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How Safe is Our Product – Beef? Do We Have a Story to Tell?

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HOW SAFE IS OUR PRODUCT--BEEF? DO WE HAVE A STORY TO TELL?

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INTRODUCTION

Americans are vitally concerned about the safety of their food supply. Agriculture is likewise concerned about the safety of its products. In fact, the agricultural community agrees that, along with the environment, diet/health, and animal welfare, food safety is a major issue as we approach the 21st century.

Confidence in our food supply was eroded by the alar/apples and cyanide/grapes calamities in February and March of 1989. As the Food Marketing Institute (FMI) survey data in Table 1 illustrate, public confidence in food safety, once shaken, is slow to rebuild.

Table 1. Consumer confidence in food safety[a]

Time period	Completely or mostly confident, %
January, 1989	81
(Feb. 26, "60 Minutes", Alar apples)	--
(Mar. 12, cyanide-injected grapes)	--
August, 1989	67
January, 1992	72
January, 1995	77

[a]FMI Surveys (1989-1995).

REGULATION OF ANIMAL PRODUCT SAFETY

Three government agencies are involved in the safety of animal products that enter the U.S. food supply:

1. Environmental Protection Agency (EPA)
2. Food and Drug Administration (FDA)
3. USDA's Food Safety and Inspection Service (FSIS)

EPA

EPA regulates pesticides that can be used in food production as well as other industrial chemicals that have the potential for contaminating food. Included among its duties is that of establishing tolerance levels for pesticides and other chemicals used in growing food.

FDA

FDA regulates animal drugs, including feed additives, and environmental contaminants. It is charged with the responsibility of determining in a very rigorous scientific manner whether or not drugs can be introduced into the market. This includes establishing tolerance levels (safe concentrations) for residues of animal drugs in edible tissues.

In establishing a safe concentration for a non-carcinogenic drug residue, FDA determines the highest daily level at which the drug causes no observable effect in lab animals (NOEL). An acceptable daily intake (ADI) is then determined by dividing the NOEL by a factor ranging from 100 to 1000 to account for possible differences between animals and humans and for individual variation among humans. Establishing a safe concentration for a carcinogenic drug entails a much more conservative approach than for non-carcinogens because the level of daily exposure must result in no more than a 1 in 1 million risk of developing cancer over a human lifetime of exposure.

USDA/FSIS

FSIS is responsible for the wholesomeness and safety of meat and poultry (whereas, FDA is responsible for foods other than meat and poultry). As part of its responsibility, FSIS has since 1967 conducted the National Residue Program (NRP). Under the NRP, FSIS samples and tests food animals and meat and poultry products to ensure the safety of such products. FSIS also enforces the residue limits in meat and poultry set by FDA and EPA.

Selection of compounds to be included in NRP is based upon a system that addresses the risk of residues as a function of two major elements: (1) degree of hazard; and (2) degree of exposure. Tissues that are sampled vary according to the compounds being tested. Included in NRP are samples from liver, kidney, muscle, fat, and urine.

When NRP was initiated in 1967, only 1000 analyses were conducted. Most of them were on a few antibiotics and the remainder were on chlorinated hydrocarbons. By 1990, a total of 1.5 million analyses were conducted on 133 compounds.

NRP consists of two basic programs: (1) Monitoring; and (2) Surveillance.

Monitoring Program

The primary objectives of the Monitoring Program are: (1) to detect violative residue levels; (2) to provide profile information on the incidence of residue violations on an annual, national basis.

The basic approach is to sample each species at a rate that will provide a 95% probability of detection of at least one violation when 1% of the animal population is violative.

Surveillance Program

Animals are sampled under the Surveillance Program because there is some indication, such as marks left by a drug injection, that the animal may contain violative concentrations. Animals suspected of being diseased also may be sampled. Because this

program is obviously biased in its design, the violative residue rates are not representative of the national situation. Only Monitoring Program data can be used as an indication of national violative rates.

