Int.J.Curr.Microbiol.App.Sci (2016) *5*(10): 875-890

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 5 Number 10 (2016) pp. 875-890**
Journal homepage: http://www.ijcmas.com

Original Research Article http://dx.doi.org/10.20546/ijcmas.2016.510.096

Antimicrobial Activity of the Varieties of Peppers (*Capsicum*) of Côte d'Ivoire on Multiresistant Strains

Kouassi Kouassi Clément[1,2,3,4], Coulibaly Bakary[1,2,5], Coulibaly Ibourahema[1,2], Koffi Affoué Carole[2,4] and Koffi-Nevry Rose[3]

[1]Universitie Jean Lorougnon Guédé, Unit training and Agroforestry Research, Teaching Unit Biochemistry, Microbiology BP150 Daloa, Côte d'Ivoire
[2]Universities Jean Lorougnon Guédé, Unit training and Agroforestry Research, Laboratory of Microbiology, Bio-industry and Biotechnologie BP150 Daloa, Côte d'Ivoire
[3]Universitie Nangui Abrogoua, Department of Food Science and Technology, Laboratory of Biotechnology and Food Microbiology, 02 BP 801 Abidjan 02 Côte d'Ivoire
[4]National Laboratory of Public health, 18, BP 2403 Abidjan 18, Côte d'Ivoire
[5]Universitie Félix Houphouët Boigny, Pharmacodynamics-biochemical laboratory, Faculty of Biosciences, 22 BP 582 Abidjan 22, Côte d'Ivoire
**Corresponding author*

Keywords

Capsicum, antimicrobial activity, MDR strains, *Enterococcus faecalis*

Article Info

Accepted:
25 September 2016
Available Online:
10 October 2016

A B S T R A C T

The resistance of microorganisms generated a loss of effectiveness of antibiotics. In Côte d'Ivoire, peppers, adjuvant in traditional medicine to treat many infections based on little scientific arguments. This present study aims to evaluate the *in vitro* antimicrobial activity of pepper on microorganisms of different profiles. Extracts were tested on the growth of strains (ATCC) and multiresistant clinical. The Gram positive have MIC and MBC respectively vary from 36-620 µgmL^{-1} and 78-620 µgmL^{-1}. Multidrug resistant have MIC and MBC, very high compared to ATCC strains (78-2500 µgmL^{-1}). The MIC and MBC of Gram-negative, respectively vary from 64-620 µgmL^{-1} and 130-1250 µgmL^{-1}. The clinics have very high MIC and CMB, sometimes out of the range of concentrations tested. *S. aureus* (KTG, MLS) *E. faecalis* ($P^RK^RAN^R$), *E. coli* (ESBL KTNet) and *P. aeruginosa* (ESBL KTG) were the least sensitive to different extracts. The MIC fungal range from 78-100 µgmL^{-1} strain ATCC against 100-620 µgmL^{-1} for the clinic. This study confirms the effectiveness of traditional herbal peppers (*Capsicum*) in the treatment of certain microbial infections. Peppers could be a promising natural resource for the exploration of new active molecules.

Introduction

The pepper is a spicy flavor to fruit-vegetable or not, derived from the rich biodiversity of many crops or not, used as a health food or for therapeutic purposes. The pepper belongs to the genus Capsicum, the SOLANACEAE family and species *Capsicum annuum* L. and *Capsicum frutescens* L., are important (Caballero *et al*., 2003; Ibarra-Junquera *et al*., 2010).

Its worldwide production is estimated at over 27 million tons per year, by against in Côte d'Ivoire, the spice is an iconic production of the fruit vegetable industry with annual production estimated at around 10 000 tons. Peppers are essentials in the Côte d'Ivoire supply and consumption are obvious reasons: the color, aromas and above all the pungent flavor (Kouassi and Koffi-Névry, 2012).

In addition, *Capsicum* fruit are used in traditional medicine to treat various diseases including diarrhea, gastroenteritis and some minor infections (Hervet-Hernandez *et al*., 2010; Kouassi *et al*., 2010). Moreover, the spice was the subject of study medicinal, pharmacological, therapeutic food (Dielek and Sevil 2011; Kouassi *et al*., 2012a; Koffi *et al*., 2015).

Significant economic benefits in the development of traditional medicine and the use of medicinal plants for the treatment of various diseases were found in industrialized countries like the United States but also in some developing countries including India (Halliwell *et al*., 2005; Muthu *et al*., 2006). Despite modernization and progress in health care, the health situation in Côte d'Ivoire is still characterized by a predominance of microbial infections.

But the main difficulties accompanying the treatment of infections and diseases by conventional drugs (cost, pathogen resistance and severe and toxic side effects) always encourage people to have very often uses local products including plants and peppers for treatment. Kouassi *et al*. (2012b) showed antibacterial activity including *Escherichia coli*, *Vibrio cholerae*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*) of different varieties of peppers grown in the Côte d'Ivoire. However, over the last decade, the control of infectious diseases, treatment by chemotherapy or natural products is severely restricted by the rapid expansion of microorganism strains resistant to available molecules. One of the ways to solve this thorny problem is the development of research of new molecules from natural heritage.

The peppers would be one of the available resources. The present work aims to evaluate the antimicrobial activity of extracts of pepper varieties (*Capsicum*) grown in Côte d'Ivoire on pathogenic multiresistant microorganisms of different profiles involved in many human infections in tropical regions.

Materials and Methods

Materials

Plant Material

The study material consists of five main varieties of peppers grown and widely used by the Ivorian people. This is *Capsicum annuum* variety antillais, *Capsicum annuum* variety jaune, *Capsicum frutescens* variety doux, *Capsicum frutescens* variety soudanais and *Capsicum frutescens* variety attie (Figure 1).

The varieties of peppers are obtained directly from four main district of Abidjan markets: the station Abobo market in Abobo, the Siporex market in Yopougon town, the large market of Kumasi and Gouro market, located in the town of Adjamé. Fruit varieties of *Capsicum annuum* antillais, *Capsicum annuum* jaune and *Capsicum frutescens* doux are obtained fresh while those varieties of *Capsicum frutescens* soudanais and *Capsicum frutescens* attie are desiccated (dried form). These varieties have identified all summers University Floristic National Center Félix Houphouët-Boigny.

A: mature unripe fruit (green) and ripe (red) of *Capsicum frutescens* var. doux
B: mature unripe fruit (green) and mature (yellow) of *Capsicum annuum* var. jaune
C: mature unripe fruit (green) and ripe (red) of *Capsicum annuum* var. antillais
D: ripe and dried fruit of *Capsicum frutescens* var. attie
E: ripe and dried fruit of *Capsicum frutescens* var. soudanais
Figure 1: Photograph of varieties of Capsicum studied

Microbial strains

Reference strains deductions as prescribed by the CLSI (2009), isolated clinical strains in laboratories in Côte d'Ivoire including the National Public Health Laboratory (LNSP), the Institut Pasteur in Côte d'Ivoire (IPCI) have been the subject of this study. The bacterial strains include eight (8) Gram-negative bacilli comprising enterobacteria (*E. coli* and *Salmonella*), non-enterobacteria (*P. aeruginosa*), six (6) Gram-positive cocci comprising (*S. aureus* and *Ent. Faecalis*) and bacilli (*Bacillus*). Two (02) fungal strains (*Candida albicans*) are also tested.

Methods

Search enzymatic phenotypes and mechanisms of microbial strains resistance

Antimicrobial susceptibility as antifungal predicts the sensitivity of an organism to one or more antibiotics in an essentially therapeutic approach. It establishes the resistance profile of microbial strain to some antibiotics prescribed or recommended. Antimicrobial susceptibility was performed according to the method of Cavallo and Merens (2008), CA-SMF requirements (2009) and those of the CLSI (2009).

