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PATHOGENS and RESIDUES
How Safe is Our Meat?

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INTRODUCTION

The consumption of food of animal origin which includes meat, milk, eggs and their products has increased over the years. Malaysia not only imports live animals but also meat and meat products, dairy products and fish, crustaceans, molluscs and their preparations. Currently, the government is going all out to increase livestock populations in the country, in particular cattle and goat populations, because in terms of consumption demands Malaysia is currently producing only 22% beef, 8% mutton and 3% milk. However, Malaysia is self-sufficient in poultry meat, eggs and pork. The demand for meat, milk, eggs and seafood has caused major changes in the way food-producing animals are raised and managed. With increase in populations, these food-producing animals are exposed to threat of diseases, including zoonotic diseases. Larger herds and flocks are reared in smaller areas resulting in high stocking densities. The environment in which they are reared, feed and water that may be contaminated and the use of additives and drugs may result in the presence of various hazards in the animals. This in turn can cause the hazards or contaminants to be present in food of animal origin. These varied hazards, which are grouped into i) microbiological contaminants - such as pathogenic microorganisms, ii) chemical contaminants - which include pesticides and antibiotics residues (being most common) and iii) physical contaminants - such as presence of soils and dirts, are of importance to public health.

Without proper management and hygiene, the herds and flocks are exposed to enteric food-borne pathogens such as *Salmonella* spp., *Campylobacter* spp., *E. coli* O157:H7 and *Listeria monocytogenes*. Apart from enteric bacterial pathogens, animals may also acquire parasites that may lead to the presence of cysts containing parasitic larvae in the muscle tissues (meat) and edible organs (Table 1). Infections can occur when humans consume raw or undercooked meat. Human can also acquire parasitic food-borne zoonoses when food becomes contaminated with the eggs or oocysts of certain parasites (Table 1).

Table 1. Some pathogens in foods of animal origin

Meat-borne parasites(present in meat as cysts)	Food-borne parasites (presence of protozoan oocysts or helminth eggs as contaminants in foods)	Bacterial and viral pathogens (present in foods as contaminants or in infected foods of animal origin)
Taenia saginata *Taenia solium* *Taenia asiatica* *Trichinella spiralis* *Toxoplasma gondii* *Gnathostoma spinigerum* *Sarcocystosis suihominis* *Sarcocystosis hominis* *Diphyllobothrium latum* (fish) *Anisakis* spp. (fish)	*Taenia solium* *Echinococcus granulosus* *Toxoplasma gondii* *Sarcocystosis suihominis* *Sarcocystosis hominis* *Clostridium perfringens*	*Salmonella* spp. *Campylobacter* spp. *Listeria monocytogenes* *E. coli* O157:H7 *Yersinia enterocolitica* *Vibrio parahaemolyticus* (fish, shellfish) Hepatitis E virus Bovine spongiform encephalopathy (BSE) (prion)

ZOONOTIC FOOD-BORNE BACTERIAL PATHOGENS

In an attempt to control the vulnerability to diseases, livestock farmers and various animal industries need to work closely with veterinarians to have herd or flock health programmes in place. To ensure that food originating from animals are safe for humans to consume, control of diseases and proper management and hygiene must be implemented along the entire continuum of the food chain, from farm (pre-harvest stage), processing (harvest stage) to post-processing (post-harvest stage) to table.

In many countries worldwide, bacterial food-borne zoonotic pathogens are the most common cause of human gastroenteritis. *Salmonella* spp. and *Campylobacter* spp. are reported to account for over 90% of all reported cases of bacteria-related food-borne diseases worldwide. Poultry and poultry products have been incriminated in the majority of food-borne diseases. Other important pathogens include *Listeria monocytogenes*, *Escherichia coli* O157:H7 or VTEC (verocytotoxin-producing *E. coli*) and *Staphylococcus aureus*. These pathogens produce acute gastroenteritis and can cause severe chronic sequelae, creating important public health problems and food safety concerns. Although Enterococci are not important pathogens for animals; however, in humans they have been implicated in infective endocarditis and urinary tract infections. Over the last decade, enterococci have emerged as major nosocomial or hospital-acquired pathogens. Enterococci are intrinsically resistant to many antibiotics and the emergence of their resistance to vancomycin in the early 90s is of concern as it is the only treatment drug that remains effective against enterococcal-associated hospital infections. In US, vancomycin resistant enterococci (VRE) are from hospital settings whereas in Europe, they are from community settings – frequently isolated from pigs, poultry and humans. In Malaysia, the control of salmonellae and VRE is given greater emphasis partly because of trade implications. Several works have documented the occurrence of salmonellae, listeriae, campylobacters, VTEC and VRE in various meats in Malaysia as shown in Table 2.

Table 2. Occurrence of food-borne pathogens and VRE in raw meat and eggs

References	Microbial species	Types of Raw Meat (No. of samples)	Occurrence rates
Akma *et al.* (2006)*	*E. coli* O157:H7	Chicken meat (29)	24.1%
		Chicken patties (11)	9.1%
		Beef patties (18)	0%
Bhusal (2004)	*Salmonella*	Chicken meat (360)	56.0%
	VRE		40.0%
	Campylobacter		6.7%
Wong (2002)	*Salmonella*	Beef (48)	8.3%
Son *et al.* (1998)	*E. coli* O157:H7	Beef (25)	36.0%
Son *et al.* (1999)	VRE	Beef (75)	13.3%
Rusul *et al.* (1996)	*Salmonella*	Chicken carcasses (445)	35.5%
Arumugaswamy *et al.* (1994)	*Listeria monocytogenes*	Chicken carcasses (32)	60.0%
		Beef (12)	50.0%
Hassan *et al.* (2005)	*Salmonella*	Chicken eggs (79)	8.9%

*Isolated *E. coli* O157:H7 from 6.9% (6/87) beef burger and 0% (0/64) from chicken burger.

CAMPYLOBACTER

According to currently available reports, cases of human campylobacteriosis exceed those of salmonellosis in several developed countries. Six of the 14 "validly described" *Campylobacter* are reported pathogenic for man, namely *Campylobacter jejuni*, *C. coli*, *C. lari* (these three species are known as thermophilic campylobacters because they grow at 42°C), *C. upsaliensis*, *C. fetus* (occasionally) and *C. hyointestinalis*. *Campylobacter jejuni* is responsible for 80-90% of campylobacteriosis in man. The thermophilic campylobacters colonise primarily in the lower portion of the intestinal tract and are mainly found in poultry.

