

# Assessment of risk factors of bacteriological contamination of vegetables sold on the markets of Niamey, Niger

## Abstract:

Vegetables are an important and varied source of food that complements the dietary needs of populations whose basic diet consists mainly of carbohydrates, the main energy source. The general aim of this study is to identify the risk factors for bacteriological contamination of vegetables associated with sales practices, through a survey of sales markets. Vegetable sales are carried out by men (87.59%), most of them are aged between 20 and 39 (68.70%) and are not educated (68.70%). Practices at risk of bacteriological contamination include using public toilets (80.87%), not washing hands with soap after using the toilet (36.56%), washing vegetables at the reception (39.13%), using water from public toilets (55.56%), displaying vegetables on unhygienic supports (60.00%), selling vegetables by the side of public roads (55.65%) or near open canals (4.35%). These practices are likely to result in bacteriological contamination of vegetables on the markets. Therefore, it seems much more necessary to training vegetable vendors and raise their awareness of the risks of bacteriological contamination of vegetables.

Key words: contamination, risk, market, bacteriological, Niamey (Niger)

## Introduction

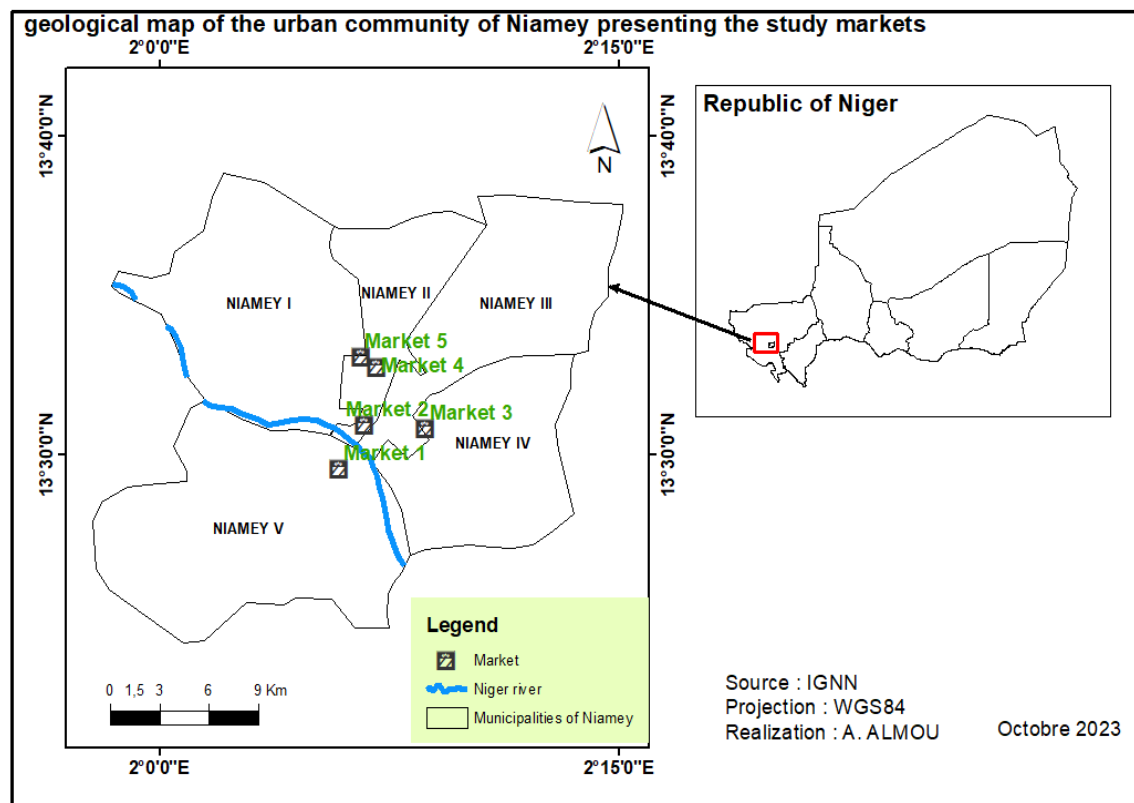
The last decade has been marked by rapid population growth in the cities of developing countries [1]. This population explosion and extensive urbanization are subjecting population to difficulties relating to the supply of fresh food products and the availability of usable land [2,3]. In Africa, urban market gardening is seen as a solution to the problems of supplying vegetables to increasingly populated cities. This intensive form of agriculture is very dynamic [4,5]. It provides fresh fruits and vegetables and has grown in importance over the last 30 years in West Africa [6]. Fruits and vegetables are increasingly recognized as essential for food and nutritional security. Vegetable production offers a promising economic opportunity to reduce rural poverty and unemployment in developing countries and is a key component of agricultural diversification strategies [7]. In the United States, per capita consumption of fresh fruits and vegetables increased [8]. In many developing countries, these fruits and vegetables are sold at the roadside or in open-air markets. Vegetables are therefore subject to numerous risky practices that are likely to encourage bio-contamination, both during cultivation and sale and during preparation for mass catering [9]. It is now commonly accepted that fruit and vegetable consumption is a risk factor for infection with enteric pathogens [10]. In developing countries, many risk factors are considered to be the main contributors to contamination, such as poor post-harvest handling, particularly in markets, and unhygienic food handling practices [11,12,13,14].