Preparation of bacterial and fungal inocula and seeding

The pure fungal and bacterial strains 24 hours are used for the preparation of inocula. A suspension is prepared with pure colonies of 18 to 24 hours in 2 mL of sterile physiological saline contained in a hemolysis tube. Once well homogenized, the suspension is read Densimat adjusting it until the opacity of 0.5 Mc.Farland. The final inoculum of the species is obtained by adding 100 µl of this suspension to 10 mL of sterile physiological saline disposed in a screw test tube. This final suspension containing approximately 10^8 CFU/mL inoculum was used for making susceptibility testing. This inoculum is poured onto the surface of a Muller-Hinton agar previously cast in a Petri dish with a thickness of 4 mm. After 5 minutes of contact time, the surplus of the inoculum was removed with a micropipette. Using a cotton swab, the excess of the inoculum was removed by pressure on the edges of the box at an angle of 60°. The box is dried at 37° C for 5 min. The antibiotic discs are applied to the agar surface with a clamp in accordance with the conditions prescribed for each group of germs and taking care to space 2 cm discs. Plates are incubated 18 to 24 hours at 37°C

for all strains except for strains of *S. aureus* which culture with oxacillin was at 30°C in an aerobic atmosphere. Depending on the species, group of species or the antibiotic, special arrangements are made to follow CA-SMF's recommendations (2009). For enterobacteria, antibiotic discs are arranged in a specific order to help research on type of resistance.

Reading and interpretation

The effect of the antibacterial or antifungal disc on the bacterial or fungal agent is assessed by measuring a growth inhibition zone around the disc. Depending on the diameter of inhibition, the strain is classified as sensitive (S), intermediate (I) or resistant (R) to the antibiotic, group or families of antibiotics according to the manufacturer's instructions. The method of double synergy was used for the systematic detection of beta-lactam antibiotics with extended spectrum (ESBLs), placing around the acid amoxicillin clavulanic disk, the disk cefotaxime, ceftazidime or ceftriaxone at a distance of 3 cm from the center, as recommended by the CA-SFM (2009). The presence of ESBL is suspected in an appearance "champagne cork". The resistance phenotypes were defined from the three markers that are aminoglycosides gentamicin, tobramycin and amikacin. Different phenotypes correspond to different resistance mechanisms. The following five phenotypes were investigated:

Phenotype wild: sensitive to all aminoglycosides markers.

KTMGM or KTG: cross-resistance to kanamycin, gentamicin and tobramycin.

KGMTMANt or KTGANt: cross-resistance to all aminoglycosides.

KTMNm or KTNM: cross-resistance to kanamycin, tobramycin and neomycin.

KTMANt or KTANt: cross-resistance to kanamycin, tobramycin and amikacin.

(K = kanamycin; TM or T = Tobramycin; GM or G = Gentamicin; AN = Amikacin; Nt = netilmycin).

Macrolides were also studied because of their indication in the combination of antibiotics in infections of resistant bacteria. The resistance phenotype was defined from three macrolide susceptibility markers that are erythromycin, lincomycin and pristinamycin.

Preparation of various methanol extracts of peppers varieties

Selected peppers fruits were sorted washed and dried in an oven at 55°C for 6 days separately for varieties of *Capsicum frutescens* and 8-14 days for varieties of *Capsicum annuum*. Dried fruits were sprayed in an electric blender (Blender 38BL40 8010E model) at 3000 rev/min). The resulting mixture was sieved (mesh 1 mm diameter). The powders obtained have served to make previews. The solids/solvent ratio used is 1 g of substance per 10 mL of solvent. The principle of serial extraction is to administer several solvents of different polarity in a specific order to extract all extractable compounds, solvent after solvent, according to the methods described by Eloff *et al*. (2005) and Angeh (2006). It starts with petroleum ether, then dichloromethane, acetone and finally methanol. Five grams (5 g) of each powder variety of pepper is weighed into a vial in which it brings 50 mL of petroleum ether. The whole is supported on a shaker for one hour. After settling, the supernatant is filtered using Whatman filter paper # 2. The

same quantity of solvent is added to the mark (paste) and then heated again on the shaker for one hour. The supernatant is again filtered after settling. The process is repeated six times. The pomace is then removed from the flask and dried in the open air. After evaporation and drying complete, the pomace is introduced into a flask and taken up in 50 mL dichloromethane, and then brought to the shaker for an hour and filtered after settling. The same process is further repeated 5 times. The marc is again dried and subsequently taken six times with acetone in the same conditions and then optionally dried and taken up with methanol six times by the same methods. Each filtrate collected as the solvent used is placed in a different dish in the oven at 50°C to evaporate the solvent. The mass removed by each solvent is measured by weighing. The different masses extracted will be used in different biological tests.

Evaluation and determination of minimum inhibitory concentrations (MIC)

The MICs were determined following the revelation of an antibacterial or antifungal activity of different varieties of peppers by contacting (wells) method of methanol extracts of different varieties of peppers taken up with distilled water to 100 g/mL. Inhibition diameters in contact extracts were determined. MICs were determined by the methods of Kubo *et al*. (2005) and Angeh (2006). The different strains inocula are made of the Muller-Hinton broth for the bacterial strains and Sabouraud broth for fungal strains. A serial dilution of each extract by geometric progression of reason 2 is made, or from 36 to 25,000 µg. The application of the technique was done in 96 microwell plates (Greiner Bio-one®, Germany). The following successive operations are carried out. The seeded Sabouraud broth is distributed to the wells at a rate of 270 µl per well. A volume of 30 µl of the dilution series of *Capsicum* extract to be tested is added to each well bringing the culture volume to 300 µl. The same procedure is performed for the various witnesses. The plates are introduced in humidified boxes, then incubated at 37°C for 18 to 24 hours. A first macroscopic reading is performed to identify the wells where no growth (disorder) of yeast is observed for the study of MIC. A developer (with para-iodonitrotetrazolium (INT)) was used. In his presence, and after incubation, the wells harboring levuriennes growths vary from yellow to purplish red. The MIC is used for the well containing a small concentration of the extract where the color has not changed after the second incubation.

Determination of minimum bactericidal concentrations or fungicides (CMB/F)

MBC or MFC were determined according to methods Kubo *et al*. (2005) and Angeh (2006) and completed following the MIC and in the same conditions. After determining the MIC, the middle of the wells showing no disorder is diluted 1/100 in fresh medium. The plates are placed in humidified boxes and incubated at 37°C for 24 hours. After incubation, the developer is directly administered in an amount of 30 µl per well. The plates are again incubated for 30 to 60 minutes. The MFC is determined in the well containing the lowest concentration of the extract where culture has not turned purplish red.

Statistical Analyses

The Statistica software (99th edition) was used to calculate the average and standard deviations of the data obtained. The various parameters analyzed were then subjected to

analysis of variance (ANOVA). ANOVA was used to test the variability between different samples of a variety of Capsicum. The choice of this parametric test was guided by the fact that the data has a normal distribution and a variance equal.

Results and Discussion

Characteristics of microbial strains

Main stem characteristics are summarized in table.1.

Phenotypes and mechanisms of resistance to antibiotics of Gram positive bacteria

Reference strains studied exhibit no particular resistance, against different phenotypes have been identified environmental and clinical strains. All isolated strains are resistant to penicillin. Clinical SSA1 strains (*S. aureus*), SBC1 (*B. cereus*) and Senf1 (*Ent. faecalis*) have resistance to aminoglycosides, macrolides. The *S. aureus* (SSA1) strain exhibits resistance to methicillin while *B. cereus* (SBC1) resistant to tetracyclines. Enzymatic resistance mechanisms have been identified. The inhibitory mechanisms from simple (penicillinase) to complex were recorded. MLS phenotypes were identified on the *S. aureus* strains.

