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Safe Food Through Safe Feed

Ensuring safe food is paramount for the protection of human health and for enhancing the quality of life. Safe food plays an important role, whether domestically produced and consumed, imported or exported. In addition, the production of safe food represents an opportunity for income generation and market access. Over the last decades, the food chain approach has been recognized as an important step forward to ensure food safety from production up to consumption. This approach requires the commitment of all players in the food chain, involving producers, traders, processors, distributors, competent authorities as well as consumers.

In recent year's public concern about the safety of foods of animal origin has heightened due to problems that have arisen with Bovine Spongiform Encephalopathy (BSE), chemical contamination, outbreaks of food borne bacterial infections, as well as growing concern about veterinary drug residues and microbial resistance to antibiotics. These problems have drawn attention to feeding practices within the livestock industry and have prompted health professionals and the feed industry to closely scrutinise food quality and safety problems that can arise in foods of animal origin as a result of animal feeding systems.

Coupled with this is the increasing interest in 'natural alternatives' to chemical and pharmaceutical products. The role of animal feed in the production of safe food is also recognized worldwide, and several events have underlined its impact on public health, feed and food trade, and food security.

Threats to food safety

The World Health Organization (WHO, 1996) notes the following reasons for the increased prevalence of emerging food borne diseases:

- The globalization of the food supply.
- Travellers, refugees, and immigrants exposed to unfamiliar foodborne hazards while abroad. International travellers may become infected by foodborne pathogens that are uncommon in their countries. For eg. About 90% of all cases of salmonellosis in Sweden are imported.
- Changes in microorganisms. Changes in microbial populations can lead to the evolution of new pathogens, development of new virulent strains in old pathogens, development of antibiotic resistance that might make a disease more difficult to treat, or to changes in the ability to survive in adverse environmental conditions.
- Change in the human population. The population of highly susceptible persons is expanding world-wide because of ageing, malnutrition, HIV infections and other underlying medical conditions. Age is an important factor in susceptibility to foodborne infections because those at the extremes of age have either not developed or have partially lost protection from infection. Particularly for the elderly, foodborne infections are likely to invade their blood stream and lead to severe illness with high mortality rates. People with a weakened immune system also become infected with foodborne pathogens at lower doses which may not produce an adverse reaction in healthier persons. Seriously ill persons, suffering, for example, from cancer or AIDS, are more likely to succumb to infections with *Salmonella, Campylobacter, Listeria, Toxoplasma, Cryptosporidium*, and other foodborne pathogens. In developing countries reduced immunity due to poor nutritional status render people, particularly infants and children, more susceptible to foodborne infections.
- Changes in lifestyle. Greater numbers of people go out and eat meals prepared in restaurants, canteens, fast food outlets, and by street food vendors. In many countries, the boom in food service establishments is not matched by effective food safety education and

control. Unhygienic preparation of food provides ample opportunities for contamination, growth, or survival of foodborne pathogens.

Areas leading to Food hazards

1. Bacterial infections

Salmonella

Crump et al. (2002) cited the emergence of *S. enterica* serotype Agona infections in humans in the United States as an example of human food borne bacterial infections traced to contaminated animal feed. It is among the top 10 most frequently isolated *S. enterica* serotypes from human infections. An epidemiologic study identified the source of these *S. enterica* serotype Agona infections as chicken meat originated from poultry facility where Peruvian fish meal was used as a feed ingredient (Clark et al. 1973; Crump et al. 2002). Crump et al. (2002) estimated that since the introduction of *S. enterica* serotype Agona in poultry feed in 1968, this serotype has likely caused over 1 million human bacterial illnesses in the United States.

Based on the assumptions that food-production animals are the source of 95% of human nontyphoidal Salmonella cases and that 10% of food-production animals are infected by Salmonella spp. through the ingestion of contaminated animal feed, it has been estimated that approximately 134,000 cases of human nontyphoidal salmonellosis (including 55 deaths and 1,560 hospitalizations) could be attributed to contaminated animal feed each year (Angulo 2004).

2. Antibiotic-resistant bacterial infections

The use of antibiotics in animal feed is also a public health concern. Antibiotics are administered at non therapeutic levels in feed and water to promote growth and improve feed efficiency. Eighty-five percent of all feed ingredients sampled contained bacteria resistant to one or more of the following four antibiotics: ampicillin, amoxicillin, clavulanic acid, and cephalothin. Poultry meal and MBM (non-poultry) samples represented the greatest number of feed ingredient samples containing bacteria resistant to five or more antibiotics (Hofacre et al. 2001).

