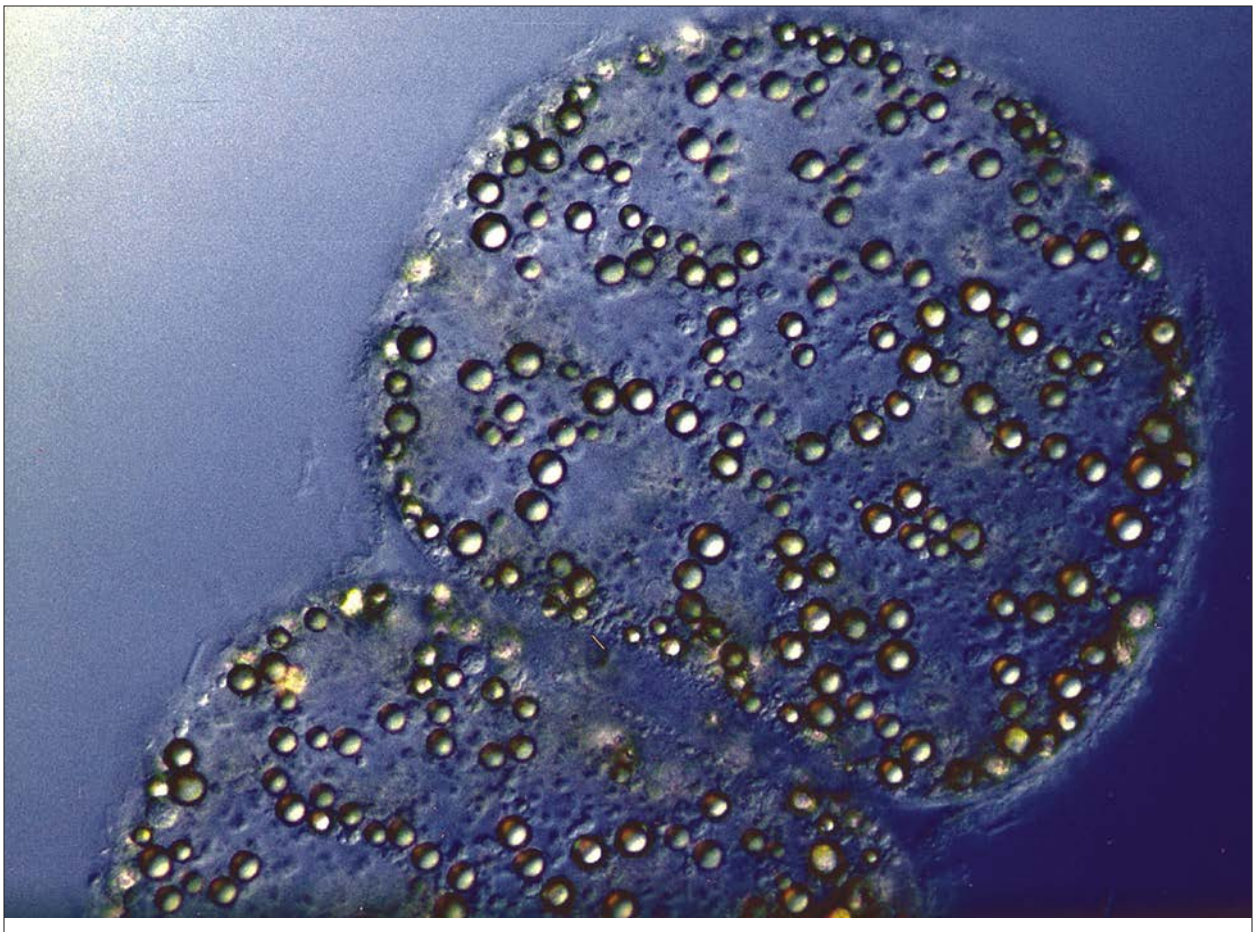

Microbiology

Journal

ISSN 2153-0696

Academic
Journals Inc.