This study aims to identify the main risk factors for vegetable bacteriological contamination associated with the sale of vegetables on markets in urban community of Niamey.

## 1. Materials and methods

### 1.1. Study area

The study was carried out in the urban community of Niamey. The Niamey region is located in the south-western part of Niger between 13° 24' and 13°35'N latitude and, 2°00' and 2°15'E longitude with an altitude of between 160 and 250 m. Its administrative boundaries cover 552.27km<sup>2</sup>, of which approximately 297.46km<sup>2</sup> is urbanized [15]. The population of Niamey is estimated at around 1,407,635. The city of Niamey is subdivided into 5 communal districts with the following population distribution by communal district: Niamey I: 287,902 inhabitants; Niamey II: 338,455 inhabitants; Niamey III: 223,685 inhabitants; Niamey IV: 376,271 inhabitants; Niamey V: 181,321 inhabitants [16]. Five (5) Niamey vegetable markets were the subject of this study (Harobanda market, small market, Wadata market, Dolé market and Dar es sallam market) (fig. 1).



**Figure 1:** geological map of the urban community of Niamey presenting the study markets

### 1.2. Type and population of study

This is a descriptive cross-sectional study of vegetable sellers in five (5) markets in the city of Niamey.

### 1.3. Contract selection criteria

The survey markets were chosen on the basis of a survey of the various markets in the urban community of Niamey. This survey made it possible to select five (5) markets in the urban community of Niamey where vegetables are sold.

#### 1.4. Survey sample size

The sample size is estimated from the report by [17]. They reported 14.5% as the prevalence of fresh vegetables sale in Niamey. A total of one hundred and fifteen (115) vegetable vendors randomly selected from the five (5) markets in the city of Niamey were surveyed.

#### 1.5. Market Survey

The survey was carried out in each of the five (5) markets selected, in order to find out the behavior and habits of the vendors and the hygiene conditions likely to influence the bacteriological quality of the vegetables. To this end, a questionnaire was drawn up to determine the socio-demographic characteristics of the vendors (age, gender and level of education) and the environment and conditions in which the vegetables were sold (type of vegetables sold, how the vegetables were displayed, how the vegetables were processed at the market and where they were stored).

#### 1.6. Statistical analysis

The survey questionnaire was designed in Microsoft Word and then exported to the **KOBO Toolbox**, an open source field data collection instrument developed in collaboration with Harvard Humanitarian Initiative and Brigham and Women's Hospital ([www.koboToolbox.org](http://www.koboToolbox.org)). The ODK collect data version 21.2.4 application was used to collect data on smartphones. The collected data were exported from the server as a Microsoft Excel spreadsheet (.xlsx) and subjected to one-way analysis of variance (ANOVA) using SPSS software version 23.0.0. Differences are considered significant for values of  $P < .05$ .

## 2. Results

### 2.1. Socio-economic characteristics of vegetable sellers

The socio-economic characteristics of vegetable sellers are shown in **Table (1)**. **The sale of vegetables is carried out (89.57%) by men, compared to women (10.43%)**. Market 1 (Harobanda market) has the highest number of women vegetable sellers (28.13%), followed by market 3 (Wadata market) with 18.18%. No female seller was recorded in market 5 (Dar es Salam market). The majority of sellers are Nigeriens (98.26%). The average age was  $34.04 \pm 10.40$ , with 68.26% aged between 20 and 39. Non-Nigeriens represent 9.09% on market 3 and 2.04% on market 4 (Dolé market). **Table 2** also shows that the majority of vegetable sellers are unschooled (68.70%), followed by secondary education (21.74%). Sellers with less than 10 years' experience of selling vegetables are the most numerous in all markets. They accounted for 50% of vegetable sellers in market 1 and 90% in market 5. Retail traders were the most numerous in all markets (over 50%). No significant differences were observed between these characteristics and the different markets surveyed.