Man acquire campylobacteriosis mainly through consumption of undercooked poultry meat, raw milk or contaminated water; and also through handling or contact with poultry, cattle, pigs or their products and pet animals. Consumption of undercooked poultry meat poses a significant risk, 49 times (odds ratio, OR=49) compared to 7 times (OR=7.2) if cooked meat is consumed, while persons tasting undercooked meat are 12 times at risk (OR=12) while for those drinking untreated well water, the risk of acquiring campylobacteriosis is about 1.5 to 2 times (Deming *et al.* 1987; Saleha, 1998; Evans *et al.* 2003).

The occurrence and distribution of *Campylobacter* in the country are reflected by studies which were carried out in poultry and in animals other than poultry as shown in the following Tables 3 and 4.

Table 3. Occurrence of *Campylobacter* sp. in poultry in Malaysia

Authors	Poultry species and Occurrence rate			*Campylobacter* species
	Species (No. of farms or owners)	No. of samples	Percentage positive	
Bhusal (2004)	Broiler chickens in wet markets (before slaughter)	541	41%	na
Moh (2002)	Broiler chickens (1 farm)	30	93.3%	*C.jejuni* - 87.9%
	Village chickens (2 owners)	30	8.9%	*C.coli* -12.1%
	Guinea fowls (1 owner)	15	6.7%	
	Turkeys (1 owner)	15	0%	
Saleha (2002)	Broilers (10 farms; 5000– 22000 chickens per farm)	508 (25 – 90)	0 - 98.2% (72.6%)	*C.jejuni* - 73.2% *C.coli* - 26.8%
Rohaidah *et al.* (2000)	Broiler chickens (3 farms)	415 (100-145	20 - 53%	na
	Village chickens (4 owners)	53 (11-18)	8 - 27%	
Saleha *et al.* (1997)	Broiler chickens in 3 poultry processing plants (before slaughter)	90	26.7 - 56.7%	na
Saleha *et al.* (1996)	Village chickens (10 owners; 10 —30 Village chickens chickens/owner)	138 (5 – 10)	81.9%	*C.jejuni* - 65.5% *C.coli* - 34.5%
Zeenathul (1994)	Broiler chickens (2 farms)	68	96 -100%	*C. jejuni* - 48,
	Village chickens (2 owners)	70	44 - 56%	*C. coli* - 51% *C. lari* - 1%
Joseph *et al.* (1989)	Poultry (colon/caecal swabs) from 4 different sources	44	72.7%	*C. jejuni* - 50% *C. coli* - 23%
Lim (1996)	Ducks (4 farms; from back-yards to commercial farms)	129 (20 – 38)	18 - 75%	*C. jejuni* - 49% *C. coli* - 51%
Saleha *et al.* (1996)	Quails (3 farms; 1000 – 10000 birds per farm)	130 (20-30)	64 - 80%	na

na – not available

Table 4. Occurrence of *Campylobacter* in animals other than poultry in Malaysia

Authors	Animal species and Occurrence rate			*Campylobacter* species
	Animal species	No. of samples	Percentage positives	
Joseph *et al.* (1989)	Breeding bulls	697	0.6%	*C. fetus*
	Dogs	30	0%	
	Cats	9	0%	
Saleha *et al.* (2000)	Cats Dogs	59	25%	*C. coli* - 43%,
	(in 2 locations)	59	14%	*C. lari* - 35%,
				C. jejuni - 17%,
				C. upsaliensis - 4%
Saleha *et al.* (2001)	Flying birds	127	18%	na
	(5 species)	(1 – 63)	(0 – 23.7%)	
Khor (2001)	Hamsters (2 species)	85	0%	-
Chong (2001)	Crows	79	25.3%	na
Wong (2002)	Cattle	48	2.1%	*C. jejuni* - 75%,
				C. coli - 25%
Tann (2002)	Pigs	85	64.7%	*C. coli* - 100%
Farrah (2004)	Goats (3 farms)	46	2.2%	*C. lari*

na – not available

From these studies, *Campylobacter* is shown to occur widely in livestock particularly in poultry, pet animals and flying birds. A study was carried out on the epidemiology and colonization of *Campylobacter* in chickens in the farms. The sources of campylobacters in the chicks were not clear. However, once campylobacters have entered a flock, they readily spread to all chickens in the flocks and to other flocks (Saleha, 2004). Other studies found that factors such as untreated drinking water, houseflies, workers, presence of pests as well as poor management and hygiene practices play important roles in the colonization of campylobacters in chickens.

The occurrences of *Campylobacter* on carcasses in abattoirs and poultry processing plants as well as in retail outlets and markets were also studied (Table 5).

Table 5. Occurrence of *Campylobacter* in poultry, beef and pig carcasses in Malaysia

Authors	Types of Meat Samples and Occurrence rate			*Campylobacter* species
	Types of Meat	No. of samples	Percentage positives	
Nazarina (1998)	Chicken carcasses from 3 types of markets	90	87% (83.3 – 100%)	*C. jejuni* - >50%
Saleha *et al.* (1997)	Chicken carcasses and parts in 3 poultry processing plants at 5 different processing sites	87	11.1 – 62.5%	na
Joseph *et al.* (1989)	Poultry carcass rinses from 4 different sources	44	31.8%	*C. jejuni* – *15.9%* *C. coli* - 0%
Saleha *et al.* (2003)	Beef carcasses	48	8.3%	*C. jejuni* - 75% *C. coli* - 25%
Saleha *et al.* (2003)	Pig carcasses	76	60.5%	*C. coli* - 100%

na – not available

In the study on contamination of chicken carcasses with campylobacters during processing, it was found that colonized chickens were the possible source and subsequently improper handling and processing procedures caused contamination of equipment, the environment and the carcasses and meat (Saleha *et al.* 1997).

Campylobacter causes enteritis in man which cannot be distinguished clinically from *Salmonella* or *Shigella* infection with symptoms which include diarrhoea (may contain blood), fever and abdominal pain. The infection is self-limiting, lasts 2-5 days or up to 10 days. In some cases, it tends to be more severe and mimic acute appendicitis. Less frequently reported was bacteraemia and septic arthritis. The infective dose is about 500-800 cells.

