detected in the culture environment of *S. macrocarpum*.

Toxicological analyses

Regarding the content of lead in the droppings used in the amendment of the sites, the averages in mg/kg were of 3.618 ± 0.051 (Glo-Djigbé); 0.887 ± 0.017 (Houéyiho); 1.921 ± 0.079 (Fidjrossè); 0.696 ± 0.048 (Agongbomey) ($p < 0.05$). The averages about lead content in soils were: Glo-Djigbé (5.189 ± 0.058 mg/kg); Houéyiho (46.320 ± 0.651 mg/kg); Fidjrossè (2.544 ± 0.158 mg/kg), Agongbomey (12.154 ± 0.529 mg/kg) ($p < 0.05$).

Samples of irrigation water contain residues of lead at levels below the standard recommended by the FAO which is 5 mg/L [10]. Chidikofan [11] who worked on the site of Houéyiho reached the same conclusions. Concerning the lead content in the leaves of *S. macrocarpum*, the averages were: Glo-Djigbé (0.936 ± 0.070 mg/kg); Agongbomey (0.416 ± 0.050 mg/kg) ($p < 0.05$); Houéyiho (1.178 ± 0.250 mg/kg); Fidjrossè (1.195 ± 0.050 mg/kg).

Conclusion and perspectives

The results of this study showed a contamination of irrigation water by fecal coliforms including *E. coli* at all sites except Glo-Djigbé. Contamination of leaves of *S. macrocarpum* by fecal coliform and *E. coli* was also revealed in all sites. By cons, no environmental contamination of *S. macrocarpum* by Salmonella was detected on production sites. Lead was detected in all sites, with values sometimes exceeding the standards recommended by the FAO. The presence of pathogenic microorganisms and heavy metals in vegetables of different study sites could be at the origin of food poisoning and pollution. Composting of chicken manure before application on vegetables and channeling irrigation water are mitigating measures. This augurs new research perspectives to clean the vegetables consumed by the population of Cotonou.

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