

Bacterial Contamination and Public Health Risk Associated with the Use of Banks' Automated Teller Machines (Atms) in Ebonyi State, Nigeria

Stanley Chukwudozie Onuoha^{1*}, Kayode Fatokun²

¹Department of Biotechnology, Ebonyi State University, PMB 053 Abakaliki, Ebonyi State, Nigeria

²Department of Agriculture, University of Zululand, PMB X1001 Kwa Dlangezwa 3886, South Africa

*Corresponding author: sconuoha@yahoo.com

Received January 31, 2014; Revised February 23, 2014; Accepted March 10, 2014

Abstract Contamination of environmental objects and surfaces is a common phenomenon. Human beings have a marked tendency to pick up microorganisms from environmental objects, and specially the hand has been shown to play a role in the transmission of organisms. The ATM machine is likely to be contaminated with various microorganisms due to their vast contact by multiple users. This study was aimed to investigate ATM as a potential source of bacterial contamination. The study was conducted from August to October, 2013 and it involved collection of samples by using cotton swabs, culturing on different media such as nutrient agar, MacConkey as well as identifying the isolated organisms using its colonial, morphological and biochemical characteristics. The results of the study indicated that some of the Automated Teller Machines were positive for the presence of microorganisms as indicated: *Staphylococcus auerus* 4 (28.57%), Coagulase-negative staphylococcus 3 (21.43%), *Streptococcus* species 2 (14.29%), *Pseudomonas* species 1 (7.14%), *Enterobacter* species 1 (7.14%) and *Escherichia coli* 3 (21.43%). The antibiogram study was done using Kirby Bauer disc- diffusion method and the results showed that majority of the bacteria were highly resistant to standard antibiotics. Susceptibility of isolates ranged from 6.25% to of 25.0%, indicating that most of the antibiotics used were ineffective. *Staphylococcus. aureus*, *Streptococcus spp* and *P. aeruginosa* showed 68.75% resistance to the antibiotics, whilst *E. coli* (56.25%), *Enterobacter spp* (50%) and CNS showed 18.75% susceptibility each. Overall, Gentamicin was the most effective antibiotic, while Ofloxacin, Clindamycin, Cefixine, Levofloxacin and Ciprofloxacin were least effective. Hand washing after ATM usage and proper cleaning regimen should be practiced to reduce contamination on the ATMs.

Keywords: Automated teller machines, antibiotics, bacteria, Ebonyi State

Cite This Article: Stanley Chukwudozie Onuoha, and Kayode Fatokun, "Bacterial Contamination and Public Health Risk Associated with the Use of Banks' Automated Teller Machines (Atms) in Ebonyi State, Nigeria." *American Journal of Public Health Research*, vol. 2, no. 2 (2014): 46-50. doi: 10.12691/ajphr-2-2-2.

1. Introduction

An Automated Teller Machine (ATM) is a computerized telecommunications device that enables the clients of a financial institution to perform financial transactions without the need for cashier, human clerk or bank teller. ATMs are known by various other names including ATM machine, automated banking machine, cash dispenser and various regional variants derived from trademarks on ATM systems held by particular banks [28]. Automated Teller machine are the most widely used form of computer driven public technology [18] with an estimated over 2.4 million units in use [1] since their invention and use in the late 1960's. A typical usage of the ATM machine involves slotting a card into a recipient hole and following on screen instructions, by punching the keys of the metallic keypads to enter secret codes and commands; thus instructing the machine as to kind of service one requires [2].

Contamination of environmental objects and surfaces is a common phenomenon. Human beings have a marked tendency to pick up microorganisms from environmental objects, and the hand has been shown to play a role in the transmission of organisms. The ATM machine is likely to be contaminated with various microorganisms due to their vast contact by multiple users. There is no restriction as to who has access to the facility and no guideline to ensure hygienic usage. But like all surfaces microbial colonization of these metallic keypads are eminent, particularly when there are no proper cleaning regimens in place for most of these facilities.

The presence of viable pathogenic bacteria on inanimate objects has been reported by earlier investigators [9,13,14,24]. Salmonella Species and *Escherichia coli* strains has also been shown to be transferred from hands to raw processed and cooked foods, even at low levels on the fingers [19,30]. Furthermore, microorganisms found to contaminate formites has also

been shown to persist on environmental surfaces in varying periods of time ranging from hours to months [12].