The following sections will discuss the primary concerns involved in the safety of the U.S. beef supply.

ANABOLIC STEROID IMPLANTS

Hormone Levels in Beef

Implanting results in a physiologically insignificant increase in the hormone content of beef tissue. For example, beef muscle from an implanted steer contains 0.022 nanograms per gram (ng/g) of estrogen compared to 0.015 ng/g in the muscle of a non-implanted steer. Typical 3 oz. servings would contain 1.9 and 1.3 ng of estrogen, respectively. In either case, these are extremely low levels when compared with the estrogen content of other common foods and estrogen levels produced daily in the human body (Table 2).

Table 2. Estrogen content of various foods and estrogen levels produced daily in humans

Item	Estrogen level, nanograms
Estrogen content of various foods (3 oz. serving)	
Beef from non-implanted steer	1.3
Beef from implanted steer	1.9
Milk	11
Potatoes	225
Peas	340
Ice cream	520
Wheat germ	1700
Cabbage	2000
Soybean oil	170,000
Estrogen produced daily in the human body	
Male child, before puberty	41,000
Female child, before puberty	54,000
Adult male	136,000
Non-pregnant female	480,000
Pregnant female	20,000,000

Carcinogenic Risk

The simplest definition of a carcinogen is: any agent that increases the age– standardized risk of cancer development in a defined population of laboratory animals or humans. Using this definition, the sex hormones can be technically classified as carcinogens. However, research has shown they are not "tumor initiators." Tumor initiators are classified as such because they alter the genetic material (DNA) of cells. The sex hormones may stimulate the proliferation of cells which have previously been altered by a tumor initiator. Consequently, they are classified as

"tumor promoters," which should not be confused with tumor initiators. As shown in Table 3, the sex hormones exhibit a very low Covalent Binding Index (CBI), a measure of DNA-binding potential, which in turn is a measure of initiation.

Table 3. Covalent Binding Index (CBI) of hormonal growth promotants[a,b]

Growth promotant	CBI[c]
Estradiol	11.4
Zeranol	8.5
Trenbolone acetate	5.6
Testosterone	4.8

[a]Rico and Burgat-Sacaze (1983).
[b]CBI is a measure of carcinogenicity.
[c]Strong=over 1,000; Moderate=100 to 1,000; Weak or none=10 to 100.

ANTIBIOTICS AND OTHER ANTIMICROBIAL DRUGS

A total of nine antibiotics and four sulfonamides are tested in the National Residue Program: chlortetracycline, erythromycin, gentamicin, neomycin, oxytetracycline, penicillin, streptomycin, tetracycline, tylosin, sulfachlorpyridazine, sulfadimethoxine, sulfamethazine, and sulfathiazole.

Antimicrobial Residues in Beef

In the most recent summary of the National Residue Program (1993) there were no antimicrobial residues reported for slaughter bulls, feedlot steers, or feedlot heifers. In beef cows, the violative rate was only 0.15%, which is well below the 1% rate that FSIS generally considers to be unacceptable. However, the violative rate for dairy cows was 1.34%; two-thirds of the violations consisted of gentamicin and/or sulfadimethoxine residues.

In formula-fed veal calves, the violative rate was only 0.19%. The veal industry has come a long way since 1988, when its violative rate for antibiotic residues was 3.2%. The story is different for Bob calves, whose violative rate in 1993 was 1.64%, not much different than it was 5 years earlier. The antimicrobial violative rate for all other classes of calves was 0.66%.

The Antibiotic Resistance Controversy

There is some concern among public health professionals that using antibiotics in animal production poses a human health risk. The controversy has focused on those drugs which are cleared for both human and animal use, primarily penicillin and the tetracyclines. There are three principal issues that have been raised:

(1) Do antibiotic residues in meat consumed by humans cause development of resistant bacteria in the human body?
(2) Are antibiotic-resistant bacteria more virulent than non-resistant, sensitive bacteria?