Phenotypes and mechanisms of resistance to antibiotics of Gram-negative bacteria

The reference strains tested present no particular resistance. Clinical strains appear resistant to multiple antibiotics. Clinical strain Sec1 (*E. coli*) is more resistant *E. coli* reference. It is resistant to aminoglycosides, the carboxypénicillines, the ureido-penicillins, tetracyclines, sulfonamides and fluoroquinolones. Clinical *Salmonella typhimurium* strain is resistant to cephalosporins and aminoglycosides. In addition to the high degree of natural resistance to ampicillin, amoxicillin, cotrimoxazole and chloramphenicol, a strong resistance was also observed in *Pseudomonas aeruginosa* clinically (SPA1) isolated. Aminoglycoside resistance markers have established cross-resistance phenotypes (kanamycin, gentamicin and tobramycin) (KTMGM). Mono and bi resistors of phenotypes (K, KTM TMGM) were noted. Different enzymatic mechanisms of resistance have been identified for betalactam antibiotics including inductors ESBL (extended beta lactamase or spread spectrum), penicillinases. Inhibiting enzymes from the simplest (penicillinase) to complex have therefore been recorded.

Fungal strains resistant Profile

Strains of *Candida albicans* appear multiresistant to antibiotics and different resistance phenotypes were also recorded. This strains (Sca1) is resistant to imidazole derivatives (clotrimazole, econazole, ketoconazole) and fluorinated pyrimidine.

Antimicrobial Activity of Capsicum varieties

The antimicrobial activity of different varieties of *Capsicum* is evaluated first by the determination of minimum inhibitory concentrations (MIC) and finally by minimum bactericidal concentrations or fungicides (MBC / MBF).

Antibacterial activity of the varieties of *Capsicum* on Gram positive bacteria

Analyses of MIC and MBC are summarized in Table 2. These results show that all the reference strains without particular profile are more sensitive to extracts of Capsicum tested. The MIC and MBC respectively vary

from 36-620 µgmL^{-1} and 78-620 µgmL^{-1}. Moreover *Bacillus cereus* ATCC 11778 is most sensitive with MIC and lower MBC. For other clinical multiresistant strains, MICs are very high compared to reference strains. The MIC range from 78-2500 µgmL^{-1} and very high, so MBC are out of range of extract concentrations tested. Multidrug resistant *S. aureus* strains (KTG, MLS) and *Ent. faecalis* ($P^RK^RAN^R$) were less sensitive to different extracts. The acetone and methanolic extracts of *C. annuum* are most active on all strains tested. The antimicrobial activity is bactericidal kind (MBC / MIC ≤ 4) for all reference strains and bacteriostatic or limited activity for multiresistant strains. The MIC and MBC of the reference antibiotic (tetracycline) are all lower than those recorded with the extracts of *Capsicum*.

Antibacterial activity of *Capsicum* varieties on Gram negative bacteria

The results of the MIC and MBC analyzes are summarized in Table 3. These results show that all the reference strains without particular profile are more sensitive to extracts of *Capsicum* tested. The MIC and MBC respectively vary from 64-620 µgmL^{-1} and 130-1250 µgmL^{-1}. Furthermore *Salmonella typhimurium* ATCC 13311 is the most sensitive with MIC and MBC lower especially acetone and methanolic extracts. For other clinical and environmental strains resistant and multiresistant, MICs are very high compared to reference strains. The MIC range from 130-2500 µgmL-1 and very high, so MBC are out times out of range of extract concentrations tested. The *E. coli* strains (ESBL, KTNet) and *P. aeruginosa* (ESBL, KTG) were the least sensitive to different extracts. Thus their MBC have to be determined with numerous extracts of different peppers varieties (etheric extracts and dichlorométhaniques). Generally, the acetone and methanol extracts are most active and varieties of *C. annuum* antillais and jaune are the most active. The antimicrobial activity is bactericidal kind (MBC/MIC ≤ 4) for all reference strains and bacteriostatic or limited activity for multi-resistant strains. The MIC and MBC of the reference antibiotic (tetracycline) are all lower than those recorded with the extracts of *Capsicum*.

Antifungal Activity varieties of peppers (*Capsicum*)

Analyses of MIC and MFC are summarized in Table 4. The extracts are active on both the reference strain and the pathogenic and clinical MDR strain. Note that the MIC and MFC weaker are obtained with the methanol extracts of all spice varieties. However the varieties of *C. annuum* antillais and jaune are the most active. For *C. albicans* (ECO^R KET^R $5FC^R$ CTR^R), the MIC extracts of *C. annuum* jaune and antillais respectively 310 and 220 µg/mL; the MFC are 520 µg/mL. The antimicrobial activity of extracts of different varieties of peppers is fungicide type for the strains tested.

All pathogenic bacterial strains studied clinical Gram positive were resistant to penicillins. Strong resistance to penicillins observed is consistent with those generally described in the literature (Leclercq, 2002; Muller *et al*., 2003; Abbasi *et al*., 2004). Bacterial strains isolated Gram-negative (*E. coli* (Sec1), *Sal. typhimurium* and *P. aeruginosa* (SPA1)) are also producing penicillinase. This resistance to penicillin often with a resistance to ampicillin, amoxicillin, ticarcillin and piperacillin could be explained by a production of high-level penicillinase. The isolation of *S. aureus* (SSA1) resistant to methicillin-type antibiotics is worrying because beta lactamase producing extended spectrum.

Multiresistant these bacterial species have been reported in other studies (Ben Romdhane *et al*., 2007; Kurlenda and Grinholc 2012). According to these authors, enterobacteria, *P. aeruginosa* and *S. aureus* have priority and clearly multiresistant bacteria because of their high potential pathogenic, commensal their character (skin portage, throat and digestive) which promotes clonal dissemination, making their spread fear in the population. Priority multirésitantes are *E. coli* (enterobacteria) resistant to cefotaxime, *P. aeruginosa* resistant to ceftazidime and S. aureus resistant to methicillin (MRSA). This situation is very worrying because according to the work of Kurlenda and Grinholc (2012), the emergence of infections enterobacteria producing beta-lactamases extended spectrum has important consequences on mortality and hospital costs. Compared to other studies, it should be noted that in recent years has seen an extension of the resistance of Gram positive cocci in particular *S. aureus* (Ben Romdhane *et al*., 2007). The acquisition therefore these multiple resistances generated a loss of effectiveness of antibiotics to ultimately often lead to a therapeutic impasse. The exploration of natural resources appears to be more promising because they constitute, by their biodiversity, the largest reserve of active substances.

The antimicrobial activities of five pepper *Capsicum* varieties consumed in households and used in traditional medicine on the in vitro growth of these microbial strains with different profiles (reference strains and multidrug-resistant strains).

The most significant growth inhibition diameters were observed for the reference strains. Furthermore, analysis of MIC and MBC clearly indicated that the acetone extracts and methanolic different varieties of *C. annuum* were most active. MICs for Gram positive reference strains vary from 36 to 200 µg/mL against 310-620 µg/mL for the Gram-negative. The MIC multi-resistant strains including *S. aureus* (KTG, MLS), *E. coli* (ESBL KTNet) or *P. aeruginosa* (ESBL, KTG) range from 620 to 12,520 µg/mL. These 25 extracts also inhibited the growth of fungal strains.

