Global Food Supply Chain Risks

Antibiotics and the emergence of antibiotic-resistant bacteria in the food chain

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Antibiotic-resistant bacteria are predicted to kill 10 million people every year by 2050.[1] No country will be immune as common pathogenic bacteria are rapidly becoming resistant to many of the antibiotics used in human health. The overuse and misuse of antibiotics in humans and the widespread use of 'antibacterial' products—together with the prolonged use of antibiotics in our animal production systems—has led to the inevitable emergence of antibiotic-resistant bacteria.

With the advent of antibiotics in the mid-20th century there came a sense of invincibility as they were hailed as being the be all and end all in treating bacterial infections. We now know that over time bacterial resistance has developed and the long-term efficacy of antibiotics is in question. There is little doubt that antibiotics would have been used much more judiciously in both humans and animals if this had been foreseen.

Resistance is a natural, evolutionary process involving random genetic mutations where bacteria with exposure to low levels of antibiotics eventually develop resistance against a specific antibiotic or group of antibiotics. The dilemma is that the more we use antibiotics, whether in humans or animals, the less effective they become.

Antibiotic use in animal production systems

The problem isn't simply that antibiotics have been used in animal production systems, it's the way they have been used over an extended period of time. The widespread use of antibiotics in animals started in the 1950's when it was discovered that a consistent, low-level dose of antibiotics administered to chickens in their feed had enormous production benefits. This discovery has underpinned cost-effective intensive animal production systems ever since.

Antibiotics continue to play a key role in animal production systems in three different ways:

- **Treating animals with acute bacterial infections (therapeutic use)**
- **Preventing infections (prophylactic use)**
- **Promoting growth by gut microbial flora modification (growth promotion)**

The therapeutic use of antibiotics in food-producing animals will continue into the foreseeable future as they still provide a cost-effective solution to acute disease management and ensure acceptable animal welfare standards are maintained. The continued use of antibiotics as growth promotants and prophylactics is coming under increasing scrutiny. In many developed countries they are being phased out entirely. However the total antibiotic volumes used worldwide both for human and animal use, is still forecast to increase by 40% between now and 2030.[2] This expected growth in consumption is due to the sheer increase in numbers of both food-producing animals and humans using antibiotics over that time. As the human population increases, so does the global demand for animal proteins as the world's developing countries become more affluent.
There are two distinct issues arising from the use of antibiotics in the food supply chain:

- **The presence of antibiotic residues in animal-derived foods**
- **The evolution of antibiotic-resistant bacteria**

Antibiotic residues

The presence of antibiotic residues in animal-derived foods has been a known human health risk due to low-level antibiotic exposure and also the potential issue of antibiotic allergies. These risks have been managed with regulations being set for Maximum Residue Limits (MRLs) in most countries. MRLs define the maximum concentration of a particular chemical or antibiotic permitted in food. The actual MRLs for various substances may vary between countries and the scale and rigour of the testing programs varies considerably. While raw milk is routinely tested for the presence of antibiotics, this is done primarily to manage a processing risk as antibiotic residues will inhibit the cultures used to manufacture yoghurt and cheese.

Multi-drug-resistant bacteria

The digestive system of all animals, including humans, is a complex myriad of micro-organisms. The vast majority of these are in fact beneficial to the host and only a few pathogenic bacteria cause disease. When antibiotics are used to treat disease in an animal or human most of the bacteria will be killed. However any bacteria resistant to the particular antibiotic survive and then multiply. E.coli is of particular concern as this pathogen is especially efficient in transferring antibiotic resistance across species[1]. The greater the variety of the antibiotics the bacteria is exposed to, the more resistant these bacteria become, hence the term multi-resistant bacteria or 'superbugs'. These bacteria can then be passed from food or the environment on to humans and are very difficult to treat. In some cases they fail to respond to existing antibiotics at all.

There are several ways multi-resistant bacteria can be transferred from animals to humans:

- The presence of antibiotic residues in animal-derived foods
- Direct animal-to-human transfer of resistance can occur from animals such as poultry and pigs that are in close contact with farm workers.
- Animal-to-human transfer of resistance can occur when animals are slaughtered and processed. The antibiotic-resistant bacteria in the animal's digestive system can contaminate the meat, this can then spread through cross-contamination to other foods or by consuming undercooked meat. By eating antibiotic-resistant bacteria in our food, we can transfer those resistant bacteria to our digestive system.[1]
- Foodborne infection outbreaks where antibiotic-resistant Salmonella and Campylobacter are known to cause an estimated 410,000 antibiotic-resistant infections in the United States alone each year.[3] Specific outbreaks of multi-drug-resistant Salmonella have been traced back to raw milk in the US in 1985, pork in Denmark in 1998[4], followed by ground beef and poultry[5] in the US in 2011, 2012 and 2013.