Similar to the challenge of determining whether human bacterial illnesses are associated with contaminated animal feed, there are insufficient data available to determine the percentage of antibiotic-resistant human bacterial infections that are attributed to animal feeding practices versus practices and behaviors occurring in human clinical settings.

There is evidence that antibiotic-resistant bacteria can be transmitted from swine and poultry to humans (Aarestrup et al. 2000). Sorensen et al. (2001) reported that after the ingestion of antibiotic-resistant *Enterococcus faecium* originating from contaminated chicken and pork, the resistant bacterium can be isolated from the stool of infected individuals for up to 2 weeks, indicating that antibiotic-resistant *E. faecium* can survive and multiply in the human gastrointestinal tract.

In addition, there is strong temporal evidence suggesting that some domestically acquired antibiotic-resistant bacterial infections in humans emerged in the United States only after the approval of specific human antibiotics for use in animal feed or water. For example, prior to 1985 there were little or no fluoroquinolone-resistant *Campylobacter jejuni* isolated from either poultry or humans in the United States (Smith et al. 1999). However, post FDA approval (1995) fluoroquinolone-resistant *C. jejuni* were detected in both poultry and human isolates. The Minnesota Department of Health completed an analysis of *C. jejuni* isolates from humans and retail poultry products and found that the proportion of fluoroquinolone-resistant *C. jejuni* isolated from humans increased from 1.3% in 1992 to 10.2% in 1998 (following the 1995 fluoroquinolone approval) (Smith et al. 1999).

3. Agricultural and other chemicals

Potential contaminants in feedstuffs include excessive residues of pesticides and fungicides, or other environmental contaminants such as the polychlorinated biphenyls (PCBs), dioxins and heavy metals including mercury, lead, or cadmium.

Dioxins and PCBs are ubiquitously present in the environment and its humn exposure is mainly through dietary intake. PCBs and dioxins are both lipophilic and persistent compounds that accumulate in the food chain. Foods of animal origin are the greatest source of human exposure to these contaminants and animal feeds may be an important source of contamination for livestock. Contaminated fats or oils added either intentionally or unintentionally to manufactured feeds can be a source of dioxins and PCBs. These industrial pollutants may be emitted into the air contaminating soil and water and remaining deposited on pastureland. In this case grass-fed animals in highly contaminated areas may give rise to unsafe food products. Fish oils used as animal feed ingredients may contain high levels of lipid-soluble contaminants if they are produced from fish grown in polluted areas.

Foetal exposure to dioxins and/or PCBs might be associated with cognitive deficits in infants and children. An increase in tumour incidence, as well as neurological, endocrine, hepatoxic and immunotoxic effects were observed in populations accidentally exposed to high levels of PCBs, polychlorinated dibenzofurans and polychlorinated quaterphenyls. Maximum levels of these contaminants allowed in foods of animal origin have been established in some countries, but existing limits are quite variable.

4. Heavy metals: Arsenic

Inorganic As^{III} and As^{V} are known human carcinogens, hence there is considerable concern regarding human exposures to these compounds. Lasky et al. (2004) study indicated that individuals who consume average amounts of poultry (60 g/day) could ingest 1.38–5.24 µg/day of inorganic arsenic from the ingestion of poultry alone. (FAO)/WHO Expert Committee on Food Additives (2 µg/kg/day) (WHO 1983).

Animal feeds have been modified to include ingredients ranging from rendered animals and animal waste to antibiotics and organoarsenicals. The most commonly used organoarsenical, roxarsone (4-hydroxy-3-nitrobenzenearsenic-acid), is administered to feeds at concentrations ranging from 22.7 g/ton to 45.4 g/ton to promote growth and improve feed efficiency (Chapman and Johnson 2002). When used in combination with ionophores, roxarsone also act as a co-coccidiostat to control intestinal parasites (Chapman and Johnson 2002). Once roxarsone is ingested by animals, the parent compound can be degraded into inorganic arsenite (As^{III}) and inorganic arsenate (As^{V}) in animal digestive tracts and animal waste (Arai et al. 2003; Stolz et al. 2007).

5. Mycotoxins

The frequency of mycotoxin contamination of poultry feeds appears to be on the increase globally. This is a serious threat, since complex poultry rations are highly susceptible. As a result, such contamination can seriously affect bird performance. Proper measures are needed to minimise losses.