Analyses of MIC and those of MFC indicated that acetone and methanol extracts of varieties of *C. annuum* were most active. MICs for reference strains vary from 78 to 250 µg/mL against 100-830 µg/mL for clinical multiresistant strains including *Candida albicans* (ECO^R, KET^R, CTR^R). If the organic extracts have shown inhibitory activity on the growth of microorganisms, however it is the methanol extracts were the most active and especially those varieties of *Capsicum annuum*.

These extracts inhibited in a dose-effect relationship, the growth of microorganisms tested: reference strains and pathogens multiresistant clinical strains. The antimicrobial activity of peppers varieties including antifungal and antibacterial activity was also revealed by several authors (Kouassi *et al*., 2012a; Sulaiman *et al*., 2012; Soumya and Bindu, 2012; Do Nascimento *et al*., 2014 ; Koffi *et al*., 2014).

The MIC, the MBC and the MFC are quantitative values that have quantified the studied antimicrobial activity. The activity of pepper extracts on bacteria bactericide type for the reference strains recommended by the recognized organizations and bacteriostatic for multidrug-resistant clinical strains of *S. aureus* (KTG, MLS), *E. coli* (ESBL KTNet) and *P. aeruginosa* (ESBL KTG). Similarly, the fungal strains, the activity of the extracts of fungicide type for the recommended reference strain and fungistatic for clinical strain.

Table.1 Phenotypes and mechanisms of resistance to antibiotics of microbial strains

Gram positive bacteria	**Resistance phenotypes**	**Resistance enzymes**
S. aureus ATCC 25923	P^S AM^S AMX^S AMC^S OX^S TIC^S CTX^S GM^S K^S TM^S TE^S E^S SP^S L^S CIP^S	-
S. aureus (Ssa 1)	P^R AM^R AMX^R OX^R CTX^R GM^R K^R TM^R E^R SP^R L^R	Pase, AAC(6')-APH(2''), MLS_BC
Ent. faecalis ATCC 6055	P^S AM^S AMX^S AMC^S TIC^S CF^S CTX^S STR^S GM^S K^S TM^S TE^S E^S L^S SXT^S	-
Ent. faecalis (Senf 1)	P^R AM^R AMX^R K^R AN^R E^R SXT^R	Pase, APH(3')-III
B. cereus ATCC 11778	P^S AM^S AMX^S AMC^S TIC^S CTX^S GM^S K^S TE^S C^S L^S TM^S	-
B. cereus (Sbc 1)	P^R AM^R AMX^R AMC^R K^R AN^R TE^R C^I L^R	Pase, APH(3')-III
Gram négative bacteria	**Resistance phenotypes**	**Resistance enzymes**
E. coli ATCC 25922	AMX^S AMC^S TIC^S TCC^S PIP^S CF^S FOX^S CTX^S CAZ^S ATM^S GM^S TM^S K^S AN^S NET^S TE^S CS^S SXT^S NA^S PEF^S CIP^S	-
E. coli (Sec 1)	AMX^R TIC^R TCC^I PIP^I CF^R CTX^R CAZ^R GM^R K^R TM^R NET^R TE^R SXT^R NA^R PEF^R CIP^R	BLSE ; Pase ; AAC(2') ; AAC(3)-VI
Sal. typhimurium ATCC 29212	AMX^S AMC^S TIC^S PIP^S FOX^S CTX^S CAZ^S GM^S TM^S SXT^S CIP^S	
Sal. typhimurium (Ssal 2)	FOX^R TM^R	Pase (TEM)
P. aeruginosa ATCC 27853	AM^R AMX^R SXT^R C^R AMC^R TIC^S PIP^S CRO^S CAZ^S ATM^S GM^S TM^S CIP^S	-
P. aeruginosa (Spa 1)	AM^R AMX^R SXT^R C^R AMC^R TIC^R PIP^R CRO^R CAZ^R GM^R TM^R K^R CIP^R	BLSE (ceftazydinase) ; ANT(2'')
Fungal strains	**Resistance phenotypes**	
C. albicans ATCC 90028	ECO^S NY^S KET^S $5FC^S$ CTR^S	-
Candida albicans (Sca 1)	ECO^R KET^R $5FC^R$ CTR^R	

- : no enzyme

Antibiotic and resistance enzymes of Gram-positive bacteria

P (pénicilline G), AM (ampicilline), AMX (amoxicilline), AMC (Amoxicilline + Acide Clavulanique), OX (oxacilline), TIC (Tircaciline), CTX (céfotaxime), GM (gentamycine), TM (tobramycine), K (kanamycine), E (érythromycine), SP (spiramycine), L (lincomycine), TE (tétracycline), CIP (ciprofloxacine), STR (streptomycine), AN (amikacine), TIC (ticarcilline), CF (céfalotine), CTX (céfotaxime), C (chloramphénicol) RA (rifampicine), SXT (triméthoprime + sulfamides.; Pase = pénicillinase (bas niveau ou haut niveau) ; APH(3')-III = Aminoglycoside phosphotransferase (3')-III ; AAC(6')-APH(2'') = Aminoglycoside acétyltransferase (6')- Phosphotransferase (2'') ; MLS_BC = érytromycine, lincomycine pristinamycine sensible au composé B constitutif ; AAC(2'), AAC(3)-VI = Aminoglycoside acétyltransferase (2')/ Aminoglycoside acétyltransferase (3')-VI ; ANT(4'')-II = Aminoglycoside nucléotidyltransferase (4'')-II ; ANT(2'') = Aminoglycoside nucléotidyltransferase (2'') ; APH(3')-I, -II = Aminoglycoside phosphotransferase (3')-I ou Aminoglycoside phosphotransferase (3')-II.

Antibiotic and resistance enzymes of Gram-negative bacteria

AMX (amoxicilline), AMC (amoxicilline + acide clavulanique), TIC (ticarcilline), TCC (ticarcilline + acide clavulanique), PIP (pipéracilline), CF (céfalotine), FOX (céfoxitine), CTX (céfotaxime), CAZ (ceftazidime), ATM (aztréonam), TM (tobramycine), GM (gentamicine), AN (amikacine), K (kanamicine), NET (nétilmicine) TE (tétracycline), SXT (cotrimoxazole), CS (colistine), NA (acide nalidixique), PEF (péfloxacine), CIP (ciprofloxacine). Pase = pénicillinase (bas niveau ou haut niveau) ; APH(3')-III = Aminoglycoside phosphotransferase (3')-III ; AAC(6')-APH(2'') = Aminoglycoside acétyltransferase (6')- Phosphotransferase (2'') ; MLS_BC = érytromycine, lincomycine pristinamycine sensible au composé B constitutif ; AAC(2'), AAC(3)-VI = Aminoglycoside acétyltransferase (2')/ Aminoglycoside acétyltransferase (3')-VI ; ANT(4'')-II = Aminoglycoside nucléotidyltransferase (4'')-II ; ANT(2'') = Aminoglycoside nucléotidyltransferase (2'') ; APH(3')-I, -II = Aminoglycoside phosphotransferase (3')-I ou Aminoglycoside phosphotransferase (3')-II.

Fungal

EC (éconazole), NY (nystatine), KET (kétoconazole), 5FC (5 fluoro-cytosine), CTR (clotrimazole).