www.academicjournals.com

Microbiology Journal 1 (2): 47-53, 2011
ISSN 2153-0696 / DOI: 10.3923/mj.2011.47.53

Escherichia coli, it Prevalence and Antibiotic Resistant in Malaysia: A Mini Review

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ABSTRACT

The bacterium *Escherichia coli* is a Gram negative, facultative anaerobe that ferments glucose/lactose and lives naturally in the gastrointestinal tract of animals and humans. Though most *Escherichia coli* strains are non-pathogenic and inhibit their host as commensals, few pathogenic ones exist that causes diseases in humans especially in immune-challenged individuals. Pathogenic *Escherichia coli* can be contracted from the consumption of contaminated foods. The prevalence of *Escherichia coli* as reported in Malaysia ranged from 22.6 to 88.0%. Majority of the work on *E. coli* is concentrated on beef samples. Furthermore, most Malaysians eat out; therefore, posing a high risk of ingesting pathogenic *Escherichia coli* strains. A report on the prevalence and antibiotic resistance of *Escherichia coli* strains in Malaysia is necessary to create more awareness of the existence of the pathogen in the food chain and subsequently its implication on public health.

Key words: *Escherichia coli*, Malaysia, non-pathogenic, pathogenic, prevalence

INTRODUCTION

The prevalence of food-borne pathogens in animals, humans, environmental samples or foods of animal and plant origin is a concern worldwide and has caught the attention of researchers, the food industry, health organizations, governments and all stake holders. Such data gives an idea of the possibility of pathogenic organisms being transferred from any of the afore-mentioned sources to humans and subsequently causing food-borne diseases, illnesses or food poisonings. Studies for tracing the source of human food-borne diseases and/or food poisonings have relied on molecular characterisation of isolates from both humans and their suspected sources to determine their genetic relatedness. Among these important food-borne pathogens are *Campylobacters*, *Salmonellae*, *Listeria*, *Staphyloccoccus*, *Clostridium*, *Vibrio*, *Shigella*, *Baccillus* and *Escherichia coli*.

Escherichia coli are Gram negative, facultative bacteria that ferment glucose and are members of the family Enterobacteriaceae (Feng and Weagant, 2009). They are widely distributed in the intestine of animals and forms part of the normal intestinal flora that maintains the physiology of a healthy animal (Conway, 1995). Thus most *E. coli* strains are non-pathogenic but pathogenic strains that cause gastrointestinal illness in humans and opportunistic ones that normally affect immune-compromised patients exists (Nataro and Kaper, 1998). Symptoms of pathogenic *E. coli* infections include watering diarrhoea, little or no fever, bloody diarrhoea and haemolytic uremic syndrome (Nataro and Kaper, 1998). Reliable and efficient methods of isolating food-borne pathogens are essential for reporting and treatment purposes (Frederick and Nurul, 2011; Adzitey and Nural, 2011; Adzitey *et al*., 2011a). As such polymerase chain reaction assays that are more efficient, rapid, sensitive and reliable for detecting and genotyping *E. coli* species have

been evaluated and used (Gomes *et al.*, 2005; Sherfi *et al.*, 2006, 2007; Parekh and Subhash, 2008; Jomezadeh *et al.*, 2009).