In USA, Canada and Europe, the incidence rates of *Campylobacter* enteritis surpasses that of salmonellosis; in USA, it is estimated that there are 1-4 million cases annually and in other developing countries, it was reported as 30-50 times higher. In Malaysia and Singapore, the few published reports gave low isolation rates of *Campylobacter* at 3-5%. However, according to Puthucheary et al (1994), the true incidence may be 5-10 times greater than that of the industralised countries. In Asia, children below 5 years were more frequently affected with *Campylobacter.*

Occasionally, complications occur with serious sequelae, among which Guillain Barre' Syndrome (GBS) is more commonly reported. GBS is an acute inflammatory demyelinating polyneuritis marked by paralysis, pain and wasting muscles . It has a more interesting association where the following was reported by Nachamkin *et al.* (2000) on GBS in USA - that 30% of patients with GBS had recent evidence of *Campylobacter* infection (1- 3 weeks after infection), GBS occurs more commonly in males than females (3 to 1), occurs in patients of all ages and GBS following *Campylobacter* infection appeared to be more severe and more likely to involve axonal injury. Although the risk of developing GBS following *C. jejuni* infection is low (in USA, approximately 1 case of GBS per 1058 cases of *C. jejuni* infection), in one outbreak of gastroenteritis affecting 5000 persons, 16 developed GBS (Nachamkin et al, 2000). In Asia, GBS is relatively not known; however in Japan it was reported at 22% .

ARCOBACTER, HELICOBACTER AND NON O157 *E. COLI* AS EMERGING HUMAN PATHOGENS

In comparison to *Campylobacter*, information on *Arcobacter* and *Helicobacter* is very limited. It is reported that these organisms also occur in poultry and poultry products.

Arcobacters were first referred to as aerotolerant campylobacters due to their ability to grow in air. They also differ from *Campylobacter* spp. as they grow at lower temperatures of between 15 to 30°C. In 1991, the genus *Arcobacter* was proposed to contain these organisms. Among the five species, *Arcobacter butzleri* have been frequently associated with human enteritis and occasionally bacteraemia. Livestock animals, such as dairy cattle and pigs are significant reservoirs. The presence of arcobacters in raw meat has received increasing attention, particularly in chicken meat and pork. Arcobacters have also been detected in various types of water. It is possible that drinking contaminated water can result in colonization of the animals and human illnesses (Snelling *et al.* 2006) and that using such water can cause contamination of carcasses and meat especially in chickens because many studies fail to isolate the organisms in chickens. A preliminary study on the occurrence of arcobacters in chicken meat retailed around Serdang area was carried out and it was found that 22% were contaminated with the organisms (Saleha *et al.* 2007).

The phenotypic similarities between helicobacters and campylobacters as well as the specific isolation requirements may have led to the misdiagnosis of the organisms in the past. Today, several works reported the increasing occurrence of helicobacters in animals, possibly because of improved isolation and detection methods. Among the species that are specific to humans, *Helicobacter pylori* is of utmost importance, causing dyspepsia, gastritis, gastroduodenal ulcers and as a risk factor for gastric carcinoma. A number of studies carried out in Malaysia by Goh and Parasakthi (2001) showed "racial cohort" phenomenon with the prevalence rates of 49.4-52.3% in Indians, 26.7-57.5% in Chinese and significantly lower rates in Malays at 11.9-29.2%. The presence of *H. pylori* in pet animals is said to be acquired from infected owners.

Several species of *Helicobacter* are found to colonise the gastrointestinal tracts of several mammalian animals and avian hosts and some are zoonotic, such as *Helicobacter canis, H. heilmannii* and *H. rappini.* Currently, of concern is the occurrence of *Helicobacter pullorum*, a new species defined in 1994, as it has been associated with vibrionic hepatitis and enteritis in poultry and with gastroenteritis, diarrhoea and liver and gall bladder diseases in human and may even possibly play a role in Crohn's disease (Ceelen *et al.* 2005). A limited number of studies showed the high occurrences of *H. pullorum* in chickens and chicken meat which may constitute vehicles for human *H. pullorum* infections (Ceelen *et al.* 2006; Atabay *et al.* 1998).

Most studies focused on food-borne Enterohaemorrhagic *Escherichia coli* (EHEC) which produce enterohaemolysin, also referred to as shiga toxin (ST) or verocytotoxin (VT); hence the term STEC or VTEC for positive strains that cause haemorrhagic colitis in humans. In small proportions of patients, particularly young children and the elderly, the infection may lead to a life-threatening haemolytic uraemic syndrome (HUS). HUS is characterised by acute renal failure, haemolytic anaemia and thrombocytopaenia. *E. coli* O157: H7 is currently the predominant EHEC and the main reservoirs for EHEC appear to be cattle and other ruminants. It is estimated that 43% of the carcasses and meat coming out of the abattoir are contaminated with the pathogen (Schlundt *et al.* 2004). However, today, increasing occurrence of other O serotypes of *E.coli* are being reported; known as non-O157 *E. coli*, such as O26, O103, O111, O118 and

0145, that are also pathogenic in man. It was also reported that the frequency of non-O157 STEC rivals that of O157:H7 in certain geographic regions. Clinical manifestations of non-O157 *E. coli* infection can range from mild diarrhoeal illness to just as severe as illnesses induced by *E. coli* O157:H7. Similar to EHEC, humans are infected primarily through undercooked meat or contaminated foods and water, raw milk, as well as upon direct contact with farm animals. The study on non-0157 *E. coli* in beef in wet markets and supermarkets around Serdang area found 32% and 21% positive, respectively (Nadia, 2007).

Research works are currently being undertaken in the Faculty of Veterinary Medicine on the occurrence and epidemiology of arcobacters and helicobacters in chickens (under the eScience Fund) and non-O157 *E. coli* in ruminants (under RUGS). Works on *Campylobacter* continues.

RESIDUES IN MEAT

Residues in meat, milk, eggs and their products can occur as a result of inappropriate treatment of animals with veterinary drugs including antibiotics and giving feed containing excessive feed additives, pesticides, mycotoxins and environmental contaminants, such as dioxins and polychlorobipenyls (PCBs).