In addition, cross infection of microorganisms between environmental surfaces and a host has equally been established [16]. It has also been shown that microbes once attached to hands and some surfaces may survive for a while and may be difficult to remove [10,17]. Many factors have been shown to influence the bacteria transfer between surfaces, including the source and destination surface features, bacterial species involved, moisture levels, pressure and friction between the contact surfaces [7,22,30,35].

While the contamination of banks ATMs by microorganisms has been established, most of the previous study has been concentrated within Abakaliki, the capital city of Ebonyi State, or such study was specific to the isolation of a particular microorganism. In view of this, the present study was undertaken to investigate probable bacterial contamination and antibiogram of bacteria present on the touched metallic keypads of Banks ATMs within the two major towns in Ebonyi State (Abakaliki and Afikpo) where these machines are in use.

2. Materials and Methods

2.1. Study Area

This study was carried out in two major towns within Ebonyi State (Afikpo and Abakaliki). The study was undertaken between June to December, 2013.

2.2. Sample Collection and Processing

ATMs of seventeen different banks namely: First bank, Zenith bank, Eco bank, Fidelity bank, Enterprise bank, United Bank for Africa (UBA), Diamond bank, FCMB and Keystone bank, situated in Ebonyi State was used for the study. Permission was sought from the management of all these banks to use their facilities.

Cotton Swabs made on applicator stick was slightly moistened with sterilized distilled water. One milliliter aliquots of each nutrient broth culture from swabs was pour-plated on nutrient agar, diagnostic sensitivity test agar and CLED agar, all was incubated at 37°C. Colonies from nutrient agar plates was also tested for faecal coliforms in MacConkey broth with Durham tubes [33]. Representative colonies was sub-cultured repeatedly on fresh media until pure isolates was obtained.

2.3. Identification and Characterization of Isolates

The isolates were identified, using their colonial and cellular morphology, gram reaction and conventional biochemical identification procedures (Cheesbrough, 2006).

2.4. Antibiotic Susceptibility Testing

The antibiotic susceptibility patterns of the isolates to 16 antibiotics were determined by the modified Kirby-Bauer diffusion technique. The concentration of the Standard antibiotics used were Ceftriaxone (30µg), Ampiclox (30µg) Cefixine (10µg), Levofloxacin (10µg),

Norfloxacin (10µg), Ciprofloxacin (10µg), Gentamicin (10µg), Ofloxacin (10µg), Clindamycin (30µg), Erythromycin (30µg), Chloramphenicol (10µg), Ampicillin (30µg), Nitrofurantoin (100µg), Clarithromycin (30µg), Pefloxacin (10µg), Augmentin (30µg).

Standardized culture of each isolate was prepared by picking two distinct colonies using a sterile wire-loop and emulsifying them in 3 ml of physiological saline in a sample bottle. This suspension was then incubated at 37°C overnight. The standardized overnight culture of each isolate was used to flood the surface of Mueller-Hinton agar plates. The excess was drained off and the plates allowed to dry. The standard antibiotic disc was then aseptically placed at reasonable equidistance on the inoculated Muller-Hinton agar plate and the plate allowed standing on the bench for 1 hour. The plates were then incubated at 37°C for 18 hrs. The diameter of the zone of inhibition produced by each antibiotic disc was measured and recorded in millimeters [23].

3. Results

The results obtained from both the morphological and biochemical test carried out on the isolates obtained from the ATM machine showed six different bacteria isolates: *Staphylococcus aureus*, *Coagulase negative staphylococcus* (CNS), *Escherichia coli*, *Streptococcus Specie*, *Pseudomonas aeruginosa* and *Enterobacter specie*. The distribution pattern of the bacterial isolates between the two major towns in Ebonyi State shows that a total of 14 bacterial isolates were obtained from the ATMs sampled, and out of the 14 isolates, 3 (21.4%) were obtained from ATMs from Afikpo, while 11 (78.6%) were from ATM from Abakaliki metropolis.

From Table 1, it was observed that *Staphylococcus aureus* was the commonest organism isolated (28.57%) followed by *E. coli* and *Coagulase negative Staphylococcus* with (21.43%) respectively. *Pseudomonas aeruginosa* and *Enterobacter species* showed the least percentage occurrence with (7.14%) respectively.