The prevalence of *E. coli* and subsequently it out break has been reported in other countries. In South Africa (Muller *et al.*, 2003) reported a prevalent rate of 20% *E. coli* 0157:7 from sewage and environmental sources. In Ghana, the presence of *E. coli* in beef, mutton and chevon sold in some selected market in the Tamale Metropolis has been reported by Adzitey *et al.* (2010a,2011b). In Trinidad, Hosein *et al.* (2008) reported a prevalence of 4.5% in ready-to-eat products in supermarkets across the country. An outbreak of *E. coli* was reported in the United States in 2002 which was associated with the consumption of ground beef (Vogt and Dippold, 2005). In Japan, an outbreak of *E. coli* 0157:H7 was linked to contaminated radish sprouts (Mermin and Griffin, 1999) In India, Nanu *et al.* (2007) analyzed raw milk samples collected from farmers belonging to three farmer dairy societies of Kerala and reported a prevalence rate of 31.6%. Mahalakshmi *et al.* (2011) examined water and sediments samples from the Cudadalore Fishing Harbour and reported maximum values of *E. coli* to be 5.9×10^4 cfu mL^{-1} and 4.7×10^4 cfu g^{-1}. In Saudi Arabia, Abulreesh (2011) found that 2.5% of 400 pigeon faecal samples were positive for shiga toxin-producing *E. coli*.

In Malaysia, data on the prevalence of certain food-borne pathogens such as *Salmonella, Listeria, Staphylococcus, Campylobacter* and *E. coli* are available (Arumugaswamy *et al.*, 1994; Saleha, 2002; Adzitey *et al.*, 2011c). Nonetheless, data on outbreaks of a particular food-borne pathogen is very scarce if not unavailable. Malaysia consumers as found in most developed nations are also becoming increasingly aware and concern on food safety issues. Few studies on the prevalence and antibiotic resistance of *E. coli* isolates from Malaysia are available. This mini-review briefly discusses the pathogen *E. coli,* it prevalence and antibiotic resistance as reported in some samples in Malaysia. By this consumers are being made aware of the existence of both pathogenic and non-pathogenic *E. coli* species in food products on the market and the need for the government to put up strategies to reduce it occurrences and outbreaks.

ESCHERICHIA COLI

Escherichia coli was identified by the German paediatrician, Theodor Escherich in 1885 (*Escherich*, 1885; *Neill et al.*, 1994). The pathogen is Gram negative, rod-shaped, predominant facultative anaerobe widely distributed in the gastrointestinal tract and ferments glucose/lactose (Neill *et al.*, 1994; Conway, 1995). It belongs to the family Enterobacteriaceae, together with *Salmonella, Shigella* and *Yersinia* (Ewing, 1986). The pathogen has long been used to indicate the presence of faecal contamination and frank pathogens and recently being used to indicate the presence of recent faecal contamination and unsanitary processing conditions (Feng and Weagant, 2009). Even though most strains of *E. coli* are considered harmless, opportunistic and pathogenic strains that cause gastroenteritis are present (Feng and Weagant, 2009). The pathogenic group of *E. coli* are enterotoxigenic *E. coli* (ETEC) which causes diarrhoea without fever; enteropathogenic *E. coli* (EPEC), causes traveller's diarrhoea; enterohemorrhagic *E. coli* (EHEC), causes bloody diarrhoea without fever; enteroinvasive *E. coli* (EIEC), causes dysentery-like diarrhoea with fever; enteroaggregative *E. coli* (EAEC), cause non-bloody diarrhoea; diffusely adherent *E. coli* (DAEC) and others that are not yet well characterized (Nataro and Kaper, 1998). Thus the first four groups have been authentically implicated in food and water-borne illnesses and O157:H7 is the prototypic EHEC most often implicated in illness worldwide (CDC, 1999; Nataro and Kaper, 1998; Feng and Weagant, 2009). *Escherichia coli* O157: H7 has also been

implicated in haemorrhagic colitis, haemolytic uremic syndrome and thrombotic thrombocytopenic purpura which are very detrimental (Blackburn and McCarthy, 2000).