The inappropriate or excessive use of pesticides on pastures and crops used for animal feed and the occurrence of environmental contaminants, such as dioxins and PCBs can result in the presence of residues in animal feed. Residues can also occur in water supplies due to run offs. The feeding of mouldy feed to animals can lead to the presence of mycotoxins such as aflatoxins in the organs of the animals, such as in their livers and kidneys and also in the milk. The improper use of disinfectants on surfaces of equipments may results in their residues being present in foods. This is illustrated in Figure 1.

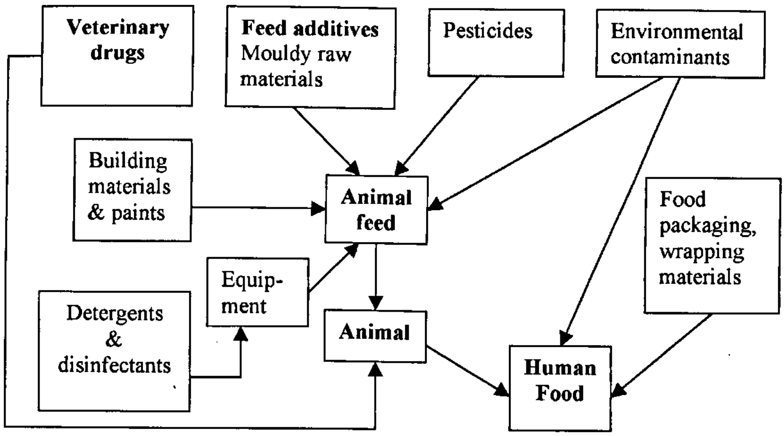


Figure 1. Pathway of residues into food of animal origin

The current issue of increasing concern is the presence of veterinary drug residues, notably antibiotic residues, in foods of animal origin. In 1999, it was reported that 8.5million kg of antibiotics were fed to chickens, pigs and cattle each year for non-therapeutic purposes as feed additives to improve growth and feed efficiency. In the USA, 29 million pounds of antimicrobial agents are used annually in food animals of which 25 million pounds (86%) are for non-therapeutic purposes (Anderson, 2003). Australia imports 700 tonnes of antimicrobials annually of which two-thirds (67%) are for veterinary use and a major portion is used as feed additives (JETACAR, 1999). In contrast, in EU countries 35% is for veterinary use of which 6% is for growth promotion (Wegener, 2000). One of the main factors for the occurrence of such "violative residues" is failure to observe the recommended withdrawal period, that is, the interval of time required for the residue of a drug to reach safe concentration as defined by the tolerance level. This is to ensure that no potentially toxic residue is still present in the body of the animal at the time of slaughter for human consumption. Other factors which contribute to the occurrence of antibiotic residues in foods include extended usage or excessive dosage of approved drugs, using drugs not according to label direction ("extra/off label") and failure or poor record keeping or identification of treated animals.

The health risks associated with antibiotic residues are toxicological (antibiotic toxicities) and immunopathological hazards (allergic reactions). Furthermore, the presence of violative residues is a barrier to trade as such tainted foods are banned by importing countries.

In Malaysia, the presence of antibiotic residues and veterinary drugs such as nitrofurans and beta agonists is of concern. Refer to Table 6.

Table 6. The detection of veterinary drug residues in meat

Year/No. samples	No. positive (%)	Residues	Types of meat	References
2000				
549 samples	107 (19.5%)	Beta-agonist	85% - pork 12% - beef 3% - mutton	MoH* Report in NST (2002)
na	3.7%	Nitrofuran	chicken	
50 samples	3 (6%)	Chloramphenicol	chicken	Salam Abdullah & Prameswaran (2000)
2001				
638 samples	37 (6.0%)	Beta-agonist	95% - pork 5% - beef	MoH Report in NST (2002)
1053 samples	1(0.1%)	Nitrofuran	chicken	
47 samples	17 (36.0%)	Antibiotics	chicken	Tin Tin Myaing and Saleha (2001)

Table 6: Continued

2003	
70% beef, 84% pork positive for beta-agonist May to June – 70.3% pork positive July to September – 84.3% pork positive (samples from Selangor, Perak, Malacca, Penang)	MoH Report in NST (2004)
2004	
January – 75% pork positive for beta-agonist November – 57-76% pork positive	Chua (2005)
2006	
June – 9 of 66 (13.6%) pork positive for beta-agonist	MoH Report in The Star (2006)

*MoH Ministry of health, NST New Straits Times

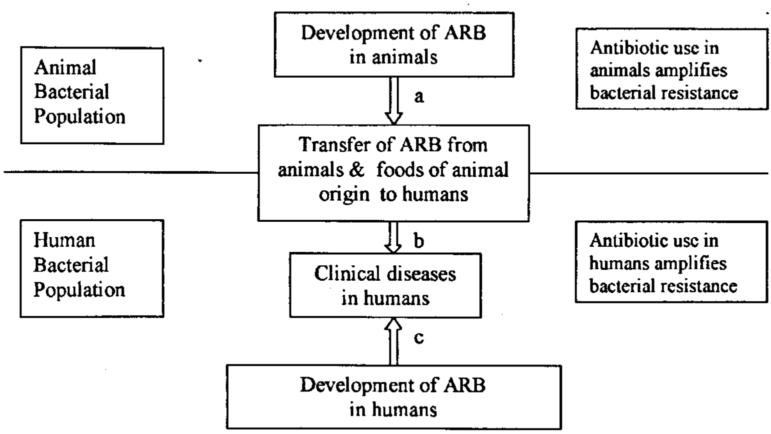
Monitoring of veterinary drug residues is carried out by DVS on beef and pork at abattoirs and poultry meat at processing plants. The outcome of this activity from 1998 – 2005 is as below:

Meat	Veterinary drugs analysed	No. of samples	Positive for residues
Pork	• antibacterial substances	989	40-60%
	• beta agonists	177	11-21%
Poultry meat	• antibacterial substances	2142	6.7%
	• nirofurans	1009	
	• chloramphenicol	777	
	• beta agonists	252	
Beef	• antibacterial substances	1408	0%
	• beta agonists	264	

Source: Sapar *et al.* 2006

ANTIBIOTIC RESISTANT BACTERIA IN ANIMALS AND MEAT

The use of antibiotics in both humans and animals has resulted in microbiological and environmental hazards. The microbiological hazard is associated with the development and dissemination of antibiotic resistant bacteria. It is of great concern as such bacteria can spread from animals to animals, animals to humans and humans to humans. These resistant bacteria from food animals may be passed by direct contact and handling as well as through the food chain to humans resulting in resistant infections (Figure 2). As such, this can lead to treatment failure or limit treatment options due to the shortened lifespan of an antibiotic's usefulness which in turn may cause longer treatment courses, increased morbidity, mortality and medical costs. The environmental hazard posed by these resistant bacteria is due to their persistence for prolonged periods in slurries and sewage (faecal and urine wastes) thereby becoming potential reservoirs for resistant factors (R-factors) in the environment.