The most significant species of mycotoxin-producing fungi that have an impact on poultry production would include Aspergillus and Fusarium. The most significant mycotoxin produced by Aspergillus fungi are the aflatoxins. Aflatoxin is a potent hepatocarcinogen in humans. Another important mycotoxin is the nephrotoxin ochratoxin A. As with aflatoxin, there is concern that residual ochratoxin A in poultry products could pose a threat to human health due to the possible carcinogenic nature of this compound. It can accumulate in meat of animal. But trace levels of ochratoxin A in pork and poultry samples were likely to pose insignificant risks to consumers (Guillamont et al. 2005; Jorgensen 1998).

Mycotoxins, or their metabolites, can be detected in meat, visceral organs, milk and eggs. Their concentration in food is usually considerably lower than the levels present in the feed consumed by the animals and unlikely to cause acute intoxications in humans. However residues of carcinogenic mycotoxins, such as aflatoxin B_1 and M_1, and ochratoxin A, when present in animal products pose a threat to human health, and their levels should be monitored and controlled.

Monitoring these hazards through Better Livestock production

1. Alternate ways to produce Animal origin food:
   a. Change from intensive housing to open rearing
   b. Switch to organic farming
2. Banning of Usage of Antibiotics and related chemicals.
   a. Utilisation of AGP alternatives.
   b. Application of strict biosecurity measures
3. Safeguarding Livestock from exposure to Mycotoxins and other industrial toxins.
   a. Scrutinizing feed ingredients.
   b. Adopting nutritional strategies to reduce Mycotoxins load
4. Adopting Good manufacturing practices.

Alternate ways to produce animal origin food

1) Change from Intensive housing to open rearing system

The conventional cage production system is still the predominant system worldwide for housing laying hens. However, ethical concern about the degree of restriction of the hens' behaviour and movement in conventional cages has led to an increasing movement towards alternative systems. Some of this is driven by consumer purchasing preferences, and some by legislation (European Union).

Poultry raised on pasture are processed on-farm and direct marketed, creating supplemental income on small diversified family farms. The main reason for the superior taste is considered to be the use of slow-growing birds instead of the fast-growing birds used in the conventional industry. The slow-growing birds are from specialty “rustic” genetic stock and are harvested close to sexual maturity. The meat is flavorful and firm, but not tough. Slower-growing breeds are more suited to outdoor production than the existing broiler breeds. Keggfarms group in North India is developing similar genetics and offers Free Range dual purpose parents (Kuroilers). The use of slow-growing genetics and the low density production system offer distinct health advantages—ascites, leg problems, and sudden death is minimal, and birds have good immunity.

The switchover to alternate systems is not rosy either. It has its own share of difficulties.

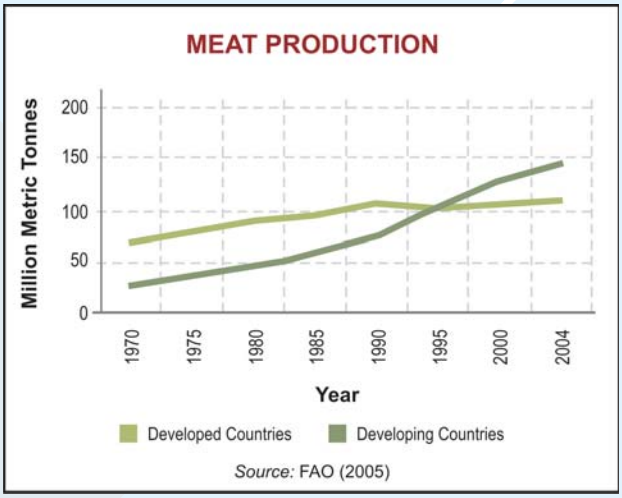
The farmers changed to this type of housings face problems like

1. Poor Air quality, which can affect health and hygiene, which is relevant not only for hen welfare but also for food safety.
2. The large amount of litter and the greater bird movement result in higher microbial concentrations in the air and in dust compared with conventional and furnished cage systems. Greater dust concentrations have been associated with more serious pulmonary lesions, typical of chronic bronchitis, in cage-free birds (Michel and Huonnic, 2003).
3. Stronger inflammatory reaction and increased bronchial responsiveness have been found in humans working in these farms.
4. Additional biosecurity risks and increased risk of predation.
5. Increased feather pecking and increased cannibalism.