(3) Does feeding of antibiotics to animals increase levels of disease-resistant bacteria which may be transferred to humans via contaminated meat, thereby resulting in illness?

First, there is no research on whether antibiotic residues in animal products result in more resistant bacteria in humans consuming these products. However, it is highly improbable that these extremely low residue levels could bring about a shift in the bacterial population to more resistant strains.

Second, available evidence suggests there is little or no difference in virulence between resistant and sensitive strains.

Third, the use of antibiotics does appear to increase the proportion of resistant bacteria in the animal's body. However, the transfer of resistant bacteria from animals to humans, resulting in illness, has not been established.

Finally, a distinguished committee of scientists representing the Institute of Medicine, National Academy of Sciences, reached the following conclusion: "Using all available resources, the committee was unable to find direct evidence of a human health hazard in the use of antibiotics in animal feeds; much of the available data are primarily circumstantial, often ambiguous and sometimes conflicting."

PESTICIDES

A total of 24 pesticides are tested in the National Residue Program. They consist of two classes of compounds, chlorinated hydrocarbons and organophosphates. Although pesticide residues are viewed by the public as a major health threat, their prevalence in the human food chain is very low. For cattle and calves, there were only two violations out of a total of 4,032 samples (0.05%) in the National Residue Monitoring Program.

OTHER CHEMICALS

Ivermectin

The parasiticide, ivermectin, is the most widely sold animal drug in the U.S. In 1993, there were nine violations out of 2,176 samples (0.41%). Eight of the nine violations were in calves; the remaining violation was in a steer.

Levamisole

Levamisole is a widely used deworming drug. Out of 3,260 samples in 1993, there were no violations in any of the classes of cattle and calves.

SUMMARY OF NATIONAL RESIDUE PROGRAM

Total violative rates for all chemicals in all species and in all classes of cattle and calves

in the 1993 National Residue Monitoring Program are presented in Table 4. These data clearly indicate that there are very few chemical residues in beef originating from bulls, beef cows, heifers, steers or formula-fed veal calves. As noted before, antimicrobial residues in Bob calves and cull dairy cows represent a significant problem.

Table 4. Total violative rates for all chemicals in all species and in all classes of cattle and calves tested in 1993 National Residue Monitoring Program[a]

Species/class	Violative rate, %
Swine	0.20
Poultry	0.15
Sheep and lambs	0.21
Goats	0.33
Horses	1.63
Cattle and calves:	
Bulls	0.00
Beef cows	0.06
Dairy cows	0.54
Heifers	0.00
Steers	0.09
Bob calves	1.64
Formula-fed veal calves	0.11
Other calves	0.43
Average, all cattle and calves	0.25
Average, all species	0.26

[a]FSIS (1993).

OTHER RESIDUE RESEARCH

Colorado State University

Colorado State University researchers (Smith *et al*., 1994) conducted extensive analyses of beef tissues for residues of 41 chemicals for which testing is required in order to sell muscle or organ meats to the European community. A total of 1,780 tests were conducted for 25 pesticides, 6 sulfonamides, 4 anabolic steroids, 2 tranquilizers, 2 environmental contaminants, 1 beta-agonist, and 1 beta-blocker. Samples were taken from steers, heifers and cows from 8 packing plants in 4 states. The incidence of violative residues was zero. The authors concluded that U.S. beef is unlikely to contain levels of chemicals considered to be potential hazards to public health.

Causes of Drug Residue Violations

Causes of violative animal drug residues are shown in Table 5. Clearly, the major cause is failure to adhere to approved withdrawal times. More recent research has confirmed this finding.

Table 5. Causes of animal drug residue violations[a]	
Cause	% of total violations
Failure to observe withdrawal times Use of an unapproved drug Improper medication records All other	51% 17% 12% 20% 100%
[a]Paige and Kent (1987).	