ARB - antibiotic resistant bacteria
Transfer of antibiotic resistance genes a - between animal bacteria
b - from animal to human bacteria
c - between human bacteria

Figure 2. Spread of antibiotic resistance bacteria between animals and humans

Table 7. The occurrence of antibiotic resistant food-borne pathogens in chickens and beef meat

References	Types of meat	Microbial species	Types and % resistant to antibiotics	No. of antibiotics resistant to
Son (1994)	Village chickens	*Salmonella enteritidis*	Erythromycin = 100%	1-3
Saleha *et al.* (1998)	Broiler chickens	*Campylobacter* spp.	Tetracycline = 100%; 6 other antibiotics = 22-83%	1-7
Rasul *et al.* (1999)	Chicken meat	*Listeria monocytogenes*	Ceftriazone, Cefuroxime = 90% 13 others = 1-10%	2-8
Son *et al.* (1999)	Beef	VRE	Bacitracin, streptomycin, erythromycin = 100%	5-9
Son *et al.* (1998)	Beef	*E.coli* O157:H7	92% to voncomycin; to 15 others = 0-63%	4-9

Among the antibiotic resistant bacteria of great concern are *Salmonella typhimurium* DT104, fluoroquinolone-resistant *Campylobacter*, vancomycin resistant enetrococci (VRE) and methicillin resistant *Satphylococcus aureus* (MRSA).

The multidrug-resistant *S. typhimurium* DT104, which is resistant to ampicillin, chloramphenicol, streptomycin, sulphonamides and tetracycline (hence known as MR DT104 of R-type ACSSuT), was first isolated from exotic birds in UK and then found in cattle, poultry, pigs, sheep and horses.

Human infection has been mainly associated with the consumption of chicken, beef, pork sausages and meat paste. It is reported that the organisms cause many hospitalizations and deaths. Todate MR DT104 is additionally resistant to trimethoprim (R-type ACSSuTTm) and showed decreased sensitivity to ciprofloxacin (R-type ACSSuTCp). It has been suggested that the resistance to trimethoprim may have resulted from the use of trimethoprim-containing compounds in cattle against infection with DT104 of R-type ACSSuT. The reduced sensitivity to ciprofloxacin followed the veterinary use of related fluoroquinolone enrofloxacin in cattle and poultry. In a study on reduced fluoroquinolone susceptibility in *Salmonella enterica* serotypes in travellers returning from Southeast Asia, it was reported that the infection rates by these organisms were highest in Finnish travellers returning from Thailand and Malaysia.

Fluoroquinolones is often the drug of choice for human patients who have chronic enteritis, are immunocompromised or have extraintestinal infections. It was reported that when fluoroquinolone was approved for veterinary use for treatment of respiratory diseases in chickens and turkeys, it led to the emergence of fluoroquinolone-resistant *Campylobacter*. The increasing rate of human infections caused by resistant strains of *C. jejuni* makes clinical management of cases of campylobacteriosis more difficult as antimicrobial resistance can prolong illness and compromise treatment of patients with bacteremia. The rate of antimicrobial-resistant enteric infections is highest in the developing world, where the use of antimicrobial drugs in humans and animals is relatively unrestricted.

A number of studies investigated by Wegener *et al.* (1999) found that the use of glycopeptides avoparcin as a growth promoter has created a reservoir for VRE in food animals, particularly in broiler chickens and pigs. In countries where avorparcin had not been used, such as Sweden and US, VRE was not detected. VRE in humans is due to exposure to inadequately cooked food or cross-contaminated ready-to-eat food. Interestingly, a study reported that VRE was not detected in strict vegetarians in The Netherlands, supporting the view that the source of VRE is contaminated meat (Wegener *et al.* 1999).

Increasing antibiotic resistance in other food-borne zoonotic pathogens bacteria, such as *E. coli* O157:H7, *Listeria monocytogenes* and *Yersinia enterocolitica* is another developing dilemma that must be monitored closely as it may have future clinical implications for the treatment of the diseases they cause.

SAFE MEAT

Abattoirs and processing plants for foods of animal origin can create hazards for the human food chain as raw materials can become contaminated if hygiene measures are not managed in the premises and during processing operations.

The traditional organoleptic meat inspection procedures were developed to detect and eliminate diseased carcasses and meats from the slaughter lines. Such procedures were not able to detect contamination of carcasses and meats with meat-borne pathogens. Hence, apart from the conditions of animals presented for slaughter, ante and post mortem inspections, the hygiene of establishments, facilities and equipment, process control, establishment maintenance and sanitation and personal hygiene of workers are important aspects in meat hygiene requirements.

The present meat inspection procedures and their regulations should be able to meet current and future challenges. Hence, the *Codex Code of Hygienic Practice for Meat* (2006) (which supersedes several Codex Codes of Practice on meat hygiene since 1976) covers hygiene provisions for raw meat, meat preparations and manufactured meat from the time of live animal production to the point of retail sales. It also includes the concepts of risk assessment and hazard analysis critical control point (HACCP) systems. In Malaysia, the Animals Act 2006, imposed restrictions on slaughter and movement of cattle so that the overall records and the standing population of cattle in a State are conserved and monitored. The Meat Inspection Rules 1985 are to ensure that the slaughter of any livestock is subjected to proper meat inspection procedures in approved abattoirs or slaughterhouses. *The Guidelines for Humane Handling, Transport and Slaughter of Livestock* and *Manual on Meat Inspection for Developing Countries* produced by FAO (2000) (available online at *www.fao.org*) provide valuable guidance and information not only for experienced veterinarians and meat inspectors but also for trainees.