The susceptibility pattern of the isolates to some prescribed antibiotic show that *S. aureus* and CNS showed the highest susceptibility (25% and 18.75% respectively) to the applied antibiotics, while all the other bacteria showed varied degrees of resistance to the antibiotics tested (Table 2).

Table 1. Percentage distribution of bacterial contaminants on the interfaces of different bank ATMs

Bacteria	Percentage (%)
<i>Staphylococcus aureus</i>	28.57
Coagulase negative staphylococcus(CNS)	21.43
<i>Streptococcus Species</i>	14.29
<i>Pseudomonas aeruginosa</i>	7.14
<i>Enterobacter species</i>	7.14
<i>Escherichia coli</i>	21.43

Table 2. Susceptibility of bacterial isolates from ATM interfaces to commonly used antibiotics

Antibiotics	S. aureus	CNS	Streptococcus spp	P. aeruginosa	Enterobacter	E. coli
AUG (30µg)	R	R	R	R	R	I
PEF (10µg)	R	R	R	R	I	R
CLT (30µg)	R	R	R	I	R	R
CHL (10µg)	R	R	I	R	R	R
AMP (30µg)	R	R	R	R	R	R
NIT (100µg)	R	I	R	S	I	I
OFL (5µg)	S	I	S	R	I	R
CLD (5µg)	I	R	I	S	R	S
ERY (10µg)	R	R	R	R	R	R
CEF (5µg) R		S	R	R	S	I
CET (30µg) R		I	R	I	R	R
AMP (30µg)	R	R	R	R	I	I
LEV (10µg)	S	R	S	R	R	R
NOR (10µg)	R	I	R	I	I	R
CIP (10µg) S		S	R	R	R	I
GEN (30µg) S		S	I	R	I	S
SUSCEPTIBLE	25%	18.75%	12.5%	12.5%	6.25%	12.5%
INTERMEDIATE	25%	25%	18.75%	18.75%	43.75%	3.25%
RESISTANT	68.75%	18.75%	68.75%	68.75%	50%	56.25%

Key: AUG = Augmentin, PEF = Pefloxacin, CLT = Clarithromycin, CHL = Chloramphenicol, AMP = Ampicillin, NIT = Nitrofurantoin, OFL = Ofloxacin, CLD = Clindamycin, ERY = Erythromycin, CEF = Cefixime, CET = Ceftriaxone, AMP = Ampiclox, LEV = Levofloxacin, NOR = Norfloxacin, CIP = Ciprofloxacin, GEN = Gentamicin, CNS = Coagulase negative staphylococcus

Key: AUG = Augmentin, PEF = Pefloxacin, CLT = Clarithromycin, CHL = Chloramphenicol, AMP = Ampicillin, NIT = Nitrofurantoin, OFL = Ofloxacin, CLD = Clindamycin, ERY = Erythromycin, CEF = Cefixime, CET = Ceftriaxone, AMP = Ampiclox, LEV = Levofloxacin, NOR = Norfloxacin, CIP = Ciprofloxacin, GEN = Gentamicin, CNS = Coagulase negative staphylococcus.

4. Discussion

In our study an attempt was made to study probable bacterial pathogens that are present in ATM centres in the two major towns of Ebonyi State. The study was conducted to create awareness to the public and users of ATM machines on the possible diseases that are likely to be contacted due to the presence of pathogen at ATM Centres. The result of this study showed bacterial contaminations on the surfaces of the metallic keypads of ATMs in Ebonyi State. A total of six bacterial isolates were recovered from ATM interface in this study. Qualitative analysis of the bacterial isolates revealed the abundance of skin flora belonging to Coagulase - negative Staphylococcus (CNS), *Staphylococcus aureus*, *Escherichia coli*, *Streptococcus spp*, *Pseudomonas aeruginosa*, and *Enterobacter spp*. The percentage distribution of the bacterial isolates showed that *Staphylococcus aureus* was the commonest isolate with percentage occurrence of 28.57%, CNS, 21.43%; *Streptococcus specie*, 14.29%, *Pseudomonas aeruginosa*, 7.14%, *Enterobacter spp*, 7.14% and *E. coli*, 21.43% (Table 1).