Antibiotics are also used extensively in aquaculture. Farmed fish production in Asia has increased dramatically with China now providing around 80% of the world's production of farmed shrimp and carnivorous fish.[2] Depending on the country of origin, farmed seafood is subject to varying levels of regulation. This has allowed a wide variety of antibiotics to be used in large quantities in some aquaculture operations. While the use of antibiotics in aquaculture has the potential to develop resistant bacteria in farmed fish and crustaceans, this resistance can also be transferred on to wild fish populations and to the water and sediments.[2]

While the issue of antibiotic resistance in animal and farmed seafood products is somewhat obvious, the same transfer of bacterial resistance can also occur between manure and soil, and then from that soil into plants. Antibiotic-resistant bacteria found in agricultural soils are a result of animal manure and effluents being sustainably re-used and applied to soils to fertilize crops and pastures. Up to 75% of an antibiotic dose can be excreted into animal manure[2] and the magnitude of this is compounded by the number of animals treated with antibiotics and the volume of manure applied as a fertilizer in any given area. If this soil is used to grow vegetables, antibiotic-resistant bacteria can be present in the vegetables at harvest. However the transfer of antibiotic resistance bacteria from fruits and vegetables to people has yet to be proven.[1]

Actions for the food industry

Reducing antibiotic resistance will require collaboration between primary producers, manufacturers, retailers, the pharmaceutical industry, regulators and consumers.

Alternate strategies will be required in animal production and aquaculture systems as the use of antibiotics for prevention of diseases and growth promotants is gradually phased out. This has already occurred in the EU.[2] However developing countries are still dependent on antibiotics as their other production practices—such as probiotics or intergrated preventative practices—generally lag behind those in developed economies.[2]

The poultry and pork industries in most developing countries have made significant changes to the way they use antibiotics through the use of vaccines, probiotics, modified feed and improvements in infection control strategies and production practices.

While most countries have formal MRL testing programs in place to detect antibiotic residues, there is little or no testing or screening processes for antibiotic-resistant bacteria in food as many countries do not have standards in place. Existing tests for the presence of antibiotic-resistant bacteria are costly and time-consuming. Foods such as fresh seafood have a short shelf-life and any delay in release for sale pending a microbiological test result may make this impractical.

Social media campaigns have recently targeted prominent fast-food chains demanding they cease the use of meat sourced from animals treated with antibiotics used in humans.[6] Similarly, consumer awareness of multi-resistant bacteria in food is likely to be the ultimate driver pressuring industry to address the problem.

Minimize the risk:

- Increase supply chain transparency and traceability to identify the true source of the food to expose the inherent risks unique to the country of origin.
- Carry out a thorough risk assessment based on:
  - Product type
  - Country of origin
    - Agricultural production systems used
    - Rigour of on-farm quality assurance programs
    - Strength of governing regulations and compliance to MRLs
    - Prevalence of resistant bacteria
- Identify and implement control measures:
  - Restrict the source of supply to approved suppliers
  - Know your suppliers and understand their animal production techniques and practices
  - Request compliance to rigorous primary producer assurance schemes which specify the use of registered agriculture chemicals, appropriate training, the maintenance of accurate chemical treatment records and a strict adherence to pre-processing withholding periods
  - Request certificates of analysis for antibiotic MRLs
  - Conduct independent analytical microbiological testing for resistant bacteria

Food retailers will also then exert pressure on supply chains to provide greater transparency around antibiotic resistance risks. Paddock-to-plate assurance schemes and certification bodies will be part of the mix to recognize and reward industry progress.

In the meantime, what can individual food companies reliant on global sourcing of animal derived products do to recognize and minimize the risks of both the presence of antibiotic residues and resistant bacteria?

Procurement functions in many food businesses have traditionally focused on cost and continuity of supply, however there are now a plethora of potential food safety risks to consider, identify and manage. As the threat of antibiotic resistance becomes more widespread—and with its potential for on-going human health impacts—food businesses need to carefully consider their brand reputation and future sustainability.

The risk posed to human health by antibiotic-resistant bacteria in animal-derived foods and potentially plant foods is serious and appears likely to worsen. It's time to get antibiotic resistance on the radar of your business. By managing the issue at the farm gate through the introduction of rigorous primary producer schemes, you can help manage antibiotic resistance in the food supply chain and deliver a better product to your customers.

References:

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Our services for the food sector include certification, training, assessment and supply chain solutions. Combined, they can help assure your customers and make your organization more resilient by enabling you to manage the risks and opportunities associated with your products, processes, people and respective supply chains.

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