Various sources of *E. coli* transmission to humans and outbreaks have been reported. They include drinking water, recreational water (swimming pool), environmental sources, sewage, sediments and irrigation water, wild animals, domestic animals and pets, livestock, poultry, liver and intestines, meat and meat products, milk and milk products, cheese, fruits and vegetables and their products, ready-to-eat meals (Hosein *et al.*, 2008; Muller *et al.*, 2003; Rad, 2004; Ekici *et al.*, 2004; Zamxaka *et al.*, 2004; Tambekar and Mundhada, 2006; Tambekar *et al.*, 2006; Warsama *et al.*, 2006; Brichta-Harhay *et al.*, 2007; Oyetayo *et al.*, 2007; Shojaei and Yadollahi, 2008; Mihdhdir, 2009; Adzitey *et al.*, 2011b).

PREVALENCE OF *E. COLI* IN SOME SELECTED FOODS, ANIMALS AND THEIR PRODUCTS IN MALAYSIA

The prevalence of *Escherichia coli* O157: H7 from beef samples purchased from retail stores in Malaysia was reported to be 36% (9/25) by Son *et al.* (1998). The strains were found to produce Shiga toxin 2 with or without Shiga toxin 1 and had the *eae* gene and a plasmid size of 60-MDa. They also suggested that the strains may have originated from different sources due to their diversity after being analyzed by antibiograms and profiles of the arbitrarily primed polymerase chain reaction.

Similarly, Apun *et al.* (2006) isolated *E. coli* (including Shiga-like toxin producing *E. coli* (STEC), serogroup O157:H7 and *E. coli*) from raw beef marketed in Sarawak and Sabah, East Malaysia. Pulsed field gel electrophoresis of some of the isolates revealed that some isolates were closely related while others were non-related.

Apun *et al.* (2010) carried out a study to assess the occurrence of both pathogenic and non-pathogenic *E. coli* in bats, birds and rodents in two urban forests and an oil palm plantation located along the Rejang Basin, Sibu in the Sarawak State. They analysed a total of 105 bird hosts, 44 of rodent hosts and 84 bat hosts (which comprises 48 species of birds, one species of rodent and ten species of bats) for the presence of *Escherichia coli* and reported a prevalence of 43, 18 and 11% in rodents, birds and bats, respectively. They did not detect the *slt-I, slt-II, rfbE* genes in any of the *E. coli* isolates. Therefore, they reported that bats, birds, or rodents from their study area did not serve as an important reservoir of *Escherichia coli* O157:H7 and thus were of no risk in the epidemiologic cycle of emerging enteric bacterial zoonoses in the state of Sarawak, Malaysia.

Sahilah (1997) analyzed beef samples purchased from 4 supermarkets in Selangor and the Federal Territory of Malaysia between March to June 1996 and found that nineteen (76%) of the samples were positive for *E. coli* O157:H7.

Sukhumungoon *et al.* (2011) also analysed beef samples imported from Malaysia to Thailand for the presence of *E. coli* O157 and found 7 positives out of 31 beef samples examined (22.6%). Six *E. coli* isolates belonged to the *E. coli* O517:H7 serogroup and had the stx_1^+, stx_2^+ and eae^+ genes and one isolate belonged to O116:H31 serogroup and had the stx_1^+, stx_2^+ and eae^- genes. They found that beef imported from Malaysia to Thailand had *E. coli* strains that were more heterogeneous compared to *E. coli* strains isolated from Thailand beef.

A cross sectional study was conducted in the Municipal Council jurisdiction of Kota Bharu on 362 food premises to evaluate their hygienic standard based on standard form used by the district health office. An *E. coli* count of 27% was observed and they were detected more in staple foods than in snacks (Zaliha and Rusli, 2004).

Chye *et al.* (2004) observed an overall prevalence of *E. coli* from 360 dairy farms in Peninsular Malaysia in raw milk samples to be 65% (600/930) and 33.5% for only *E. coli* O517:H7. They reported on the biological quality of raw milk and found the counts of *E. coli* alone from the Southern, Central, Eastern and Northern region to be 15.0×10^3, 5.4×10^3, 4.8×10^3 and 1.9×10^3, respectively. The prevalence of *E. coli* was 68.5% (261/381), 57.2% (115/201), 72.2% (91/126) and 59.9% (133/222) for the Southern, Central, Eastern and Northern region, respectively. The incidence of *E. coli* O571:H7 was 28.6% (109/381) for the Southern, 38.8% (78/201) for the Central, 36.5% (46/126) for the Eastern and 35.6% (79/222) for the Northern region.