**Table 1: Socio-economic characteristics of vegetable sellers in Niamey city markets**

Features		Breakdown (n)% (%)					Total
		market 1	market 2	market 3	market 4	market 5	
Type	Male	23(71,88) <sup>a</sup>	13(100,00) <sup>b</sup>	9(81,82) <sup>ab</sup>	48(97,96) <sup>ac</sup>	10(100,00) <sup>a</sup>	103(89,57)
	Female	9(28,13) <sup>a</sup>	0(0,00) <sup>b</sup>	2(18,18) <sup>ab</sup>	1(2,04) <sup>ac</sup>	0(0,00) <sup>a</sup>	12 (10,43)
	<b>Total</b>	<b>32(100)</b>	<b>13(100)</b>	<b>11(100)</b>	<b>49(100)</b>	<b>10(100)</b>	<b>114(100)</b>
Age	<20	0(0,00) <sup>b</sup>	1(7,69) <sup>a</sup>	1(9,09) <sup>b</sup>	1(2,04) <sup>c</sup>	1(10,00) <sup>b</sup>	4(3,48)
	20 to 39 years	22(68,75) <sup>b</sup>	5(38,46) <sup>a</sup>	7(63,64) <sup>b</sup>	37(75,51) <sup>c</sup>	8(80,00) <sup>b</sup>	79(68,70)
	≥40 years	10(31,25) <sup>b</sup>	6(46,15) <sup>a</sup>	3(27,27) <sup>b</sup>	11(22,45) <sup>c</sup>	1(10,00) <sup>b</sup>	31(26,96)
	<b>Total</b>	<b>32(100)</b>	<b>13(100)</b>	<b>11(100)</b>	<b>49(100)</b>	<b>10(100)</b>	<b>115(100)</b>
Nationality	Nigerien	32(100,00) <sup>c</sup>	13(100,00) <sup>b</sup>	10(90,91) <sup>ab</sup>	48(97,96) <sup>a</sup>	10(100,00) <sup>ab</sup>	113(98,26)
	Burkinabè	0(0,00) <sup>c</sup>	0(0,00) <sup>b</sup>	0(0,00) <sup>ab</sup>	1(2,04) <sup>a</sup>	0(0,00) <sup>ab</sup>	1(0,87)
	Nigerian	0(0,00) <sup>c</sup>	0(0,00) <sup>b</sup>	1(9,09) <sup>ab</sup>	0(0,00) <sup>a</sup>	0(0,00) <sup>ab</sup>	1(0,87)
	<b>Total</b>	<b>32(100)</b>	<b>13(100)</b>	<b>11(100)</b>	<b>49(100)</b>	<b>10(100)</b>	<b>115(100)</b>
Level of education	Unschoolèd	24(75,00) <sup>ab</sup>	8(61,54) <sup>c</sup>	8(72,73) <sup>a</sup>	32(65,31) <sup>b</sup>	7(70,00) <sup>c</sup>	79(68,70)
	Primary	3(9,38) <sup>ab</sup>	3(23,08) <sup>c</sup>	0(0,00) <sup>a</sup>	4(8,16) <sup>b</sup>	0(0,00) <sup>c</sup>	10(8,70)
	Secondary	5(15,63) <sup>ab</sup>	1(7,69) <sup>c</sup>	3(27,27) <sup>a</sup>	13(26,53) <sup>b</sup>	3(30,00) <sup>c</sup>	25(21,74)
	Hight level	0(0,00) <sup>ab</sup>	1(7,69) <sup>c</sup>	0(0,00) <sup>a</sup>	0(0,00) <sup>b</sup>	0(0,00) <sup>c</sup>	1(0,87)
	<b>Total</b>	<b>32(100)</b>	<b>13(100)</b>	<b>11(100)</b>	<b>49(100)</b>	<b>10(100)</b>	<b>115(100)</b>
Sales experience	<10 years	17(53,12) <sup>a</sup>	9(69,23) <sup>ab</sup>	6(54,54) <sup>b</sup>	27(55,10) <sup>a</sup>	9(90,00) <sup>b</sup>	68(59,13)
	10 to 20 years	9(28,13) <sup>a</sup>	2(15,38) <sup>ab</sup>	2(18,19) <sup>b</sup>	12(24,49) <sup>a</sup>	0(0,00) <sup>b</sup>	25(21,74)
	≥20 years	6(18,75) <sup>a</sup>	2(15,38) <sup>ab</sup>	3(27,27) <sup>b</sup>	10(20,41) <sup>a</sup>	1(10,00) <sup>b</sup>	22(19,13)
	<b>Total</b>	<b>32 (100°)</b>	<b>13(100)</b>	<b>11(100)</b>	<b>49(100)</b>	<b>10(100)</b>	<b>115(100,0)</b>
Type of business	Retailler	31(96,88) <sup>b</sup>	13(100,00) <sup>a</sup>	11(100) <sup>c</sup>	45(91,84) <sup>a</sup>	10(100,00) <sup>d</sup>	110(95,65)
	Wholesellers	1(3,13) <sup>b</sup>	0(0,00) <sup>a</sup>	0(0,00) <sup>c</sup>	4(8,16) <sup>a</sup>	0(0,00) <sup>d</sup>	5(4,35)
	<b>Total</b>	<b>32(100)</b>	<b>13(100)</b>	<b>11(100)</b>	<b>49(100)</b>	<b>10(100)</b>	<b>115(100)</b>

Market 1: Harobanda; market 2: small market; market 3: Wadata; market 4: Dolé; market 5: Dar es sallam. Values with the same letter in the same column are not significantly different ( $P > .05$ ).