(Source: Ohio state university fact sheet)

Achieving large scale operations in alternate rearing systems is difficult. The human population is growing at faster pace. FAO and other institutions suggests that global meat production and consumption will rise from 233 Million tons(2000) to 300 million tons in (2020), Milk from 568 to 700 million tons and eggs by 30%. These predictions show a massive increase in animal protein demand, needed to satisfy the growth in the human population and the increasing affluence of growing economies such as China, Brazil and India.

The graph below also shows the shift of animal production from developed countries towards developing nations. These types of pressures will always hamper the alternate ways of livestock production; nonetheless the developed economies will still favour the cage free rearing.



Switch to organic farming

To reduce the impact of food borne diseases, the shift towards organic farming is growing. Organic farmers never use antibiotics, or synthetic hormones or pesticides in production. For chickens, organic management starts the first day out of the egg. Birds are fed only certified organic feed and no genetically modified organisms (GMO's). All spices and ingredients used in products are approved for organic processing.

Eating organic chicken is an excellent way of minimizing risk of exposure to antibiotics and synthetic pesticides, as well as the harmful bacteria that are more likely to be found in meat produced in confined animal feeding operations (CAFO's). Lean organic chicken is a very good source of high density, low fat protein, and a good source of selenium, zinc, niacin, Vitamin E, beta carotene, and Vitamins B_6 and B_{12} Organic meat is the safest choice because it comes from healthy animals raised on healthy land.

2) Banning of Usage of Antibiotics

Through genetic improvements, the productivity of broilers has improved significantly. While this is a good thing for the poultry industry, increased rearing density has concentrated and increased disease challenges making birds more susceptible to various pathogens especially enteropathic microbes such as E. coli, Salmonella spp., *Clostridium perfringens* and Campylobacter spp.

This increased susceptibility has resulted in the use of antimicrobial growth promoters which are primarily used to enhance gut health and control sub-clinical challenges. With increasing public concerns about bacterial resistance to antibiotics, the use of antibiotics in therapeutic or sub-therapeutic doses in poultry feed has been severely limited or eliminated in many countries.

The banning of drugs for growth promotion led to decrease in the selective pressure that favours the occurrence of resistant bacteria in the animal gut. This led to reduction in occurrence of AGP resistant bacteria in foods and was followed by a similar reduction in human carriage of enteroccoci resistant strains. The Denmark study highlights the importance of non addition of AGP in the animal feed. Fig.2

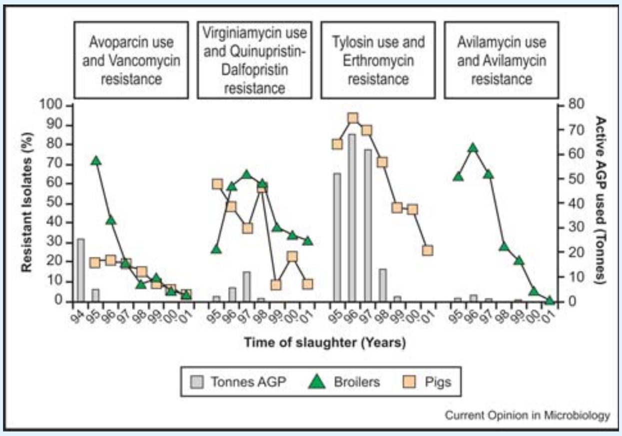


Fig. 2: **Volumes of active AGP used in food-animals in Denmark and prevalence of Enterococcus faecium resistant to important drugs in stool samples from healthy animals at slaughter 1995-2001.**

Data from DANMAP 2002. (Adapted from Wegener, 2003).

After the gradual decrease in usage of AGP in European Union, the mortality of farm animals has risen by 2%. The feed conversion ratio has been worsened after the ban as shown in the Fig.3.