In ducks (Adzitey *et al.*, 2010b) sampled duck intestines, duck wash water (water used for washing ducks), duck feaces and soil samples collected from duck farms and wet markets, and reported an overall occurrence of 79% (122/155) for *E. coli*. These were distributed as 88% (53/60), 82% (41/50), 72% (18/25) and 50% (10/20) for faeces, intestines, soil and wash water samples, respectively. They also found *E. coli* O517 in the thirty two duck intestines, eight duck faeces, four duck soil samples and two duck wash water samples.

RESISTANCE OF *E. COLI* ISOLATED FROM MALAYSIA TO ANTIBIOTICS

Alhaj *et al.* (2007) tested the susceptibility of seventy *E. coli* isolates from humans and environments samples to 10 different antimicrobial agents by the diffusion method and reported that, resistant was found in 61.2% of the isolates. They observed that the most prevalent resistances were kanamycin and tetracycline (81.4%), followed by chloramphenicol (75.7%), gentamicin, (74.3%), ampicillin (72.9%), nalidixic acid (68.6%) and sulfamethoxazole-trimethoprim (62.9%). The low prevalent were cefetoxin (44.3%), norofloxacin (27.1%) and ciprofloxacin (24.3%). Their aim was to generate a baseline data on the prevalence of antimicrobial resistance in *Escherichia coli* isolates from different sources in Malaysia.

Lim *et al.* (2009) examined forty-seven *E. coli* isolates from various public hospitals in Malaysia and reported percentage resistances to the following antibiotics: ampicillin 77%, piperacillin 64%, tetracycline 53%, trimethoprim-sulfamethoxazole 43%, cefoperazone 30%, kanamycin 30%, nalidixic acid 28%, chloramphenicol 26%, ciprofloxacin 23%, gentamicin 21%, amoxicillin-clavulanic acid 17%, cefriaxone 11%, ceftazidime 11%, aztreonam 11% and amikacin 2%. All the 47 isolates were sensitive to imipenem. Furthermore, 36 isolates (76.5%) were resistant to two or more antibiotics (multidrug-resistant).

Sukhumungoon *et al.* (2011) reported the percentage resistant of *E. coli* O571:H7 isolated from beef samples to be 38. 5% (5/13) against four different antibiotics. One each of the isolate was resistant to cephalothin, ceftriaxone, cephalothin and ceftriaxone, ampicillin and ceftriaxone, cephalothin, ampicillin and amikacin and cephalothin, ceftriaxone and ampicillin.

Sahilah (1997) tested 65 strains of *E. coli* for their susceptibility against antimicrobials and reported that all the strains were resistant to four or more antimicrobial agent tested. The 65 strains were all resistant to bacitracin (100%), methicillin (100%) and vancomycin (100%) but susceptible to cephalosporin (100%), kanamycin (100%), nalidixic acid (100%) and furazolidone (100%).

CONCLUSION

In Malaysia few published data is available on the prevalence of *E. coli* and it resistance to antibiotics. The few published data revealed the presence of pathogenic *E. coli* strains and it resistance to multiple antibiotics. Most studies also concentrated on beef samples. A number of food poisonings have been reported in Malaysia of which pathogenic *E. coli* could be one of the possible causes although data available does not linked specific organisms to reported cases of food

poisonings. Education of food handlers in improving their hygienic standard is very essential to reduce the risk of food-borne illnesses, diseases or poisonings.

ACKNOWLEDGMENTS

The author acknowledge with gratitude the support and funding given by the Institute of Postgraduate Studies, Universiti Sains Malaysia to pursue PhD in the area of Food Safety.