Injection Site Lesions

In response to complaints from steak cutter establishments and major retailers across the U.S., the National Cattlemen's Association (NCA) began an audit of top sirloin butts in 1991. The initial audit in March 1991 yielded some alarming data. As a result of intramuscular injections of pharmaceuticals and/or vaccines into the rump region, there was a 22.3% incidence of lesions in top sirloin butts; 14.2% were active, fluid-filled abcesses while the remaining 8.1% consisted of non-active scars. The average amount of tissue trimmed per lesion was 12.9 oz. NCA's Beef Quality Assurance Task Force immediately launched an educational program with the objective of encouraging cattlemen and veterinarians to move injections from the rump area to other sites and to use subcutaneous rather than intramuscular injections whenever possible. Animal health companies responded by developing products which could help fulfill these recommendations. By March 1993, injection site lesions had fallen to 9.8%. Unfortunately, the March 1994 audit revealed that the incidence had risen back up to 15.3%. Again, an exhaustive effort was made by the beef industry to reduce this level. By July 1995, the incidence had dropped back to 10.2%.

Why are injection site lesions a problem to the industry? Research has shown they are not a human health hazard because the lesions do not contain violative residues or bacterial pathogens. However, they represent an economic loss, which was shown to average $1.74 per carcass in the 1991 Beef Quality Audit. Furthermore, they represent a consumer acceptability problem for two reasons: 1) fluid-filled lesions are repulsive; and 2) research has shown that muscle fibers within 3 inches of an injection site scar are significantly tougher than those in other regions of the muscle. Moreover, these scars can appear in steak meat even if calves had been injected as early in life as the preweaning period.

FOODBORNE BACTERIAL PATHOGENS

Food scientists and health experts have long recognized that bacterial pathogens far and away represent our greatest food safety risk and that other factors such as environmental contaminants, naturally occurring toxicants, chemical residues and food additives rank a distant second. However, until recently, the U.S. public has generally ranked bacterial pathogens no higher than fourth among this list of five food safety risks. The public's attitude toward bacteria-related food poisoning shifted significantly in the aftermath of the tragic outbreak of *E. coli 0157:H7* infection from under-cooked hamburger in the northwest in early 1993, which resulted

in approximately 500 cases and four deaths. In FMI's 1995 consumer survey (Table 6), bacterial contamination was rated as the highest concern among a list of eight food safety attributes.

Table 6. Consumer concern about selected food attributes (1995)[a]

Attribute	% of shoppers rating the attribute as a serious hazard
Bacterial contamination	76
Pesticides and herbicides	74
Product tampering	58
Antibiotics and hormones in meat & poultry	52
Irradiated foods	30
Nitrites in foods	28
Additives and preservatives	22
Foods produced by biotechnology	14

[a]FMI (1995).

The incidence of foodborne illness in the U.S. is a staggering 24 to 33 million cases per year. This means that about 1 in 10 persons in the U.S. experiences a food-associated illness each year. Interestingly, most cases go unreported. Deaths have been estimated at 6,000 to 9,000 annually. Estimates of total cost (mortality, treatment, lost work time, etc.) range from $4.8 to $8.4 billion per year. The Centers for Disease Control (CDC) have determined that 92% of the diagnosed cases of foodborne illness are caused by bacterial pathogens. The remaining causes are viruses, 5%; chemical agents, 2%; and parasites, 1%. Factors contributing to foodborne disease outbreaks are: improper holding or storage temperature, 87%; poor personal hygiene, 59%; inadequate cooking, 56%; contaminated equipment, 47%; food from unsafe source, 20% (factors do not total 100% because some outbreaks involve more than one factor). Sources of foodborne illness outbreaks are: commercial or institutional establishments, 77%; homes, 20%; food processors, 3%. As a percent of total cases, specific foods associated with foodborne illness are: meats, 14.4%; dairy products, 13.3% poultry, 9.7%; seafood, 4.9%; Mexican food, 2.9%; bakery products, 2.9%; fruits and vegetables, 2.4%; non-dairy beverages, 1.7%; all other foods, 47.8%. As indicated in these CDC data, meat and poultry products are associated with approximately 25% of the cases of foodborne illness.