The health risks associated with the majority of these bacteria are well documented [26]. The bacterial contaminants seen in this study is similar to bacteria that have been recovered from surfaces and objects by other investigators. [25] reported that keypads of ATMs harbored more bacteria than computer keyboards and this

may be due to the fact that ATMs are usually located in the open, exposed to wind and rain. In addition to the bacteria isolated in our study, [25] isolated *Klebsiella pneumonia*, *Proteus spp*, *Aeromonas viridians*, *Bacillus spp* among others from Electronic hardware interfaces in Ile-Ife. Our study is also in agreement with the study by [3] who reported the presence of *Staphylococcus Species*, *Escherichia Species* and *Klebsiella Species* on the keypads of ATM machines. Also high rates of microbial contamination were found on the mobile phones and computer's keypad which has similar features with ATMs according to their physical and operational aspects. [34] reported that cell phones of patients, visitors and Health care workers carried multidrug – resistant hospital pathogens including *Acinetobacter spp*, *S. aureus* and extend-spectrum β -lactamase ESBL-positive Enterobacteriaceae. [4,5] reported that *Staphylococcus aureus* were more prevalent on computer keypad and mouse. Interestingly, our study revealed similar result where *S. aureus* showed the highest prevalence among other isolates. *S. aureus* is the major component of the normal flora of the skin and nostril, which probably explains its high prevalence as contaminant, and can be easily discharged by several human activities, like sneezing, talking and contact with moist skin [20].

Escherichia coli are the second commonest isolates recovered in our study. *E. coli* is an enteric pathogen that spread diseases through touch, improper sanitary activities of individuals. Transient pathogens are excreted in feces, various body fluids or tissues by persons infected or colonized by these pathogens. *E. coli* can cause diseases like gastroenteritis, urinary tract infection, septicemia, dysentery, vomiting, stomach cramps and flatulence.

Other bacteria like *Enterobacter spp* and *Pseudomonas aeruginosa*, were the least frequent bacterial contaminants, their presence on environmental surfaces like ATMs is a cause for some alarm, because they have been shown to possess the potential to cause infection, especially in a hospital settings [8]. In different studies, each of these organisms has been implicated either as a major contaminant or as the most prevalent pathogenic bacteria recovered [11,29,25].

Distribution of Isolates between the two major towns in Ebonyi State showed that a total of 14 bacterial isolates were obtained from the ATMs sampled, and out of the 14 isolates, 3 bacterial isolates representing 21.4% were obtained from ATM in Afikpo town, while 11 isolates representing 78.6% were from ATM from Abakaliki metropolis. The greater percentage of contaminations as observed among ATMs in Abakaliki in comparison to Afikpo was probably because of higher number of heterogeneous users in Abakaliki.

It has been observed that antibiotic susceptibility of bacterial isolates is not constant but dynamic and varies with time and environment [15]. There is the need for periodic screening of common bacterial pathogens for their antibiotic susceptibility profiles in different communities [27]. The antibiogram result of this study revealed that majority of the bacteria is highly resistant to standard antibiotics. Susceptibility of isolates ranges from 6.25% to 25.0% indicating that most of the antibiotics used were ineffective. *S. aureus*, *Streptococcus spp* and *P. aeruginosa* showed 68.75% resistance to the antibiotics, whilst *E. coli* (56.25%), *Enterobacter spp* (50%) and CNS

showed 18.75% susceptibility each (Table 2). This result is similar to research undertaken on bacterial isolates on computer keyboards and mice in Cape Town, Ghana [31]. All Gram-positive and Gram-negative bacteria isolates showed 100% resistance to some of the common antibiotics in use. A. In a similar study, resistances (100%) of isolates to Ampicillin, Cloxacillin, Penicillin and Cefuroxime commonly used antibiotics has been observed in previous studies presenting a public health problem [21,32]. Overall, Gentamicin was the most effective antibiotic, while Ofloxacin, Clindamycin, Cefixime, Levofloxacin and Ciprofloxacin were less effective.

5. Conclusion

This study of the bacterial contamination on ATM metallic keypads in Ebonyi state revealed the presence of pathogenic microbes like *Staphylococcus aureus*, Coagulase-negative *Staphylococcus* (CNS), *Streptococcus species*, *Pseudomonas aeruginosa*, *Enterobacter species* and *Escherichia coli* which were found to be resistant to some commonly used antibiotics. The result of this study is of public health concern as according to the result of this study ATM devices are potential areas for pathogen accumulation. Cleaning regimen aimed at reducing the population and presence of these organisms on the ATM surfaces should be developed using appropriate sanitizers and strictly adhered to by operators of such facilities. Further investigations are required to determine the status of ATMs according to fungi which were not studied in this investigation.