REFERENCES

Abulreesh, H.H., 2011. Free living rock pigeon (*Columba livia*) as an environmental reservoir of enteric bacterial pathogens resistant to antimicrobial drugs in Saudi Arabia. Curr. Res. Bacteriol., 4: 28-33.

Adzitey, F., G.A. Teye, A.G. Ayim and S. Adday, 2010a. Microbial quality of chevon and mutton sold in Tamale Metropolis of Northern Ghana. J. Appl. Sci. Environ. Manage., 14: 53-55.

Adzitey, F., N. Huda and G. Rusul, 2010b. Prevalence of *Escherichia coli* in duck intestines, faeces, soil and wash water samples in Penang, Malaysia. Proceedings of the 4th International Conference Postgraduate Education: Globalisation and Liberalisation of Postgraduate Education, Nov. 26-28, Cititel Mid Valley, Kuala Lumpur, pp: 165-167.

Adzitey, F., N. Huda and G. Rusul, 2011a. Comparison of media for the isolation of *Salmonella* (XLD and Rambach) and *Listeria* species (ALOA and Palcam) in naturally contaminated duck samples. Int. J. Food Saf., 13: 20-25.

Adzitey, F., G.A. Teye, W.N. Kutah and S. Adday, 2011b. Microbial quality of beef sold on selected markets in the Tamale Metropolis in the Northern Region of Ghana. Livest. Res. Rur. Dev., 23: 1-1.

Adzitey, F., G. Rusul and N. Huda, 2011c. Prevalence and antibiotic resistance of Salmonella serovars in ducks, duck rearing and processing environments in Penang, Malaysia. Food Res. Int., (In Press). 10.1016/j.foodres.2011.02.051.

Adzitey, F. and H. Nurul, 2011. *Campylobacter* in poultry: Incidences and possible control measures. Res. J. Microbiol., 6: 182-192.

Alhaj, N., N.S. Mariana, A.R. Raha and Z. Ishak, 2007. Prevalence 2009. Clonal diversity of *Escherichia coli* isolates from marketed beef in East Malaysia. World J. Microbiol. Biotech., 22: 661-667.

Apun, K., P.P. Chang, E.U.H. Sim and V. Micky, 2006. Clonal diversity of *Escherichia coli* isolates from marketed beef in East Malaysia. World J. Microbiol. Biotechnol., 22: 661-667.

Apun, K., K.L. Kho, Y.L. Chong, F.H. Hashimatul and M.T. Abdullah *et al*., 2010. Detection of *Escherichia coli* O157:H7 in wildlife from disturbed habitats in Sarawak, Malaysia. Res. J. Microbiol., 6: 132-139.

Arumugaswamy, R.K., G. Rusul and S.N. Abd Hamid, 1994. Prevalence of *Listeria monocytogenes* in foods in Malaysia. Int. J. Food Microbiol., 23: 117-121.

Blackburn, C.W. and J.D. McCarthy, 2000. Modifications to methods for the enumeration and detection of injured *Escherichia coli* O157:H7 in foods. Int. J. Food Microbiol., 55: 285-290.

Brichta-Harhay, D.M., T.M. Arthur, J.M. Bosilevac, M.N. Guerini, N. Kalchayanand and M. Koohmaraie, 2007. Enumeration of *Salmonella* and *Escherichia coli* O157:H7 in ground beef, cattle carcass, hide and faecal samples using direct plating methods. J. Appl. Microbiol., 103: 1557-1568.

CDC, 1999. Update: Multistate outbreak of *Escherichia coli* O157:H7 infections from hamburgers-Western United States, 1992-1993. Morbid. Mortal. Weekly Rep., 42: 258-263.

Chye, F.Y., A. Abdullahb and M. Khan, 2004. Bacteriological quality and safety of raw milk in Malaysia. Food Microbiol., 21: 535-541.