Pathogens Associated With Beef

The primary bacterial pathogens associated with beef-related foodborne illness outbreaks are *Salmonella spp., Staphylococcus aureus, Listeria monocytogenes, Campylobacter jejuni,* and *E. coli.* It should be noted that *Staph aureus* is principally of human origin rather than animal. Following are brief characterizations of the other four pathogens.

Salmonella

Salmonellosis is the leading cause of foodborne illness, accounting for over 50% of all outbreaks, but it is seldom fatal. *Salmonella* is found in the intestinal tract of humans and animals, as well as in the general environment. Total elimination is unrealistic and virtually impossible. Primary sources of infection are eggs and poultry meat followed by red meats. Freezing does not kill *Salmonella,* but refrigeration temperatures (32 to 39°F)

retard its growth. It is inactivated by proper cookery (over 140°F).

Listeria monocytogenes

CDC statistics show that from 1983-87, *Listeria* ranked tenth in number of cases, third in total costs, and first in deaths among all bacterial pathogens. Since then, the number of cases has declined. Listeria is found everywhere in the environment. It is one of the few pathogens that grows well at refrigeration temperatures. It survives freezing and is relatively resistant to heat (up to 122°F). Although outbreaks are rare, the case-fatality rate is high, ranging from 23 to 35%.

Campylobacter

Campylobacter ranks fourth in number of cases and together with *Salmonella* is a leading cause of foodborne gastroenteritis. Like *Salmonella,* it is seldom fatal. Feces from wild and domestic animals is the major source of contamination. All species of livestock and poultry have been implicated as sources of infection. *Campylobacter* is readily inactivated by cooking and will not grow at refrigeration temperatures.

E. coli 0157:H7

This strain of *E. coli* has emerged as the most serious bacterial pathogen problem facing the beef industry. Over 50% of the *0157:H7* cases that have occurred since 1982 have involved under-cooked ground beef. It causes a severe bloody diarrhea and, in a few instances, kidney hemorrhaging, kidney failure and death. Cooking ground beef to an internal temperature of 155°F (well done) will kill *0157:H7* in 2 seconds. Recently, a new *E. coli* strain, *0104:H21,* which causes symptoms similar to *0157:H7,* was identified in Montana.

Testing for Bacterial Pathogens

On October 17, 1994, USDA/FSIS initiated a microbiological testing program for *E. coli 0157:H7* in raw ground beef. As of September 30, 1995, a total of 5,291 samples had been tested. Approximately half of these samples were collected from packing plants and half from retail outlets that grind beef on a regular basis. Three of the 5,291 samples were positive for *E. coli 0157:H7,* an incidence of only 0.06%. In addition to *E. Coli 0157:H7*, FSIS is testing for *Salmonella* and *Listeria.*

Because of recent outbreaks of *0157:H7* that have been traced to fermented sausage, FSIS is now beginning to test this product for pathogens. It is also conducting tests on cooked hamburger patties. In addition, food scientists at Michigan State University are working on developing a quick test which could be used by restaurants and institutions for verifying endpoint temperatures in cooked hamburger patties.

Strategies for Reducing Bacterial Pathogens in Beef

A number of technologies having potential for pathogen reduction in beef are under consideration. Most of them would entail intervention at the packing house level. They are as follows:

- Carcass rinses
  - Hot water (>160°F)
  - Organic acids (acetic, etc.)
  - Trisodium phosphate
  - Hydrogen peroxide
  - Ozonated water
  - Chlorine compounds
- Steam vacuuming
- Superheated steam
- High intensity light pulses ("pulsed light")
- Low-dose irradiation

It remains to be determined which of these technologies will be cost-effective enough to warrant widespread implementation.

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