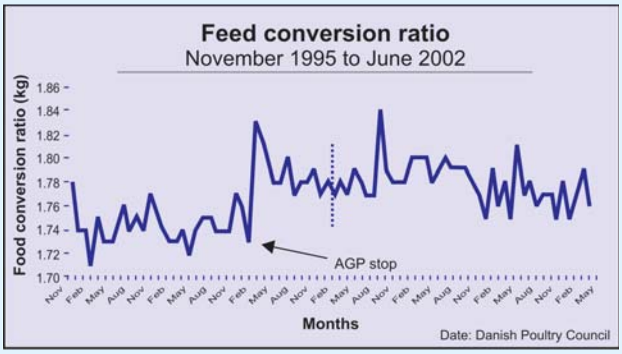


Fig.3: **Mean Monthly Feed Conversion ratio of Broiler (Danish Poultry Council)**

Alternatives to Antibiotics

There has long been interest in finding alternatives to antibiotics for poultry production. Resident microbes in the birds' digestive tract have a profound effect on some of the physiological processes of their host. With this in mind, it is important to understand the dynamics of the intestinal microbial ecology of the chicken to find alternatives to antibiotics. Under normal circumstances there is a delicate balance of beneficial and pathogenic bacteria in the gastrointestinal tract (GIT). This is influenced by symbiotic and competitive interactions and relationships. The microbial communities will not only protect the GIT but also enhance productivity in the host.

The prominent alternates for usage of antibiotics are:

1. Organic acids
2. Probiotics
3. Prebiotics

Organic acids have been used in feed preservation, protecting feed from microbial and fungal contamination. The antibacterial activity of organic acids is related to reduction of pH. The undissociated acids are lypophilic and easily enter the bacterial cell, once they are inside the cell; the acid releases the proton and decreases the intracellular pH. Bacteria try to normalize the pH and in its effect exhaust all its energy leading to bacterial cell death.

Probiotics have been defined as 'a live microbial feed supplement which beneficially affects the host animal by improving its intestinal balance' (Fuller, 1989). The probiotic mode of action is by 'competitive exclusion', meaning there is competition for attachment sites in the GIT. The bacteria of the probiotic attach to the intestinal mucosa, thereby forming a physical barrier that blocks the attachment of pathogenic bacteria (Furlan, 2005). They also produce antibacterial compounds and enzymes and stimulate the immune system.

Prebiotics are defined as non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and activity of one or a limited number of bacteria in the colon (Gibson and Roberfroid, 1995). The most common prebiotics are oligosaccharides, which are non-digestible carbohydrates. The way in which prebiotics act is by (1) supplying nutrients to beneficial microbes, or (2) tricking pathogenic bacteria into attaching to the oligosaccharide rather than to the intestinal mucosa. This reduces the intestinal colonization thereby decreasing the incidence of infection in the birds. Because the oligosaccharide is non-digestible, the microbes that are attached will travel along the GIT with the ingesta, and are excreted from the bird along with other undigested food.

Various organic acids as well as probiotcs and prebiotics are being used to see the beneficial effects by various additive manufacturers. The combination products have shown better response as compared to single one.

A synergistic composition comprising, SCFA (butyric cid) and a oligo-saccharide (prebiotic) compound has been found to act throughout the entire GIT by causing a reduction in entire gut pH, pathogenic bacterial count and improvement in beneficial microflora. The two ingredients are believed to generate Butyric Acid and other VFA in the lower intestine of a chicken, which complements the organic acid, simultaneously encouraging the growth of beneficial bacteria in the lower intestine. This thereby synergistically increases the rate of weight gain and/or feed utilization of the chicken.

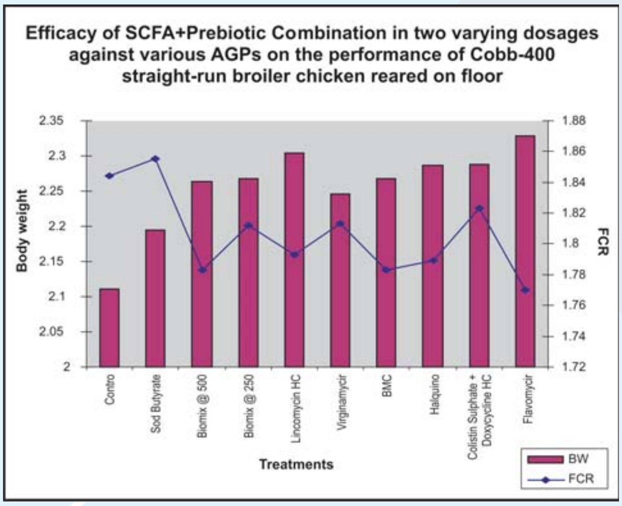
Effect of Acidifier and Prebiotic combination on Broiler Performance

Treatment	42 day BW	FCR	Mortality %	EPEF
Control	2470	1.794	0.74	325
Control + Na Butyrate	2620	1.725	1.48	356
Control + Prebiotic	2633	1.724	2.22	356
Control + Na Butyrate + Prebiotic	2668	1.709	0.74	369

Source: Nutrisys Centre for Animal Nutrition

The same combination was also tested along with various antibiotic growth promoters used. The results showed that the combination performed at par with various antibiotics. The advantage with the combination was it causes no residues in the meat and maintains eubiosis in the gastrointestinal tract of the birds.