Conway, P. and G. Macfarlane, 1995. Microbial Ecology of the Human Large Intestine. In: Human Colonic Bacteria: Role in Nutrition, Physiology and Pathology, Gibson, G. and G. MacFarlane (Eds.). CRC Press, London, pp: 1-24.

Ekici, K., H. Bozkurt and O. Isleyici, 2004. Isolation of some pathogens from raw milk of different milch animals. Pak. J. Nutr., 3: 161-162.

Escherich, T., 1885. The intestinal bacteria of the newborn and infants. Fortshr. Med., 3: 515-522.

Ewing, W.H., 1986. Edwards and Ewings Identification of *Enterobacteriaceae*. 4th Edn., Elsevier, New York.

Feng, P. and S.D. Weagant 2009. Bacteriological analytical manual. 8th Edn., Chapter 4. http: //ww. fd. gov/Food/Science Research/Laboratory Methods/ BacteriologicalAnalyticalManualBAM/UCM064948.

Frederick, A. and N. Huda, 2011. Salmonellas, poultry house environments and feeds: A review. J. Anim. Vet. Adv., 10: 679-685.

Gomes, A.R., L. Muniyappa, G. Krishnappa, V.V.S. Suryanarayana, S. Isloor, B. Prakash and P.G. Hugar, 2005. Genotypic characterization of avian *Escherichia coli* by random amplification of polymorphic DNA. Int. J. Poult. Sci., 4: 378-381.

Hosein, A., K. Muñoz, K. Sawh and A. Adesiyun, 2008. Microbial load and the prevalence of *Escherichia coli*, *Salmonella* spp. and *Listeria* spp. in ready-to-eat products in Trinidad. Open Food Sci. J., 2: 23-28.

Jomezadeh, N., A. Farajzadeh Sheikh, A.D. Khosravi and M. Amin, 2009. Detection of shiga toxin producing *E. coli* strains isolated from stool samples of patients with diarrhea in Abadan Hospitals, Iran. J. Biol. Sci., 9: 820-824.

Lim, K.T., R. Yasin, C.C. Yeo, S. Puthucheary and K.L. Thong, 2009. Characterization of multidrug resistant ESBL-producing *Escherichia coli* isolates from hospitals in Malaysia. J. Biomed. Biotechnol., 2009: 1-10.

Mahalakshmi, M., M. Srinivasan, M. Murugan, S. Balakrishnan and K. Devanathan, 2011. Isolation and identification of total heterotrophic bacteria and human pathogens in water and sediment from cuddalore fishing harbour after the tsunami. Asian J. Biol. Sci., 4: 148-156.

Mermin, J.H. and P.M. Griffin, 1999. Public health in crisis: outbreaks of *Escherichia coli* O157:H7 infections in Japan. Am. J. Epidemiol., 150: 797-803.

Mihdhdir, A.A., 2009. Evaluation of bacteriological and sanitary quality of drinking water stations and water tankers in makkah al-mokarama. Pak. J. Biol. Sci., 12: 401-405.

Muller, E.E., W. Grabow and M.M. Ehlers, 2003. Immunomagnetic separation of *Escherichia coli* O157:H7 from environmental and wastewater in South Africa. Water SA., 29: 427-432.

Nanu, E., C. Latha, B. Sunil Prejit, T. Magna and K. Vrinda Menon, 2007. Quality assurance and public health safety of raw milk at the production point. Am. J. Food Technol., 2: 145-152.

Nataro, J.P. and J.B. Kaper, 1998. Diarrheagenic *Escherichia coli*. Clin. Microbiol. Rev., 11: 142-201.

Neill, M.A., P.I. Tarr, D.N. Taylor and A.F. Trofa, 1994. *Escherichia coli*. In: Foodborne Disease Handbook, Hui, Y.H., J.R. Gorham, K.D. Murell and D.O. Cliver (Eds.). Marcel Decker, Inc., New York, pp: 169-213.