After the farm, the abattoir or slaughterhouse represents the next critical place in food animal production. Proper meat inspection and HACCP should be applied here to eliminate or reduce microbiological hazards in carcasses and meats. Hygiene measures and refrigeration apply to the transportation of carcasses and meat to avoid any cross-contamination. Good hygiene practices (GHP) and refrigerated temperature to inhibit proliferation of contaminating microorganisms need be implemented at the markets. The GHP, good processing or manufacturing practices (GPP or GMP) and HACCP are important in milk and egg industries to ensure safe milk and eggs. However, such good food hygiene practices should be implemented all the way to food service establishments, at food preparation and consumption points, as they can be sources of food-borne disease episodes or outbreaks.

Figure 3 illustrates the approach in the control of various hazards under the HACCP system.

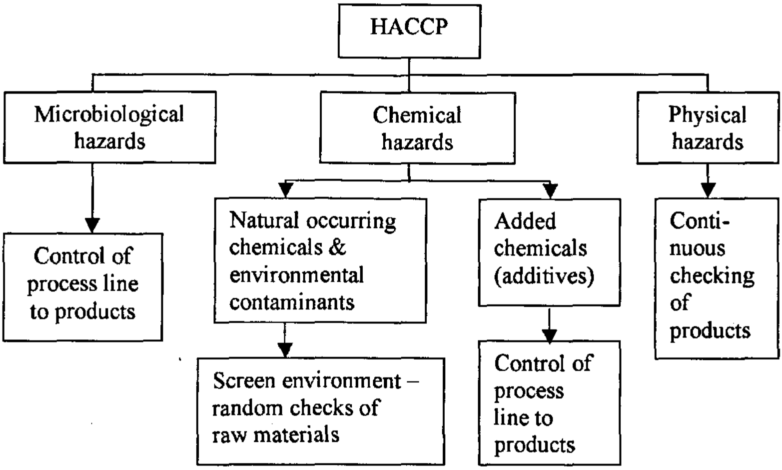


Figure 3. Main approaches to food safety within the HACCP system

In Malaysia, ensuring quality and safe food is a very challenging task. Additionally, there is the demand to produce and ensure halal food. With acts, regulations, standards and codes of practices not having the commitment of food industries and lax enforcement by regulatory agencies together with hawker or street food outlets mushrooming everywhere, food safety will be compromised. There must be concerted interaction of government agencies, food industries, academia, non-governmental organisations, consumers and other supporting parties for successful food safety implementation. The Department of Veterinary Services introduced quality assurance schemes, namely Skim *Akreditasi Ladang Ternakan* (SALT) for farms and the *Veterinary Health Mark* (VHM) for livestock-based food processing plants. Guidelines on halal requirements and GAHP should be placed at production stage and halal requirements together with GHP at processing stage. More importantly, the education and training of those in food industries and food service establishments and education and awareness on the part of the consumers can prevent episodes or outbreaks of food-borne diseases.

Today with the increasing complexity of food safety, food companies going beyond HACCP towards risk-based food safety strategies or risk analysis and food safety management programmes, can be players in the international marketplace.

PRUDENT USE OF VETERINARY DRUGS AND ANTIBIOTICS IN LIVESTOCK

The increasing antibiotic resistance in food-borne pathogens is said to be due to widespread use of antibiotics in food animals and further contributed to by the indiscriminate use of antibiotics in human medicine. To address this public health problem, the overuse, misuse and illegal use of antibiotics in food animals and humans must be reduced and closely monitored. Adherence to guidelines for prudent or judicious use of antibiotics is a must. In the *Global Principles for the Containment of Antimicrobial Resistance in Animals Intended for Foods* (2000), WHO laid out the measures to undertake: pre-licensing evaluation which include consideration for resistance, obligatory prescription for all antimicrobials used for disease control, setting up of national systems to monitor antimicrobial usage in food animals, monitoring of resistance and timely corrective actions, guidelines for veterinarians to reduce overuse and misuse and termination or rapid phasing out of antimicrobial growth promoters.

The recommendations to restrict the use of antimicrobial growth promoters (AGPs) and to restrict access to certain antimicrobials (such as fluoroquinolones) should be adhered to. Antimicrobials used in human therapeutics or which are known to be selected for cross-resistance to antimicrobials used in human medicine should not be used for growth promotion in animals. In 1998, EU banned the use of tylosin, spiramycin, bacitracin and virginiamycin because of their relatedness to the therapeutic antimicrobial drugs used in humans. Sweden banned the use of AGPs in the country from 1986 while in 1998, Danish cattle and broiler industries voluntarily stopped the use of all AGPs followed in 1999 by the pig industries. The effects of discontinuation of use of antimicrobials as growth promoters in these EU countries have been seen in a decrease in antibiotic resistance in animals, food products and humans (Anderson *et al.* 2003).

The presence of pesticides and veterinary drug residues is regulated in our Food Act 1983 and Food Regulations 1985, expressed in the form of maximum residue level or MRL. The MRL of a drug is defined as the maximum concentration of a residue of a drug that is legally permitted or recognised as acceptable in or on food, agricultural commodities or feed and is indicated in unit of μg/kg or parts per billion (ppb). At this level, it is reported as tolerable or safe and toxic, allergic or microbiological effects may not arise from the minute trace of the residue of a drug still present and usually the level is undetectable upon testing. Under Regulation 40, it is stated that a person shall not import, sell, expose or offer for sale or delivery, any food intended for human consumption which contains drug residues greater than the amount as set out in Table I and II of the 15th A Schedule. The three drugs prohibited in foods as listed in Table II are chloramphenicol, nitrofurans and beta agonists. This is because chloramphenicol can cause toxic aplastic anaemia, a deadly blood disorder in sensitive humans, nitrofuran compounds are mutagenic and possibly carcinogenic while beta agonists can affect the functions of the lung and heart in humans causing reversible symptoms of increased heart rate, muscular tremors, headache, nausea, fever and chills.

> ".... We have been living with the idea that we can keep ahead of the(se) bugs, but (in actual fact) we cannot. The only solution is to eliminate the misuse and overuse of antibiotics." (Wegener, 2000).

It is imperative that all who are involved in the authorisation (regulatory agencies), manufacture (veterinary pharmaceutical industries), sale and supply (wholesale and retail distributors), prescription (veterinarians) and use (farmers/producers) of antibiotics in animals should act legally, responsibly and judiciously so as to limit the development and dissemination of resistant bacteria among animals to protect the health of man.