Table.2 Minimum Inhibitory Concentrations and bactericides (µgmL-1) of various extracts of Capsicum on Gram positive bacteria

Varietes Extracts		***S. aureus***		***S. aureus***		***B. subtilis***		***B. cereus***		***Ent. faecalis***		***Ent. faecalis***	
Capsicum		**ATCC 25923**		**KTG, MLS (Ssa 1)**		**ATCC 6633**		**$P^R K^R AN^R$ (Sbc1)**		**ATCC 6055**		**$P^R K^R AN^R$ (Senf 2)**	
		MIC	**MBC**	**MIC**	**MBC**	**MIC**	**MBC**	**MIC**	**MBC**	**MIC**	**MBC**	**MIC**	**MBC**
***Capsicum frutescens* soudanais**	ETH	410 ± 180^{c}	520 ± 180^{c}	520 ± 180^{ef}	2500 ± 0^{f}	410 ± 180^{c}	620 ± 0^{d}	620 ± 0^{d}	1660 ± 480^{e}	620 ± 0^{d}	620 ± 0^{c}	1250 ± 0^{i}	› 2500
	DCM	310 ± 0^{c}	520 ± 180^{c}	410 ± 180^{e}	2500 ± 0^{f}	310 ± 0^{c}	620 ± 0^{d}	620 ± 0^{d}	1660 ± 480^{e}	620 ± 0^{d}	620 ± 0^{c}	620 ± 0^{g}	2500 ± 0^{e}
	ACT	200 ± 90^{b}	410 ± 180^{c}	150 ± 0^{b}	830 ± 360^{d}	200 ± 90^{b}	410 ± 180^{c}	310 ± 0^{c}	830 ± 360^{d}	310 ± 0^{c}	410 ± 180^{b}	620 ± 0^{g}	1250 ± 0^{d}
	MTH	150 ± 0^{b}	410 ± 180^{c}	200 ± 90^{bc}	830 ± 360^{d}	150 ± 0^{b}	310 ± 0^{bc}	310 ± 0^{c}	620 ± 0^{d}	310 ± 0^{c}	410 ± 180^{b}	520 ± 180^{ef}	830 ± 360^{c}
***Capsicum frutescens* attié**	ETH	410 ± 180^{c}	520 ± 180^{c}	520 ± 180^{ef}	2500 ± 0^{f}	410 ± 180^{c}	620 ± 0^{d}	620 ± 0^{d}	1660 ± 480^{e}	620 ± 0^{d}	620 ± 0^{c}	1250 ± 0^{i}	› 2500
	DCM	310 ± 0^{c}	520 ± 180^{c}	410 ± 180^{e}	2080 ± 730^{f}	310 ± 0^{c}	620 ± 0^{d}	520 ± 180^{d}	1660 ± 480^{e}	520 ± 180^{d}	620 ± 0^{c}	620 ± 0^{g}	› 2500
	ACT	200 ± 90^{b}	410 ± 180^{c}	150 ± 0^{b}	830 ± 360^{d}	200 ± 90^{b}	410 ± 180^{c}	310 ± 0^{c}	830 ± 360^{c}	310 ± 0^{c}	410 ± 180^{b}	620 ± 0^{g}	1250 ± 0^{d}
	MTH	150 ± 0^{b}	410 ± 180^{c}	150 ± 90^{b}	830 ± 360^{d}	150 ± 0^{b}	310 ± 0^{bc}	310 ± 0^{c}	620 ± 0^{d}	310 ± 0^{c}	410 ± 180^{b}	520 ± 180^{ef}	830 ± 360^{c}
***Capsicum frutescens* doux**	ETH	410 ± 180^{c}	620 ± 0^{d}	620 ± 0^{g}	2500 ± 0^{f}	410 ± 180^{c}	520 ± 180^{c}	620 ± 0^{d}	2500 ± 0^{f}	620 ± 0^{d}	1250 ± 0^{d}	1250 ± 0^{j}i	› 2500
	DCM	310 ± 0^{c}	620 ± 0^{d}	620 ± 0^{g}	2500 ± 0^{f}	310 ± 0^{c}	520 ± 180^{c}	520 ± 180^{d}	1580 ± 570^{e}	520 ± 180^{d}	1250 ± 0^{d}	1250 ± 0^{i}	› 2500
	ACT	200 ± 90^{b}	520 ± 180^{c}	150 ± 0^{b}	2500 ± 0^{f}	200 ± 90^{b}	410 ± 180^{c}	520 ± 180^{d}	1250 ± 0^{d}	520 ± 180^{d}	520 ± 180^{bc}	1040 ± 360^{i}	› 2500
	MTH	150 ± 0^{b}	520 ± 180^{c}	150 ± 0^{b}	2080 ± 730^{f}	150 ± 0^{b}	310 ± 0^{bc}	520 ± 180^{d}	1250 ± 0^{d}	520 ± 180^{d}	410 ± 180^{b}	830 ± 360^{h}	› 2500
***Capsicum annuum* Antillais**	ETH	150 ± 0^{b}	410 ± 180^{c}	150 ± 0^{b}	1040 ± 360^{e}	150 ± 0^{b}	310 ± 0^{bc}	410 ± 180^{c}	830 ± 360^{d}	410 ± 180^{c}	410 ± 180^{b}	620 ± 0^{g}	1250 ± 0^{d}
	DCM	100 ± 40^{b}	310 ± 0^{bc}	200 ± 90^{bc}	830 ± 360^{d}	100 ± 40^{b}	310 ± 0^{bc}	310 ± 0^{c}	830 ± 360^{d}	310 ± 0^{c}	410 ± 180^{b}	520 ± 180^{ef}	830 ± 360^{c}
	ACT	78 ± 0^{a}	150 ± 0^{b}	150 ± 0^{c}	620 ± 0^{d}	78 ± 0^{a}	100 ± 40^{a}	310 ± 0^{d}	520 ± 180^{c}	310 ± 0^{d}	200 ± 90^{b}	520 ± 180^{g}	830 ± 360^{c}
	MTH	78 ± 0^{a}	150 ± 0^{b}	100 ± 45^{b}	410 ± 180^{c}	50 ± 24^{a}	100 ± 40^{a}	150 ± 0^{b}	410 ± 180^{c}	150 ± 0^{b}	200 ± 90^{b}	310 ± 0^{de}	410 ± 180^{b}
***Capsicum annuum* Jaune**	ETH	150 ± 0^{b}	410 ± 180^{c}	310 ± 0^{de}	1040 ± 360^{d}	130 ± 40^{b}	310 ± 0^{bc}	310 ± 0^{c}	830 ± 360^{d}	410 ± 180^{c}	410 ± 180^{b}	620 ± 0^{g}	1250 ± 0^{d}
	DCM	100 ± 40^{b}	310 ± 0^{bc}	150 ± 0^{b}	830 ± 360^{d}	100 ± 40^{b}	310 ± 0^{bc}	310 ± 0^{c}	830 ± 360^{d}	310 ± 0^{c}	410 ± 180^{b}	620 ± 0^{g}	830 ± 360^{c}
	ACT	78 ± 0^{a}	150 ± 0^{b}	130 ± 45^{b}	620 ± 0^{d}	64 ± 24^{a}	100 ± 40^{a}	150 ± 0^{b}	410 ± 180^{c}	310 ± 0^{c}	200 ± 90^{b}	520 ± 90^{ef}	830 ± 360^{c}
	MTH	78 ± 0^{a}	150 ± 0^{b}	78 ± 0^{b}	410 ± 180^{c}	36 ± 0^{a}	78 ± 0^{a}	150 ± 0^{b}	310 ± 0^{bc}	150 ± 0^{b}	150 ± 0^{b}	250 ± 0^{d}	410 ± 180^{b}
Tétracycline		30 ± 10^{a}	30 ± 10^{a}	30 ± 10^{a}		1250 ± 0^{e}		30 ± 10^{a}		30 ± 10^{a}		36 ± 0^{a}	

ETH: Etheric; DCM: Dichloromethanic; ACT: Acetonic ; MTH: Methanolic;

Nd: not determined; the same letters in the same column indicate that there is no significant difference ($P > 0.05$) between the quantitative values (MIC and MBC).