Acknowledgement

Researcher showed appreciation to management of the different banks who consented to taking part in the study by allowing us use their facilities. Funding for this study was from personal contributions from the authors, no external funding.

References

- [1] Anonymous. Global ATM clock. Automatic teller machine industry association (ATMIA). 2011a. Accessed online. 25 may 2011 (<http://www.atmia.com/mig/globalatmclock>).
- [2] Anonymous. Components of an automated teller machine. In encyclopaedia Britannica online. 2011b. Accessed 24 may, 2011 (<http://www.britannica.com/EBchecked/media/95649/The-components-of-an-automated-teller-machine>).
- [3] Abban, S and Tano-Derah. Automatic teller machine (ATMs) as potential source of Food-borne Pathogens- a case from Ghana. *Nature Sci.*, 9; 63-67. 2011.
- [4] Anastasiades, P., Pratt, T.L, Rousseau, L.H., Steinberg, W.H and Joubert, G. *Staphylococcus aureus* on computer mice and keyboards in Intensive Care Units of The Universitas Academic Hospital, Bloemfontein and ICU staff's Knowledge of its hazards and cleaning practices. *South Afr. J. Epidemiol. Infect.* 24: 22-26. 2009.
- [5] Anderson, G and Palombo, E. A. Microbial contamination of computer keyboards in a University setting. *AM. J. Infect Control*, 37: 507-9. 2009.
- [6] Cheesbrough, M.C. *District Laboratory Practice in Tropical Countries*. 1st Edn., Cambridge University Press, Cambridge, UK. pp: 115. 2006.
- [7] Chen, Y., Jackson, K. M., Chea, F. P and Schaffner, D. W. Quantification and variability analysis of bacterial cross contamination rates of Common Food Service Tasks. *Journal of Food Protection*, 64: 72-80. 2001.
- [8] Ducl, G., Fabry, J., and Nicolle, L. Prevention of Hospital acquired Infections: A practical guide. 2nd Edition WHO/CDS/CSR/EPH/2002.12. World Health Organization Department of Communicable Disease, Surveillance and Response pp 27. 2002.
- [9] Famurewa, O and David, O.M. Cell phone: a medium of transmission of bacterial pathogens. *World Rural Observation*, 1 (2): 69-72. 2009.
- [10] Filho P.P.G, Stumpf, M., Cardoso, A. Survival of gram positive bacteria, gram negative bacteria artificially applied to hands. *J. Clin. Microbiol*, 23: 552-553. 1987.
- [11] Fraser, M.A and Girling, S.J. Bacterial carriage of computer keyboards in veterinary practices in Scotland. *Vet. Rec.*, 165: 26-27. 2009.
- [12] French, G.L., Otterb, J.A., Shannona, K.P., Aamsb, N.M.T., Watlingb, D and Parks, M.J. Tackling contamination of the hospital environment by methicillin-resistant *Staphylococcus aureus* (MRSA): a comparison between conventional terminal cleaning and hydrogen peroxide vapour decontamination. *J. Hosp. Infect*, 57: 31-7. 2004.
- [13] Gerba, C.P. Importance Of formites in the transmission of infectious diseases. Department of Soil and Environmental Science and Epidemiology and Biostatistics University of Arizona. 2005.
- [14] Gholamreza, S., Nooshin, T., Ali, M., Touraj-Reza, M and Ehsan, S. Bacterial contamination and resistance to commonly used antimicrobials of Health Care Workers Mobile Phones in Teaching Hospitals, Kermen, Iran. *Am. J. Appl Sci*, 6 (5): 806-10. 2009.
- [15] Hassan, S.H. Sensitivity of Salmonella and Shigella to antibiotics and chemotherapeutic agents in Sudan. *J. Trop Med Hyg*, 88: 243-248. 1995.
- [16] Hardy, K.J., Oppenheim, B.A., Gossain, S., Gao, F and Hawkey, P.M. Study of the relationship between environmental contamination with Methicillin Resistant *Staphylococcus aureus* (MRSA) and patients acquisition of MRSA. *Infect. Control Hosp Epidemiol*, 27 (2): 127-32. 2006.
- [17] Hood, S. K., Zottala, E. A. Adherence of Stainless Steel by Food Borne Microorganisms during growth in Model Food Systems. *Inter J. Food Microbiol*. 37: 145-153. 1997.
- [18] Hone, K.S., Graham, R., Maguire, M.C., Baber, C and Johnson, G.I. Speech Technology for Automatic Teller Machines: an investigation of user attitude and performance. *Ergonomics*, 41 (7): 962-981. 2008.
- [19] Humphery, T. J., Martin, K. W and Whitehead, M. Contamination of hands and work surfaces with Salmonella Enteritidis PT4 during the preparation of egg dishes. *Epidemiol. Infect.* 113: 403-409. 1994.
- [20] Itah, A.Y and Ben, A. E. Incidence of enteric bacteria and *Staphylococcus aureus* in day care centres in Akwa Ibom, State, Nigeria. *Southeast Asian J. Trop. Med. Pub. Health*, 35 (1): 202-9. 2004.
- [21] Khan, R.M.K and Malik, A. Antibiotic resistance and detection of β -lactamase in bacterial strains of *Staphylococci* and *Escherichia coli* isolated from foodstuffs. *World J. Microbiol. Biotechnol.* 17: 863-868. 2011.
- [22] Montville, R. and Schaffner, D. W. (2003). Inoculum size influences on bacteria cross contamination between surfaces. *Env. Microbiol*, 69 (12): 7188-7193.
- [23] NCCLS. Performance standard for Antimicrobial Disk Susceptibility tests: Approved Standards. 9th Edn. NCCLS.
- [24] Neely, A. N. and Maley, M. P. Survival of Enterococci and Staphylococci on hospital fabrics and plastic. *J. Clin. Microbiol*. 38: 724-726. 2000. PMID: 10655374.
- [25] Oluduro, A. O., Ubani A. O. and Ofoezie, I. E. Bacterial Assessment of Electronic hardware user interfaces in Ile-ife, Nigeria. *J. Basic Applied Pharmaceut. Sci.*, 32: 323-334. 2011.
- [26] Prescott, L.M., Harley, J.P and Klein, D.A. Microbiology, 5th ed. New York: Mc-Graw Hill pp 1026. 2002.
- [27] Rahman, m., Rahman, B., Rahman, T., Khan, F.R and Hosen, M.J. Pattern of antimicrobial resistance and plasmid profiles of *Escherichia coli* isolates obtained from calf, cattle and diarrheic children in Mymensingh-Bangladesh. *J. Am. Sci.*, 3: 74-84. 2007.
- [28] Rasiah, D. ATM Risk Management and Controls. *Eur. d. Econ. Finance Admin. Sci.*, 1: 161-171. 2010.