The Department of Veterinary Services Malaysia and Ministry of Health are actively carrying out monitoring and enforcement activities to stop veterinary drug abuse in food animals.

CONCLUSIONS

Human health is associated with animal health and production. In developing countries, this association between humans, animals and the surrounding environment is particularly close as animals not only provide food (meat, milk and eggs) and are a source of income but are also a means of transportation and draught power. Also, animals provide companionship and are used for sports and recreational activities. However, this close association with animals can lead to serious health hazards most of the time with severe economic consequences, particularly with the occurrence of zoonotic diseases and food-borne illnesses. Other health hazards include the presence of residues in animal food and antibiotic resistant organisms in animals and animal food.

Veterinary medicine has played a significant role in the promotion of the health and well being of humans. Veterinarians are given the responsibility to control or eliminate zoonoses in animals, to provide safe and wholesome meat, milk and eggs and monitor the proper usage of veterinary drugs in animal. Hence, full cooperation and collaboration from medical counterparts, related agencies and producers are needed in order to achieve food safe for consumption.

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BIOGRAPHY

Saleha Abdul Aziz was born on 18th November in Johore Bahru, Johore. She had her primary and secondary education in Sultan Ibrahim Girls School in Johore Bahru and did her Form Six in Tunku Kurshiah College, Seremban. The love for animals made her pursue veterinary medicine. She was offered by MARA to do Doctor of Veterinary Medicine in Universitas Gadjah Mada in Yogyakarta, Indonesia. Upon her graduation in 1977 with the title "Dokter Hewan (Drh)", she proceeded to do her Graduate Diploma in Veterinary Preventive Medicine in University of Guelph, Ontario, Canada. She did her Ph.D at UPM on epidemiology of *Campylobacter* in broiler chickens, a foodborne pathogen of public health importance.

She applied and was offered a lecturer post in Department of Veterinary Pathology and Microbiology. On 7 April 1980, she reported for work at the Faculty of Veterinary Medicine (it was then known as Faculty of Veterinary Medicine and Animal Science) and since then has never look back. In the beginning she taught Animal Health (Microbiology) and Epidemiology and Food Hygiene courses. She was given the opportunity to do a Short Course in Veterinary Epidemiology and Economics in University of Reading, United Kingdom followed by a seeing practice in Kenya, Nairobi. In the Veterinary Public Health course which she dwelled in and is her area of expertise, emphasis is given to zoonoses (infectious diseases and infections transmissible between vertebrate animals and man), microbiology and safety of food of animal origin, meat inspection and veterinary drug residues. She is a member of the National Codex Sub-Committee on Veterinary Drug Residues in Foods and National Codex Committee on Meat and Poultry Hygiene. She has been invited on a number of occasions to talk on meat microbiology, zoonoses, antibiotic residues and on *Campylobacter*.

Her research in *Campylobacter* and pathogens in food of animal origin has given her the opportunity to present her work in several international conferences in various countries, including among others in International Workshop on *Campylobacter*, *Helicobacter* and Related Organisms held every two years (latest was CHRO2007), World Congress on Foodborne Infections and Intoxications held every six years, International Conference on Antimicrobial Agents in Veterinary Medicine, International Congress of World Veterinary Poultry Association, International Symposium of World Association of Veterinary Food Hygienists and Veterinary Association Malaysia Scientific Congress. She has published several papers in national and international journals and proceedings. The April 2007 issue of Reader's Digest carried an article on Good Food Gone Bad (D.L.C. Dayao) which quoted her work on *Campylobacter*. She has published a book on Veterinary Epidemiology in Bahasa Malaysia (Dewan Bahasa dan Pustaka, 1992). Currently her research is into *Arcobacter* and *Helicobacter* in chickens and non-O157 Shiga-toxin producing *E. coli* in cattle which are emerging food borne pathogens.

Besides lecturing, doing research, supervising and co-supervising undergraduate and postgraduate students and involve in veterinary diagnostic work, she is also actively involved in developing, implementing and maintaining the Quality Management System for the Faculty. She was the Management Representative (MR) when the Faculty was MS ISO 9001: 1994 certified in July 2000 (the first Faculty in UPM) which was later upgraded to MS ISO 9001: 2000. Her interest in quality system has her now involved in Laboratory Accreditation Scheme for Malaysia (MS ISO 17025) in which she currently serves as a member of Sectoral Technical Committee for Veterinary Testing at Department of Standard Malaysia. In July 2007, she passed the examination for Technical Assessor of Laboratories based on ISO/IEC 17025 and ISO 15189, conducted by New Zealand Quality College (a training division of International Accreditation New Zealand) and

Department Standard Malaysia. Currently, she is the Deputy Dean for Academic and Students Affair, still the Faculty MR and a trainee technical assessor with Department Standard Malaysia.

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LIST OF INAUGURAL LECTURES

1. Prof. Dr. Sulaiman M. Yassin
   The Challenge to Communication Research in Extension
   22 July 1989

2. Prof. Ir. Abang Abdullah Abang Ali
   Indigenous Materials and Technology for Low Cost Housing
   30 August 1990

3. Prof. Dr. Abdul Rahman Abdul Razak
   Plant Parasitic Nematodes, Lesser Known Pests of Agricultural Crops
   30 January 1993

4. Prof. Dr. Mohamed Suleiman
   Numerical Solution of Ordinary Differential Equations: A Historical Perspective
   11 December 1993

5. Prof. Dr. Mohd. Ariff Hussein
   Changing Roles of Agricultural Economics
   5 March 1994

6. Prof. Dr. Mohd. Ismail Ahmad
   Marketing Management: Prospects and Challenges for Agriculture
   6 April 1994

7. Prof. Dr. Mohamed Mahyuddin Mohd. Dahan
   The Changing Demand for Livestock Products
   20 April 1994

8. Prof. Dr. Ruth Kiew
   Plant Taxonomy, Biodiversity and Conservation
   11 May 1994

9. Prof. Ir. Dr. Mohd. Zohadie Bardaie
Engineering Technological Developments Propelling Agriculture into the 21st Century
28 May 1994