Table.3 Minimum Inhibitory Concentrations and bactericides (µgmL-1) of various extracts of Capsicum on Gram negative bacteria

Varieties Extracts *Capsicum*		***E. coli*** **ATCC 25922**		***E. coli*** **BLSE, KTNet (Sec1)**		***Sal. Typhimurium*** **ATCC 13311**		***Sal. Typhimurium*** **P^{R} (WT)**		***P. aeruginosa*** **ATCC 27853**		***P. aeruginosa*** **BLSE, KTG (Spa1)**	
		MIC	**MBC**	**MIC**	**MBC**	**MIC**	**MBC**	**MIC**	**MBC**	**MIC**	**MBC**	**MIC**	**MBC**
Capsicum frutescens **soudanais**	ETH	620 ± 0^{e}	1250 ± 0^{d}	2500 ± 0^{g}	› 2500	520 ± 180^{d}	1250 ± 0^{f}	520 ± 180^{d}	1250 ± 0^{f}	520 ± 180de	1250 ± 0^{d}	› 2500	nd
	DCM	310 ± 0^{d}	620 ± 0^{cd}	1250 ± 0^{f}	› 2500	410 ± 180^{cd}	1040 ± 360^{f}	520 ± 180^{d}	1250 ± 0^{f}	520 ± 180de	1040 ± 360^{cd}	› 2500	nd
	ACT	310 ± 0^{c}	410 ± 180^{c}	620 ± 0^{e}	› 2500	250 ± 90^{c}	410 ± 180^{d}	310 ± 0^{c}	620 ± 0^{e}	410 ± 180^{cd}	620 ± 0^{c}	2500 ± 0^{h}	nd
	MTH	310 ± 0^{c}	410 ± 180^{c}	620 ± 0^{e}	2500 ± 0^{e}	130 ± 45^{b}	310 ± 0^{d}	200 ± 90^{c}	520 ± 180de	410 ± 180^{cd}	410 ± 180^{c}	2500 ± 0^{h}	nd
Capsicum frutescens **attié**	ETH	620 ± 0^{e}	1250 ± 0^{d}	2500 ± 0^{g}	› 2500	520 ± 180^{d}	1250 ± 0^{f}	520 ± 180^{d}	1250 ± 0^{f}	620 ± 0^{e}	1250 ± 0^{d}	› 2500	nd
	DCM	310 ± 0^{d}	620 ± 0^{cd}	1250 ± 0^{f}	› 2500	310 ± 0^{c}	1040 ± 360^{f}	520 ± 180^{d}	1250 ± 0^{f}	620 ± 0^{e}	1040 ± 360^{cd}	› 2500	nd
	ACT	310 ± 0^{c}	520 ± 180^{cd}	620 ± 0^{e}	› 2500	150 ± 0^{b}	410 ± 180^{d}	520 ± 180^{d}	620 ± 0^{e}	410 ± 180^{cd}	620 ± 0^{c}	2500 ± 0^{h}	nd
	MTH	310 ± 0^{c}	520 ± 180^{cd}	620 ± 0^{e}	2500 ± 0^{e}	130 ± 45^{b}	310 ± 0^{d}	200 ± 90^{b}	520 ± 180de	410 ± 180^{cd}	410 ± 180^{c}	2500 ± 0^{h}	nd
Capsicum frutescens **doux**	ETH	620 ± 0^{e}	1250 ± 0^{d}	2500 ± 0^{g}	nd	520 ± 180^{d}	1250 ± 0^{f}	830 ± 360^{d}	2500 ± 0^{g}	620 ± 0^{e}	2500 ± 0^{f}	› 2500	nd
	DCM	410 ± 180^{d}	1250 ± 0^{d}	2500 ± 0^{g}	› 2500	310 ± 0^{c}	830 ± 360^{e}	830 ± 360^{d}	2500 ± 0^{g}	620 ± 0^{e}	2500 ± 0^{f}	› 2500	nd
	ACT	410 ± 180^{c}	830 ± 360^{d}	2500 ± 0^{g}	› 2500	150 ± 0^{b}	410 ± 180^{d}	520 ± 180^{d}	1250 ± 0^{f}	520 ± 180^{cd}	1250 ± 0^{d}	2500 ± 0^{h}	nd
	MTH	410 ± 180^{c}	830 ± 360^{d}	2500 ± 0^{g}	› 2500	130 ± 45^{b}	310 ± 0^{d}	310 ± 0^{c}	620 ± 0^{e}	410 ± 180^{cd}	1250 ± 0^{d}	2500 ± 0^{h}	nd
Capsicum annuum **antillais**	ETH	410 ± 0^{d}	620 ± 0^{cd}	1250 ± 0^{f}	› 2500	520 ± 180^{d}	1250 ± 0^{f}	520 ± 180^{d}	1250 ± 0^{f}	620 ± 0^{bc}	1250 ± 0^{d}	1250 ± 0^{g}	› 2500
	DCM	310 ± 0^{d}	620 ± 0^{cd}	620 ± 0^{e}	2500 ± 0^{e}	150 ± 0^{b}	410 ± 180^{d}	520 ± 180^{d}	1250 ± 0^{f}	620 ± 0^{bc}	1250 ± 0^{d}	1250 ± 0^{g}	› 2500
	ACT	310 ± 0^{c}	410 ± 180^{c}	620 ± 0^{e}	2080 ± 730^{e}	130 ± 40^{b}	310 ± 0^{d}	310 ± 0^{c}	620 ± 0^{e}	410 ± 180^{b}	620 ± 0^{c}	620 ± 0^{e}	2080 ± 730^{e}
	MTH	310 ± 0^{c}	410 ± 180^{c}	620 ± 0^{e}	2080 ± 730^{e}	78 ± 0^{b}	150 ± 0^{c}	130 ± 0^{b}	310 ± 0^{d}	410 ± 180^{b}	620 ± 0^{c}	620 ± 0^{e}	2080 ± 730^{e}
Capsicum annuum **jaune**	ETH	410 ± 180^{d}	620 ± 0^{cd}	1250 ± 0^{f}	› 2500	310 ± 0^{c}	830 ± 360^{e}	520 ± 180^{d}	1250 ± 0^{f}	410 ± 180^{cd}	1250 ± 0^{d}	1250 ± 0^{g}	› 2500
	DCM	310 ± 0^{d}	620 ± 0^{cd}	620 ± 0^{e}	2500 ± 0^{e}	310 ± 0^{c}	410 ± 180^{d}	520 ± 180^{d}	1250 ± 0^{f}	410 ± 180^{cd}	1250 ± 0^{d}	1250 ± 0^{g}	› 2500
	ACT	310 ± 0^{c}	410 ± 180^{c}	620 ± 0^{e}	2080 ± 730^{e}	130 ± 40^{b}	250 ± 90^{d}	200 ± 90^{b}	620 ± 0^{e}	250 ± 90^{b}	520 ± 180^{c}	620 ± 0^{e}	2080 ± 730^{e}
	MTH	310 ± 0^{c}	410 ± 180^{c}	620 ± 0^{e}	2080 ± 730^{e}	64 ± 20^{b}	130 ± 40^{c}	130 ± 40^{b}	310 ± 0^{d}	200 ± 90^{b}	410 ± 180^{c}	620 ± 0^{e}	2080 ± 730^{e}
Tétracycline		30 ± 10^{a}	30 ± 10^{a}	36 ± 0^{a}	78 ± 10^{b}	24 ± 10^{a}	24 ± 10^{a}	24 ± 10^{a}	24 ± 10^{a}	24 ± 10^{a}	24 ± 10^{a}	36 ± 0^{a}	100 ± 40^{b}

Nd: not determined; the same letters in the same column indicate that there is no significant difference (P > 0.05) between the quantitative values (MIC and MBC).