- [29] Rutala, W.A and David W.J. The benefits of Surface Disinfection. *Am. J Infect. Control.* 32 (4): 226-31. 2004.
- [30] Rusin, P. S., Maxwell and Gorba, C. Comparative surface Comparative surface – to – hand and fingertip – to – mouth transfer efficiency of gram-negative bacteria and phage. d. *Applied Microbiol.* 3: 585-12. 2002. PMID: 12234341.
- [31] Tagoe, D. N. A. and Kumi-Ansah, F. Computer keyboard and mouse: Potential sources of disease transmission and infections. *Int. J. Public Health.* 1: 2. 2010.
- [32] Tagoe, D.N.A; Nyarko, H; Arthur, S.A; and Birikorang, E. A. Study of antibiotic susceptibility pattern of bacteria isolates in sachet drinking water sold in the cape coast metropolis of Ghana. *Res. J. Microbiol.*, (6): 453-458. 2011.
- [33] Thatcher, F.S and Clark, D.S. Microorganisms in Food 1: Their significance and method of enumeration. International Commission on Microbiological specification for Foods (ICMSF) of the International Association of Microbiological Societies (IUMS).University of Toronto Press, Toronto, Canada. 1978.
- [34] Tekerekoglu, M.S., Duman, Y., Seridag, A., Cuglan, S.S., Kaysadu, H., Tunc, E and yakupogullari, Y. Do mobile phones of patients', companions and visitors carry multi-drug resistant hospital Pathogens? *Am. J Infect. Control*, 39 (5): 379-381. 2011.
- [35] Whitehead, K. A., Verrand. J. The effect of surface topography on the retention of Microorganisms. *Food and Bioproducts Processing*, 84 (4): 256-259. 2006.