## 2.2. Practices at risk of bacteriological contamination of vegetables at the point of sale (market)

A number of factors likely to encourage contamination of vegetables at the point of sale were mentioned to the sellers. These risk factors include the type and hygiene of the supports, contact of the vegetables with food of animal origin or with money, storage conditions, treatment of the vegetables, toilets usage, wash hands failure with soap after using the toilet, etc.

### 2.2.1. Sellers behavior

Vegetable sellers adopt a number of behaviors on the markets that can lead to contamination of the products sold. These behaviors are summarized in **table (2)**. The results show that 72.73% and 53.12% of the sellers surveyed in markets 3 and 1 wore dirty clothes, compared with 38.46% and 24.49% in markets 2 and 4, respectively. Around 82% of sellers said they used public toilets and 62% used soap to wash their hands after using the toilet. Only one (1) seller reported using bleach to wash his hands. On markets 2 and 3, 100% of sellers said they used public toilets. Vegetables come into contact with money (23.48%) at the time of sale. The differences are significant between use of public toilets, hand washing after the toilet, contact of vegetables with money and the different markets surveyed ( $p = .000$ ).

**Table 2: Behavior of vegetable sellers in the various markets surveyed in the urban community of Niamey**

Parameters		Breakdown (n)% (%)					Total
		market1	market2	market3	market4	market5	
Clothing of the seller	Own	15(46,88) <sup>a</sup>	8(61,54) <sup>b</sup>	3(27,27) <sup>ab</sup>	37(75,51) <sup>c</sup>	6(60,00) <sup>a</sup>	69(60,00)
	Dirty	17(53,13) <sup>a</sup>	5(38,46) <sup>b</sup>	8(72,73) <sup>ab</sup>	12(24,49) <sup>c</sup>	4(40,00) <sup>a</sup>	46(40,00)
	<b>Total</b>	<b>32(100,00)</b>	<b>13(100,00)</b>	<b>11(100,00)</b>	<b>49(100,00)</b>	<b>10(100,00)</b>	<b>115(100,00)</b>
Use of public toilets	No	16(50,00) <sup>b</sup>	0(0,00)	0(0,00) <sup>b</sup>	5(10,20) <sup>a</sup>	1(10,00) <sup>b</sup>	21(18,26)
	Yes	16(50,00) <sup>b</sup>	13(100)	11(100,00) <sup>b</sup>	44(89,80) <sup>a</sup>	9(90,00) <sup>b</sup>	93(80,87)
	<b>Total</b>	<b>32(100,00)</b>	<b>13(100,00)</b>	<b>11(100,00)</b>	<b>49(100,00)</b>	<b>10(100,00)</b>	<b>115(100,00)</b>
Hand washing	Simply water	4(12,50) <sup>a</sup>	4(30,77) <sup>ab</sup>	7(63,64) <sup>b</sup>	16(32,65) <sup>b</sup>	3(30,00) <sup>d</sup>	34(36,56)
	Water+Javel	1(3,13) <sup>c</sup>	0(0,00) <sup>c</sup>	0(0,00) <sup>a</sup>	0(0,00) <sup>b</sup>	0(0,00) <sup>ab</sup>	1(1,75)
	Water+soap	11(34,38) <sup>c</sup>	9(69,23) <sup>c</sup>	4(36,36) <sup>a</sup>	28(57,14) <sup>b</sup>	6(60,00) <sup>ab</sup>	58(62,66)
	<b>Total</b>	<b>16(100)</b>	<b>13(100)</b>	<b>11(100)</b>	<b>44(100)</b>	<b>9(100)</b>	<b>93(100,00)</b>
Vegetable contact with money	No	31(96,88) <sup>b</sup>	13(100,00) <sup>ab</sup>	11(100,00) <sup>c</sup>	23(46,94) <sup>ab</sup>	10(100,00) <sup>a</sup>	88(76,52)
	Yes	1(3,13) <sup>b</sup>	0(0,00) <sup>ab</sup>	0(0,00) <sup>c</sup>	26(53,06) <sup>ab</sup>	0(0,00) <sup>a</sup>	27(23,48)
	<b>Total</b>	<b>32(100)</b>	<b>13(100)</b>	<b>11(100)</b>	<b>49(100)</b>	<b>10(100)</b>	<b>115(100,00)</b>

Market 1: Harobanda; market 2: small market; market 3: Wadata; market 4: Dolé; market 5: Dar es sallam. Values with the same letter in the same column are not significantly different ( $P > .05$ ).