Table.4 Minimum Inhibitory Concentrations and Fungicides (µgmL-1) of various extracts of Capsicum

Varieties Extracts *Capsicum*		*C. albicans* ATCC 90028		*C. albicans* ECO^R KET^R 5FC^R CTR^R	
		MIC	**MFC**	**MIC**	**MFC**
***Capsicum frutescens* soudanais**	ETH	620 ± 0^e	1250 ± 0^e	1250 ± 0^f	› 2500
	DCM	310 ± 0^d	620 ± 0^d	1250 ± 0^f	2500 ± 0^f
	ACT	250 ± 90^d	520 ± 180^d	620 ± 0^e	2080 ± 730^f
	MTH	150 ± 0^c	310 ± 0^d	310 ± 0^d	620 ± 0^d
***Capsicum frutescens* attié**	ETH	620 ± 0^e	1250 ± 0^e	1250 ± 0^f	› 2500
	DCM	310 ± 0^d	620 ± 0^d	1250 ± 0^f	2500 ± 0^f
	ACT	200 ± 90	520 ± 180^d	620 ± 0^e	1660 ± 480^e
	MTH	150 ± 0	310 ± 0^d	310 ± 0^d	830 ± 360^d
***Capsicum frutescens* doux**	ETH	620 ± 0^e	1660 ± 480^e	2500 ± 0^g	› 2500
	DCM	410 ± 180^d	620 ± 0^d	2500 ± 0^g	› 2500
	ACT	310 ± 0^d	520 ± 180^d	620 ± 0^e	2500 ± 0^f
	MTH	150 ± 0^c	410 ± 180^d	620 ± 0^e	2500 ± 0^f
***Capsicum annuum* antillais**	ETH	250 ± 90^d	520 ± 180^d	830 ± 360^e	1660 ± 480^e
	DCM	150 ± 0^c	310 ± 0^d	620 ± 0^e	1660 ± 480^e
	ACT	130 ± 40^d	310 ± 0^d	620 ± 0^e	1250 ± 0^e
	MTH	100 ± 40^c	200 ± 90^c	250 ± 90^d	520 ± 180^d
***Capsicum annuum* jaune**	ETH	250 ± 90^d	520 ± 180^d	620 ± 0^e	1660 ± 480^e
	DCM	150 ± 0^c	310 ± 0^d	620 ± 0^e	1660 ± 480^e
	ACT	130 ± 40^e	310 ± 0^d	620 ± 0^e	1250 ± 0^e
	MTH	78 ± 0^c	150 ± 0^c	310 ± 0^d	520 ± 180^d
Nystatine		25 ± 10^a	25 ± 0^a	50 ± 0^a	100 ± 10^c

The same letters in the same column indicate that there is no significant difference (P > 0.05) between the quantitative values (MIC and MBC).

Regarding the bactericidal and bacteriostatic activity, work Kouassi *et al*., (2010; 2012b) showed that the varieties of *C. annuum* and *C. frutescens* to feature among other alkaloids, flavonoids, tannins, sterols and polyphenols (known antimicrobial compounds) that are the source of antimicrobial properties put in evidence. Erturk (2006) showed the activity of extract of *Capsicum annuum* on *C. albicans*. Do Nascimento *et al*., (2013) revealed fungal activity with extracts of *Capsicum frutescens*. However, the MIC (5 mg/mL) (17 mg/mL) recorded respectively by Erturk and Do Nascimento *et al*., are significantly higher than those obtained in this study regardless of the profile of the strains tested. According to Sulaiman *et al*., (2011), the activity of a plant substance depends on several factors including the mode of extraction and concentration of active ingredients. The antifungal activity of extracts of *Capsicum* on *Candida albicans* may be due to the presence of polyphenols, tannins and flavonoids already reported in the literature by the work of Kouassi *et al*., (2010) and those of Hervert-Hernandez *et al*., (2010). For the mechanism and mode of action of bioactive compounds chili, studies conducted by researchers Lambert *et al*., (2001) and De Pina Vaz *et al*., (2004) found that bioactive compounds would act by increasing the permeability of the plasma membrane, changes in the pH gradient, and a release organic ions when these compounds are in contact microbial cells (bacteria and fungi).

These disturbances result, impaired membrane function of various microbial agents. These phenomena have been reported on the fungal strains (*Candida albicans*) and bacterial strains (*S. aureus, E. coli*) (Cox *et al*., 2001; Hammer *et al*., 2004). These authors also reported that the presence of these bioactive compounds, there is inhibition of cell respiration and a disturbance of chemiosmotic control which are also the source of cell death. In clear, studied peppers varieties are active on the growth of the recommended reference strains and to varying degrees multiresistant pathogens and clinical strains in tropical areas. These results partly confirm the effectiveness of traditional herbal peppers (*Capsicum*) in the treatment of certain microbial diseases. This study is a set of significant scientific arguments to justify the consumption and the use of capsicum varieties in traditional medicine to treat various infectious diseases.

In conclusion, the acquisition of multiple resistances of microorganisms generated a loss of effectiveness of antibiotics and often leads to a therapeutic impasse. The ethanol extracts, dichlorométhaniques, acetone and methanolic varieties of peppers (*Capsicum annuum* antillais, *Capsicum annuum* jaune, *Capsicum frutescens* attie, *Capsicum frutescens* doux and *Capsicum frutescens* soudanais) have antimicrobial activity on recommended reference strains (*S. aureus*, *E. coli*, *P. aeruginosa* and *Sal. typhimurium*, *C. albicans*) and multidrug-resistant pathogens clinics of the same species. The antimicrobial activity is very significant on these reference strains and relatively low on multidrug resistant clinical strains of highly pathogenic and responsible for various human diseases. The highest activities were recorded methanolic extract. This solvent better concentrate the active principles. *Capsicum annuum* antillais and *Capsicum annuum* jaune are the most active varieties of all microbial strains tested. This study is an undeniable scientific argument about the traditional use of varieties of *Capsicum* in the treatment of certain infections in Côte d'Ivoire. The different varieties of peppers (*Capsicum annuum* antillais, *Capsicum annuum* jaune, *Capsicum frutescens* attie,

Capsicum frutescens doux and *Capsicum frutescens* soudanais) could be real promising resource for the exploration of new active molecules.

References

Abbassi, M.S., Achour, W., Ben Hassen A. 2004. Caractéristiques des souches d'entérocoques isolées chez des patients neutropéniques au centre national de greffe de moelle osseuse de Tunis. *Bull. Soc. Pathol. Exot.*, 97(2): 91-94.

Angeh, J.E. 2006. Isolation and characterization of antibacterial compounds present in members of *Combretum* section, *Hypocrateroppsis*. PhD Thesis. University of Pretoria. Prétoria, Afrique du Sud. 210 pp.

Ben Romdhane, F., Bouguerra C.H., sahnoun, O., Loussaief, C.H., Kacem, B., Mastouri, M., Tabka-stambouli, R., Chakroun, M., Bouzouaïa, N. 2007. Les bactéries multirésistantes isolées chez les malades hospitalisés dans un service de maladies infectieuses *Rev. Tun. Infectiol.*, 1(4): 12-15.

Caballero, B., Trugo, L.G., Finglas, P.M. 2003. Encycloedia of Food Sciences and nutrition. Vol. 7 2nd Ed. Academic Press, United Kingdom.