Oyetayo, V.O., F.C. Akharaiyi and M. Oghumah, 2007. Antibiotic sensitivity pattern of *Escherichia coli* isolated from water obtained from wells in akure metropolis. Res. J. Microbiol., 2: 190-193.

Parekh, T.S. and R. Subhash, 2008. Molecular and bacteriological examination of milk from different milch animals with special reference to coliforms. Current Res. Bacteriol., 1: 56-63.

Rad, Z.A., 2004. An epizootic of combined *Clostridium perfringens*, *Eimeria* sp. and *Capillaria* sp. Enteritis and *Histomonas* sp. Hepatitis with *Escherichia coli* septicemia in bobwhite quails (*Colinus virginianus*). Int. J. Poult. Sci., 3: 438-441.

Sahilah, A.M., 1997. Plasmid profiling and antibiotic resistance of *Escherichia coli* and *Escherichia coli* O157 strains. Master's Thesis, Universiti Putra Malaysia.

Saleha, A.A., 2002. Isolation and characterization of *Campylobacter jejuni* from broiler chickens in Malaysia. Int. J. Poult. Sci., 1: 94-97.

Sherfi, S.A., I.E. Aradaib and H.A. Dirar, 2006. Evaluation of polymerase chain reaction for rapid detection of *E. coli* strains: A preliminary study. Asian J. Cell Biol., 1: 9-13.

Sherfi, S.A., H.A. Dirar, B.E. Hago, M.E. Ahmed, H.A. Musa, H. Abu Aisha and I.E. Aradaib, 2007. Evaluation of polymerase chain reaction for direct detection of *Escherichia coli* strains in environmental samples. Res. J. Microbiol., 2: 163-169.

Shojaei, Z.A. and A. Yadollahi, 2008. Physicochemical and microbiological quality of raw, pasteurized and UHT milks in shops. Asian J. Scientific Res., 1: 532-538.

Son, R., S.A. Mutalib, G. Rusul, Z. Ahmad and T. Morigaki *et al*., 1998. Detection of *Escherichia coli* O157:H7 in the beef marketed in Malaysia. Appl. Environ. Microbiol., 64: 1153-1156.

Sukhumungoon, P., Y. Nakaguchi, N. Ingviya, J. Pradutkanchana and Y. Iwade *et al*., 2011. Investigation of stx2+, eae+ *Escherichia coli* O157:H7 in beef imported from Malaysia to Thailand. Int. Food Res. J., 18: 381-386.

Tambekar, D.H. and R.H. Mundhada, 2006. Bacteriological quality of salad vegetables sold in Amravati city (India). J. Biological Sci., 6: 28-30.

Tambekar, D.H., N.B. Hirulkar, M.V. Kalikar, Y.S. Patil and S.R. Gulhane, 2006. Prevalence of thermotolerant *Escherichia coli* in drinking water and its multidrug resistance. Res. J. Microbiol., 1: 458-462.

Vogt, R.L. and L. Dippold, 2005. *Escherichia coli* O157:H7 outbreak associated with consumption of ground beef, June-July 2002. Public Health Rep., 120: 174-178.

Warsama, L.M., Ibtisam E.M. Elzubeir and O.A.O. Elowni, 2006. Composition and hygienic quality of Sudanese white cheese in Khartoum North markets (Sudan). Int. J. Dairy Sci., 1: 36-43.

Zaliha, I. and A.B. Rusli, 2004. A study on hygienic standard of food premises and microbiological quality of food in Kota Bharu. Working Paper. Universiti Sains Malaysia. http://eprints.usm.my/7671/.

Zamxaka, M., G. Pironcheva and N.Y.O. Muyima, 2004. Microbiological and physiocochemical assessment of the quality of domestic water resources in selected rural communities of the Eastern Cape Province. Water SA., 30: 333-340.