### 2.2.2. Packaging and processing vegetables at the point of sale

**Table 3** shows how the vegetables were packaged and handled at the point of sale. On receipt, vegetables were packaged mainly in wire bags (76.52%), followed by cartons (18.26%) and crates (4.35%). Suppliers in market 5 used wire bags exclusively (100%), as did 92% of suppliers in market 4. In addition to wire bags, cartons were mainly used in second place by suppliers in markets 3 (36.36%), 2 (30.77%) and 1 (28.3%). Finally, suppliers in market 1 also use crates (15.63%). The rate of washing vegetables on receipt was 39%. The highest rate was observed in market 5 (90%) and the lowest in market 1 (9.38%). Washing is done mainly with water from public toilet taps (55.56%), followed by water from street vendors (Garoua) (40.00%) and finally borehole water (4.44%). More than 2/3 of sellers do not clean their sales containers, except in market 5, where only 20% do not comply with this hygiene rule. The supports used to carry the vegetables are mostly unhealthy (60.00%). Around 10.43% of vegetables sold on Niamey markets come into contact with animal foodstuffs. Only 4.35% of unsold vegetables are kept in the fridge, 79% are kept on site at room temperature, 13% in a nearby shop and 4% at home. The vegetables are subjected to virtually no processing at the point of sale. There were significant differences between the packaging at reception, the washing of vegetables at reception, the source of the water used, the cleaning of containers and the different markets considered ( $p < .05$ ).

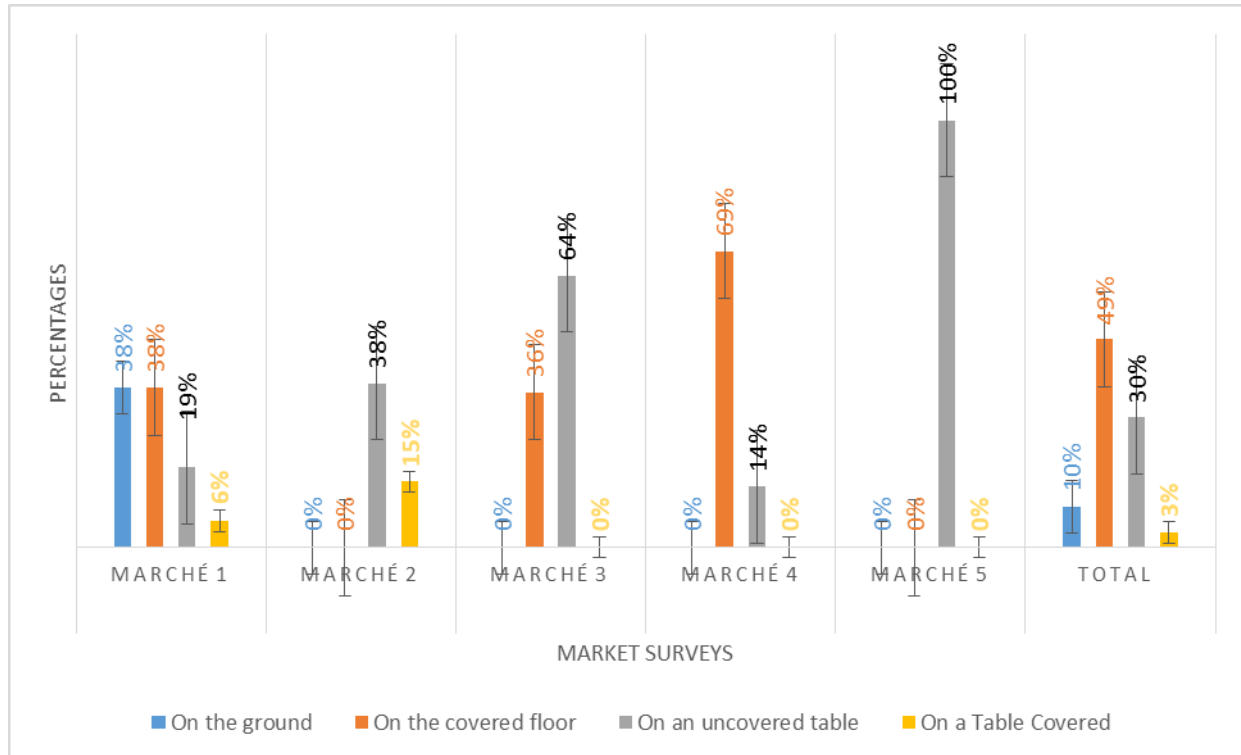
**Table 3: Method of packaging and treatment of vegetables by vendors in Niamey city markets**