CA-SMF : (Comité de l'Antibiogramme de la Société Française de Microbiologie) 2009.

Cavallo, J.D., Mérens, A. 2008. Spectre d'activité antibactérien d'un antibiotique et catégorisation clinique. *Pathol. Biol.*, 56(5): 300-304.

CLSI: (Clinical and Laboratory Standards International). 2009. Methods for dilution antimicrobial susceptibility test for bacteria that grown aerobically; Approved standard. Eight Edition, 26 (2) M07- A7.

Cox, S.D., Mann, C.M., Markham, J.L., Gustafson, J.E., Warmington, J.R., Wyllie, S.G. 2001. Determining the antimicrobial actions of Tea tree oil. *Molecules* 6: 87-91.

De Pina-Vaz, C., Goncalves, R.A., Pinto, E., Costa-de-Oliveira, S., Tavares, C., Salgueiro, L., Cavaleiro, C., Goncalves, M.J., Martinez-de-Oliveira, J. 2004. Antifungal activity of Thymus oils and their major compounds. *J. Eur. Acad. Dermatol. Venereol.*, 18: 73-78.

Dielek, K., Sevil, T. 2011. Studies on antimicrobial activities of solvent extracts of different spices. *J. Environ. Biol*. 32, 251-256.

Do Nascimento, P.L., Nascimento, T.C., Ramos, N.S., Da Silva, G.R., Camara, C.A., Silva, T.M., Moreira, K.A., Porto, A.L. 2013. Antimicrobial and antioxidant activities of *Pimenta malagueta* (*Capsicum frutescens*). *Afr. J. Microbiol. Res*., 7(27) 3526-3533.

Do Nascimento, P.L., Nascimento, T.C., Ramos, N.S., Da Silva, G.R., Camara, C.A., Moreira, K.A., Porto A.L Silva, T.M. 2014. Quantification, Antioxidant and Antimicrobial Activity of Phenolics Isolated from Different Extracts of *Capsicum frutescens* (Pimenta Malagueta) *Molecules*, *19*, 5434-5447

Eloff, J.N., Famakin, J.O., Katerere, D.R. 2005. Isolation of an antibacterial stilbene from *Combretum woodii* (*Combretaceae*) leaves. *Afr. J. of Biotechnol.* 4(10): 1167-1171.

Erturk, O. 2006. Antibacterial and antifungal activity of ethanolic extracts from eleven spice plants. *Cell Mol. Biol*., 61(3): 275-278.

Halliwell, B., Rafter, J., Jenner, A. 2005. Health promotion by flavonoids, tocopherols, tocotrienols, and other phenols: direct or indirect effects? Antioxidant or not? *Am. J. Clin. Nutr.*, 81: 268-276.

Hammer, K.A., Carson, C.F., Riley, T.V. 2004. Antifungal effects of *Melaleuca alternifolia* (tea tree oil) and its components on *Candida albicans*, *Candida glabrata* and *Saccharomyces cerevisiae*. *J. Antimicrobial Chemother*., 53(6): 1081-1085.

Hervert-Hernandez, D., Sayago-Ayerdi, SG., Goni, I. 2010. Bioactive compounds of four hot pepper varieties (Capsicum annuum L.): antioxidant capacity, and intestinal bioaccessibility. *J. Agri. Food*

Chem., 58: 3399- 3406.

Ibarra-Junquera, Guadalupe, I., Olivas, J., Pérez-Martínez, J.D. 2010. Effect of cooking on the capsaicinoids and phenolics contents of Mexican peppers. *Food. Chem*., 119 (4): 1619-1625.

Koffi, A.C., Koffi-Nevry, R., Kouassi, K.C., Loukou, Y. G. 2014. Activité des extraits de six variétés de piment (Capsicum) utilisés en Cote d'Ivoire. *J. Appl. Biosci*., 82: 7379-7388.

Koffi-Névry, R., Kouassi, C.K., Zinzerdorf, Y.N., Koussémon, M., Yao G.L. 2012 (a). Antibacterial activity to two bell pepper extracts: *Capsicum annuum* L and *Capsicum frutescens*. *Int. J. Food Prop*., 15: 961-971.

Kouassi, C.K., Koffi-Nevry R. 2012. Évaluation de la connaissance et utilisation des variétés de piments (Capsicum) cultivées en Côte d' Ivoire. *Int. J. Biol. Chem. Sci*., (1): 175-785.

Kouassi, C.K., Koffi-Névry, R., Loukou, Y.G., Nanga, Y.Z., Koussémon, M., Kablan, T. Kouassi, K.A. 2012 (b). Profiles of bioactive compounds of some pepper fruit (*Capsicum L*.) varieties grown in Côte d'Ivoire. *Innov. Rom. Food Biotechnol*., 11: 23-31.

Kouassi, C.K., Koffi-Nevry, R., Nanga, Z.Y., Teixeira da Silva, J.A., Yao, K., Lathro, J.S., Tano, K., Loukou, G.Y. 2010. Assessing the antibacterial activity and phytochemical screening of *Capsicum* varieties from Côte d'Ivoire. *Food*, 4(1) : 27-32.

Kubo, I., Fujita, K, Lee, SH., Ha, T.J. 2005. Antibacterial activity of polygodial. *Phytother. Res.*, 19: 1013-1017.

Kurlenda, J., Grinholc, M. 2012. Alternative therapies in *Staphylococcus aureus* diseases. *Altern. Ther*., 59(2):171–184.

Lambert, R.J., Skandamis, P.N., Coote, P.J. Nychas, G.J. 2001. A study of the minimum inhibitory concentration and mode of action of *Oregano* essential oil, thymol and carvacrol. *J. Appl. Microbiol*., 91(3): 453-462.

Leclercq, R. 2002. Résistance des staphylocoques aux antibiotiques. *Ann. Fr. Anest. Réanim.*, 21(5) : 375-383.

Muller, A., Thouverez, M., Talon, D., Bertrand, X. 2003. Contribution de la pression de sélection antibiotique dans l'acquisition de *Staphylococcus aureus* résistant à la méticilline (SARM) dans un centre hospitalier universitaire. *Pathol. Biol., (Paris)* 51(8-9): 454-459.

Muthu, C., Ayyanar, M., Raja, N., Ignacimuthu, S. 2006. Medicinal plants used by traditional healers in Kancheepuram District of Tamil Nadu, India. *J. Ethnobiol. Ethnomed*., 2: 43.

Shannon, K.P., French, G.L. 2004. Increasing resistance to antimicrobial agents of Gram-negative organisms isolated at a London teaching hospital, 1995-2000. *J. Antimicrob. Chemother.*, 53: 818-825.

Soumya, S.L., Bindu, R.N. 2012. Antifungal efficacy of *Capsicum frutescens* L. extracts against some prevalent fungal strains associated with groundnut storage. *J. Agr. Technol*., 8(2): 739-750.

Sulaiman, L.K., Oladele, O.A., Shittu, I.A., Emikpe, B.O., Oladokun, A.T., Meseko, C.A. 2011. In-ovo evaluation of the antiviral activity of methanolic root-bark extract of the African Baobab (*Adansonia digitata* Lin). *Afr. J. Biotechnol.*, 10: 4256-4258.

How to cite this article:

Kouassi Kouassi Clément, Coulibaly Bakary, Coulibaly Ibourahema, Koffi Affoué Carole and Koffi-Nevry Rose. 2016. Antimicrobial Activity of the Varieties of Peppers (*Capsicum*) of Côte d'Ivoire on Multiresistant Strains. *Int.J.Curr.Microbiol.App.Sci.* 5(10): 875-890. doi: http://dx.doi.org/10.20546/ijcmas.2016.510.096