A product as this may be considered as a safe alternative to antibiotic growth promoters.



3. Safeguarding Livestock from exposure to Mycotoxins and other industrial toxins.

Worldwide, approximately 25% of crops are affected by mycotoxins annually (CAST, 1989), Mycotoxins occur frequently in a variety of feedstuffs and are routinely fed to animals. Sometimes, Mycotoxins occur at concentrations high enough to cause major losses in health and performance of animals. However, a more likely scenario is to find mycotoxins at lower levels interacting with other stressors to cause sub-clinical losses in performance, increases in incidence of disease and reduced reproductive performance. To the animal producer, these sub clinical losses are of greater economic importance than losses from acute effects, but even more difficult to diagnose.

Various nutritional strategies can be adopted to minimize the effect of Mycotoxins;

- **Crude Protein**: Helped to alleviate but did not eliminate the adverse effects of ochratoxin A on body weight and feed conversion.
- **Methionine supplementation**: Incresing the dietary total sulphur aminoacids to level in excess of NRC, protected chicks from the growth depressing effects of aflatoxins by detoxification by Glutathione, a sulphur amino acd metabolite.
- **Dietary Lipids**: Diets contaning higher levels of linolenic acid supported better feed conversion and lower mortality in chicks fed diets with aflatoxin.
- **Adsorbents**: Sorbent act by reducing the bioavailability of mycotoxins by adsorption on their surface. Indeed, if a stable sorbent mycotoxin complex in the GIT can be reduced, decreasing both toxic effects for the animal and carry over in animal products for human consumption. The use of an appropriate mycotoxin adsorbent is likely the best short-term strategy available for minimising the adverse effects of feed-borne mycotoxins in poultry feeds.
- **Nucleotide**: Studies were performed on poultry and pigs, fed either a standard ration, or one with supplemented nucleotides. The results showed that the livers of the animals fed additional nucleotides had significantly lower levels of mycotoxins than those fed a standard ration. The supplementation of nucleotides will increase the resistance to bacterial infections in animals and humans.

4. Adopting Good manufacturing practices.

Good Manufacturing Practices will seek to minimize chemical and biological contaminants in livestock feeds and prevent them from entering the food chain. These include industrial chemicals, infectious agents (Salmonella, E. coli, Campylobacter, viruses, the BSE agent, etc.) and parasites. Medications and other chemicals given in feeds are a source of residues if proper precautions are not taken to insure that the right feed is produced for the right livestock with medications at the right dosage. Improper processing/mixing of feeds could contain improper levels of chemicals (including medications) and minerals. Improper maintenance of processing and measuring equipment could result in feed residues. Improper distribution and cross-contamination between batches of feedstuffs and handling equipment that could result in feed residues.

A producer should strive to use management practices that will eliminate or reduce the need for medications. For example, proper drainage and properly designed watering facilities will reduce the incidence of foot rot, the need for treatment and the subsequent possibility of chemical residues in beef. Another example is the use of antibacterial in livestock feeds. Frequently, this use can be reduced by properly managing the environment where livestock are produced.

Water quality and safety can also be considered as a good sanitation practice. While some diseases can be controlled through vaccination programs, many diseases, especially diseases of the intestinal tract, can best be controlled through effective sanitation programs. Good sanitation practices will reduce the need for livestock treatment procedures and the subsequent risks of residues that could be found in livestock food products.

Conclusions

Food safety is an important consideration for the livestock industry. Whilst maintaining efficiency in farm production, due importance needs to be given to the quality of food being produced.

The shift in the livestock production too alternate housing and organic farming is gradually happening in developed nations mainly because of consumer demands and or by legislation, but it lacks the scale to satiate the protein demand of growing populations. The shift in livestock industry production from developed nation to developing nation is the proof of the same.

Since humans are at the top of the food chain, we're vulnerable to pathogens, drugs, and contaminants consumed by the animals we eat. The developing nations will also feel the pressures experienced by developed nations in terms of animal welfare and food safety. This is the right time to align productivity with measures like using alternates for antibiotics, harmful chemicals and adopting good manufacturing practices.

References are available with author and can be made available on request.

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