Parameters		Breakdown (n)% (%)					Total
		market1	market2	market3	market4	market5	
Packaging at the reception	Caisse	5( 15.63 ) <sup>a</sup>	0(0,00) <sup>ab</sup>	0(0,00) <sup>c</sup>	0(0,00) <sup>a</sup>	0(0,00) <sup>c</sup>	5(4,35)
	Cardboard	9(28,13) <sup>a</sup>	4(30,77) <sup>a</sup>	4 (36.36 ) <sup>b</sup>	4(8,16) <sup>b</sup>	0(0,00) <sup>c</sup>	21(18,26)
	Bags	18(56,25) <sup>a</sup>	9(69,23) <sup>ab</sup>	7(63,64) <sup>c</sup>	45(91,84) <sup>b</sup>	10(100,00) <sup>ab</sup>	89(77,39)
	<b>Total</b>	<b>32(100,00)</b>	<b>13(100,00)</b>	<b>11(100,00)</b>	<b>49(100,00)</b>	<b>10(100,00)</b>	<b>115(100,00)</b>
Washing vegetables at the reception	Yes	3 (9.38 ) <sup>b</sup>	6(46,15) <sup>b</sup>	4(36,36) <sup>b</sup>	23(46,94) <sup>a</sup>	9(90,00) <sup>b</sup>	45(39,13)
	No	29(90,63) <sup>b</sup>	7(53,85) <sup>b</sup>	7(63,64) <sup>b</sup>	26(53,06) <sup>a</sup>	1(10,00) <sup>b</sup>	70(60,87)
	<b>Total</b>	<b>32(100,00)</b>	<b>13(100,00)</b>	<b>11(100,00)</b>	<b>49(100,00)</b>	<b>10(100,00)</b>	<b>115(100,00)</b>
Source of wash water	Drilling	0(0,00) <sup>c</sup>	0(0,00) <sup>c</sup>	0(0,00) <sup>c</sup>	2(8,70) <sup>b</sup>	0(0,00) <sup>c</sup>	2(4,44)
	Garoua	0(0,00) <sup>c</sup>	1(16,67) <sup>c</sup>	3(75,00) <sup>c</sup>	5(21,74) <sup>b</sup>	9(100,00) <sup>c</sup>	18(40,00)
	Public tap	3(100)	5(83,33) <sup>c</sup>	1(25,00) <sup>c</sup>	16(69,57) <sup>b</sup>	0(0,00) <sup>c</sup>	25(55,56)
	<b>Total</b>	<b>3(100,00)</b>	<b>6(100,00)</b>	<b>4(100,00)</b>	<b>23(100,00)</b>	<b>9(100,00)</b>	<b>45(100,00)</b>
Cleaning containers	Yes	8(25,00) <sup>b</sup>	4(30,77) <sup>a</sup>	3(27,27) <sup>a</sup>	14(28,57) <sup>a</sup>	8(80,00) <sup>a</sup>	37(32,17)
	No	24(75,00) <sup>b</sup>	9(69,23) <sup>a</sup>	8(72,73) <sup>a</sup>	35(71,43) <sup>a</sup>	2(20,00) <sup>a</sup>	78(67,83)
	<b>Total</b>	<b>32(100,00)</b>	<b>13(100,00)</b>	<b>11(100,00)</b>	<b>49(100,00)</b>	<b>10(100,00)</b>	<b>115(100,00)</b>
Hygienic condition of supports	Unhealthy	24(75,00) <sup>a</sup>	6(46,15) <sup>ab</sup>	8(72,73) <sup>b</sup>	25(51,02) <sup>b</sup>	6(60,00) <sup>b</sup>	69(60,00)
	Healthy	8(25,00) <sup>a</sup>	7(53,85) <sup>ab</sup>	3(27,27) <sup>b</sup>	24(48,98) <sup>b</sup>	4(40,00) <sup>b</sup>	46(40,00)
	<b>Total</b>	<b>32(100,00)</b>	<b>13(100,00)</b>	<b>11(100,00)</b>	<b>49(100,00)</b>	<b>10(100,00)</b>	<b>115(100,00)</b>
Contact with food of animal origin	Yes	6(18,75) <sup>b</sup>	2(15,38) <sup>b</sup>	1(9,09) <sup>a</sup>	2(4,08) <sup>a</sup>	1(10,00) <sup>a</sup>	12(10,43)
	No	26(81,25) <sup>b</sup>	11(84,62) <sup>b</sup>	10(90,91) <sup>a</sup>	47(95,92) <sup>a</sup>	9(90,00) <sup>a</sup>	103(89,57)
	<b>Total</b>	<b>32(100,00)</b>	<b>13(100,00)</b>	<b>11(100,00)</b>	<b>49(100,00)</b>	<b>10(100,00)</b>	<b>115(100,00)</b>
Vegetable conservation Unsold items	At home	3(9,38) <sup>a</sup>	1(7,69) <sup>a</sup>	0(0,00) <sup>b</sup>	0(0,00) <sup>a</sup>	0(0,00) <sup>b</sup>	4(3,48)
	Shop nearby	2(6,25) <sup>a</sup>	5(38,46) <sup>a</sup>	1(9,09) <sup>c</sup>	2(4,08) <sup>c</sup>	5(50,00) <sup>c</sup>	15 (13.04 )
	Fridge	3(9,38) <sup>a</sup>	0(0,00) <sup>a</sup>	0(0,00) <sup>c</sup>	2(4,08) <sup>c</sup>	0(0,00) <sup>c</sup>	5(4.35 )
	On site	24(75,00) <sup>a</sup>	7(53,85) <sup>a</sup>	10(90,91) <sup>c</sup>	45(91,84) <sup>c</sup>	(5)50,00 <sup>b</sup>	91(79.13 )
	<b>Total</b>	<b>32(100,00)</b>	<b>13(100,00)</b>	<b>11(100,00)</b>	<b>49(100,00)</b>	<b>10(100,00)</b>	<b>115(100,00)</b>
Vegetable processing during the sale	treatment	0(0,00) <sup>ab</sup>	0(0,00) <sup>c</sup>	0(0,00) <sup>a</sup>	2(4,08) <sup>a</sup>	1(10,00) <sup>a</sup>	3(2,61)
	No	32(100,00) <sup>ab</sup>	13(100,00) <sup>c</sup>	11(100,00) <sup>a</sup>	47(95,92) <sup>a</sup>	9(90,00) <sup>a</sup>	112(97,39)
	<b>Total</b>	<b>32(100,00)</b>	<b>13(100,00)</b>	<b>11(100,00)</b>	<b>49(100,00)</b>	<b>10(100,00)</b>	<b>115(100,00)</b>