10. Prof. Dr. Shamsuddin Jusop
Rock, Mineral and Soil
18 June 1994

11. Prof. Dr. Abdul Salam Abdullah
Natural Toxicants Affecting Animal Health and Production
29 June 1994

12. Prof. Dr. Mohd. Yusof Hussein
Pest Control: A Challenge in Applied Ecology
9 July 1994

13. Prof. Dr. Kapt. Mohd. Ibrahim Haji Mohamed
Managing Challenges in Fisheries Development through Science and Technology
23 July 1994

14. Prof. Dr. Hj. Amat Juhari Moain
Sejarah Keagungan Bahasa Melayu
6 Ogos 1994

15. Prof. Dr. Law Ah Theem
Oil Pollution in the Malaysian Seas
24 September 1994

16. Prof. Dr. Md. Nordin Hj. Lajis
Fine Chemicals from Biological Resources: The Wealth from Nature
21 January 1995

17. Prof. Dr. Sheikh Omar Abdul Rahman
Health, Disease and Death in Creatures Great and Small
25 February 1995

18. Prof. Dr. Mohamed Shariff Mohamed Din
Fish Health: An Odyssey through the Asia - Pacific Region
25 March 1995

19. Prof. Dr. Tengku Azmi Tengku Ibrahim
Chromosome Distribution and Production Performance of Water Buffaloes
6 May 1995

20. Prof. Dr. Abdul Hamid Mahmood
Bahasa Melayu sebagai Bahasa Ilmu- Cabaran dan Harapan
10 Jun 1995

21. Prof. Dr. Rahim Md. Sail
Extension Education for Industrialising Malaysia: Trends, Priorities and Emerging Issues
22 July 1995

22. Prof. Dr. Nik Muhammad Nik Abd. Majid
The Diminishing Tropical Rain Forest: Causes, Symptoms and Cure
19 August 1995

23. Prof. Dr. Ang Kok Jee
The Evolution of an Environmentally Friendly Hatchery Technology for Udang Galah, the King of Freshwater Prawns and a Glimpse into the Future of Aquaculture in the 21st Century
14 October 1995

24. Prof. Dr. Sharifuddin Haji Abdul Hamid
Management of Highly Weathered Acid Soils for Sustainable Crop Production
28 October 1995

25. Prof. Dr. Yu Swee Yean
Fish Processing and Preservation: Recent Advances and Future Directions
9 December 1995

26. Prof. Dr. Rosli Mohamad
    Pesticide Usage: Concern and Options
    10 February 1996

27. Prof. Dr. Mohamed Ismail Abdul Karim
    Microbial Fermentation and Utilization of Agricultural Bioresources and Wastes in Malaysia
    2 March 1996

28. Prof. Dr. Wan Sulaiman Wan Harun
    Soil Physics: From Glass Beads to Precision Agriculture
    16 March 1996

29. Prof. Dr. Abdul Aziz Abdul Rahman
    Sustained Growth and Sustainable Development: Is there a Trade-Off 1 or Malaysia
    13 April 1996

30. Prof. Dr. Chew Tek Ann
    Sharecropping in Perfectly Competitive Markets: A Contradiction in Terms
    27 April 1996

31. Prof. Dr. Mohd. Yusuf Sulaiman
    Back to the Future with the Sun
    18 May 1996

32. Prof. Dr. Abu Bakar Salleh
    Enzyme Technology: The Basis for Biotechnological Development
    8 June 1996

33. Prof. Dr. Kamel Ariffin Mohd. Atan
    The Fascinating Numbers
    29 June 1996

34. Prof. Dr. Ho Yin Wan
Fungi: Friends or Foes
27 July 1996

35. Prof. Dr. Tan Soon Guan
Genetic Diversity of Some Southeast Asian Animals: Of Buffaloes and Goats and Fishes Too
10 August 1996

36. Prof. Dr. Nazaruddin Mohd. Jali
Will Rural Sociology Remain Relevant in the 21st Century?
21 September 1996

37. Prof. Dr. Abdul Rani Bahaman
Leptospirosis-A Model for Epidemiology, Diagnosis and Control of Infectious Diseases
16 November 1996

38. Prof. Dr. Marziah Mahmood
Plant Biotechnology - Strategies for Commercialization
21 December 1996

39. Prof. Dr. Ishak Hj. Omar
Market Relationships in the Malaysian Fish Trade: Theory and Application
22 March 1997

40. Prof. Dr. Suhaila Mohamad
Food and Its Healing Power
12 April 1997

41. Prof. Dr. Malay Raj Mukerjee
A Distributed Collaborative Environment for Distance Learning Applications
17 June 1998

42. Prof. Dr. Wong Kai Choo
Advancing the Fruit Industry in Malaysia: A Need to Shift Research Emphasis
15 May 1999

43. Prof. Dr. Aini Ideris
Avian Respiratory and Immunosuppressive Diseases- A Fatal Attraction
10 July 1999

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Biological Control of Plant Pathogens: Harnessing the Richness of Microbial Diversity
14 August 1999

45. Prof. Dr. Azizah Hashim
The Endomycorrhiza: A Futile Investment?
23 Oktober 1999

46. Prof. Dr. Noraini Abdul Samad
Molecular Plant Virology: The Way Forward
2 February 2000

47. Prof. Dr. Muhamad Awang
Do We Have Enough Clean Air to Breathe?
7 April 2000

48. Prof. Dr. Lee Chnoong Kheng
Green Environment, Clean Power
24 June 2000

49. Prof. Dr. Mohd. Ghazali Mohayidin
Managing Change in the Agriculture Sector: The Need for Innovative Educational Initiatives
12 January 2002

50. Prof. Dr. Fatimah Mohd. Arshad
Analisis Pemasaran Pertanian di Malaysia: Keperluan Agenda Pembaharuan
26 Januari 2002

51. Prof. Dr. Nik Mustapha R. Abdullah
Fisheries Co-Management: An Institutional Innovation Towards Sustainable Fisheries Industry
28 February 2002

52. Prof. Dr. Gulam Rusul Rahmat Ali
Food Safety: Perspectives and Challenges
23 March 2002

53. Prof. Dr. Zaharah A. Rahman
Nutrient Management Strategies for Sustainable Crop Production in Acid Soils: The Role of Research Using Isotopes
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Is the KLSE Efficient? Efficient Market Hypothesis vs Behavioural Finance
23 November 2002

62. Prof. Ir. Dr. Radin Umar Radin Sohadi
Road Safety Interventions in Malaysia: How Effective Are They?
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