Market 1: Harobanda; market 2: small market; market 3: Wadata; market 4: Dolé; market 5: Dar es sallam. Values with the same letter in the same column are not significantly different ( $P > .05$ ).

### 2.2.3. Vegetable sales support

Most vegetables are sold on the ground covered with bags (56.52%). Other sellers display their vegetables on tables, with 30.43% displaying them on uncovered tables and 3.48% on covered tables (fig.2).



**Figure 2: Distribution of vegetable sales media by market**

### 2.2.4. Vegetable sales environnement

**Table 4** shows the environment in which vegetables are sold. In the markets, vegetables are mainly sold either beside a public road (56%) or inside the market (34%). These two (2) locations account for 100% of vegetable sales in markets 2 and 3. In markets 1 and 5, sales points are found near gutters (6.25 and 30% respectively) and in market 4 near toilets (2.04%) and rubbish dumps (10.20). Table 4 also shows that vegetables are sold in an unhealthy environment (59.13%) in the open air. The rate of unsanitary conditions ranges from 40% in market 4 to 85% in market 5. The environment in which vegetables are sold is statistically different between markets ( $p < .05$ ).

**Table 4 : Vegetable sales environment**

Parameters		Breakdown (n)% (%)					Total
		Market 1	Market 2	Market 3	Market 4	Market 5	
Seller's position in relation to the market	Inside the market	13(40,63) <sup>a</sup>	1(7,69) <sup>b</sup>	3(27,27) <sup>a</sup>	22(44,90) <sup>b</sup>	0(0,00) <sup>a</sup>	39(33,91)
	At kerbside	17(53,13) <sup>a</sup>	12(92,31) <sup>b</sup>	8(69,73) <sup>a</sup>	21(42,86) <sup>b</sup>	7(70,00) <sup>b</sup>	65(55,65)
	Near WC	0(0,00) <sup>ab</sup>	0(0,00) <sup>ab</sup>	0(0,00) <sup>b</sup>	1( 2,04 ) <sup>b</sup>	0(0,00) <sup>b</sup>	1(0,87)
	A near open gutters	2( 6.25 ) <sup>ab</sup>	0(0,00) <sup>ab</sup>	0(0,00) <sup>b</sup>	0(0,00) <sup>ab</sup>	3(30,00) <sup>c</sup>	5(4,35)
	Nearby rubbish dump	0(0,00) <sup>ab</sup>	0(0,00) <sup>ab</sup>	0(0,00) <sup>b</sup>	5( 10,20 ) <sup>b</sup>	0(0,00) <sup>a</sup>	5(4,35)
	<b>Total</b>	<b>32(100,00)</b>	<b>13(100,00)</b>	<b>11(100,00)</b>	<b>49(100,00)</b>	<b>10(100,00)</b>	<b>115(100,00)</b>
Sale environment	Own	10(31,25) <sup>b</sup>	2(15,38) <sup>c</sup>	2(18,18) <sup>ab</sup>	27(55,10) <sup>a</sup>	6(60,00) <sup>b</sup>	47(40,87)
	Dirty	22(68,75) <sup>b</sup>	11(84,62) <sup>c</sup>	9(81,82) <sup>ab</sup>	22(44,90) <sup>a</sup>	4(40,00) <sup>b</sup>	68(59,13)
	<b>Total</b>	<b>32(100,00)</b>	<b>13(100,00)</b>	<b>11(100,00)</b>	<b>49(100,00)</b>	<b>10(100,00)</b>	<b>115(100,00)</b>

Market 1: Harobanda; market 2: small market; market 3: Wadata; market 4: Dolé; market 5: Dar es sallam. Values with the same letter in the same column are not significantly different ( $P > .05$ ).

## 4. Discussion

### ***Socio-demographic characteristics of sellers***

The socio-demographic characteristics of vegetable sellers in five (5) markets in Niamey were assessed in this study (**Table 1**). The results of this study showed that 89.57% of vegetable sales in Niamey markets are carried out by men. A different finding was made by other studies in Africa, which reported that the majority of vegetables are sold by women [11,18,19]. According to these authors, more than 95% of vegetable sales are carried out by women. This distribution of activities can be explained to the fact that in society, the tasks of selling vegetables, which are less laborious and require less physical effort than production, are assigned to women [11]. The strong male predominance observed in the present study could be linked to religious practices, which generally confine women to household tasks and raising children.

In Niamey's markets, almost all the vegetable sellers are of Nigerien (98.26%) and around 68% are aged between 20 and 39. In Abidjan markets in Ivory Coast 79.30% of vegetable sellers are Ivorian and 48.00% are in 30 to 45 age bracket [11]. Non-Ivorian sellers account for 20.70%, while in Niamey markets non-Nigerien sellers account for only 1.73%.

The overwhelming majority of the population in this study did not reach school (68.70%) and stated that they had received no basic training in selling vegetables. Similar findings have been reported by other authors, particularly in Ivory Coast [11,18] and Ghana [19]. The predominance of uneducated people selling vegetables can be explained to the fact that their status offers fewer opportunities to find a job in the formal sector that pays enough to meet their needs [11,20].

### ***Risk factors for bacteriological contamination of vegetables at the point of sale (market)***

Several factors likely to encourage contamination of vegetables in markets were analyzed during this study. The study revealed that many sellers wore dirty clothes (40.35%), did not wash their hands with soap when returning from the toilet (36.56%) and only one seller used bleach to wash his hands. A large number of sellers wash their vegetables with water only, which does not eliminate certain pathogenic germs. The WHO recommends washing hands with soap or any other detergent containing an antiseptic agent to eliminate any contaminants [21]. Washing hands with a detergent reduces the risk of contaminating certain products by touching them. Thus, personal hygiene, including hand washing throughout the food chain, is recognized as critical by the FDA (Food and Drug Administration) in reducing or eliminating contamination by enteric pathogens [11,22]. The absence of hand washing with soap or any other disinfectant after defecation is associated with widespread faecal contamination of the hands [11,23]. Hand washing with water alone does not eliminate potential contaminants, which can be transferred from hands to vegetables [11].

At reception, the vegetables are washed with water, most of which comes from the taps of public toilets (55.56%) or with water carried by street vendors (called Garoua in Hausa, who are usually people with poor personal hygiene). Certain types of vegetable (such as lettuce and certain aromatic

herbs) are sprayed with this water to give them an impression of freshness. Similar findings have been reported from Burkina Faso [24], Ghana [25] and Côte d'Ivoire [11,13]. The use of this water can be a source of pathogen contamination for vegetables. In fact, as well as providing a moist environment that encourages the growth of micro-organisms on the product, this water can be a likely source of pathogenic bacteria [9], which can contribute to vegetable contamination [14,26].

Vegetables are packaged in bags, cartons, plastic, crates or baskets. A large number of sellers display their produce on the ground, either covered with bags or not. Other sellers use utensils (such as sots, trays or tables) to market the vegetables. The supports used either to carry the vegetables or for packaging are very unhealthy. The hygienic condition of these supports is very poor, due to a lack of intensive washing. This practice of carrying vegetables on low supports or even directly on the ground can encourage contamination by sand and run-off water generated on the market or from rain [11,26]. It also exposes vegetables to the influx of customers and passers-by, who can contaminate them, as has been observed in Ivory Coast on certain markets in Abidjan [19,27]. In fact, the large number of people in the markets could be a factor in bringing in micro-organisms and increasing the level of contamination of vegetables. The way vegetables are exposed is a determining practice in the spread of many diseases transmissible through contaminated food [9,27].

During this study, it was observed that vegetables are most often sold along public roads (53.91%), near open gutters (6.96%), or even near toilets (2.61%), in an unsanitary environment (59.13%) in the open air. The same observation has been made in Côte d'Ivoire [11,27]. The surrounding pollution sites are a magnet for flies, which are potential reservoirs and vectors for the transmission of pathogenic microorganisms by landing on vegetables sold nearby [11,27,28]. In addition to flies, other pests such as cockroaches, mice and nematodes can cause contamination of vegetables exposed in such an environment [18].

## Conclusion

This aspect of the study made it possible to highlight vegetable sales practices likely to cause bacteriological contamination of vegetables on markets in the city of Niamey. Several risk factors for bio-contamination emerged from this study, in particular the use of public toilets, hand washing after using the toilet, hygienic conditions of the sales aids and the position of the sales sites. The majority of sellers are uneducated and take no steps to avoid the risk of bacteriological contamination of vegetables at the time of sale.

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