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# BENEFITS AND RISKS TO PUBLIC HEALTH AND THE ENVIRONMENT FROM AGRICULTURAL AND LIVESTOCK PRODUCTION

## CONTENTS

## 1. Introduction

The Western Hemisphere has abundant natural resources for food production: rich fertile soil, a moderate climate, and a long growing season. Advantages and benefits of livestock and agriculture are unquestionable. Concerns for human diseases due to chemical and biological agents in vegetables, meat, milk and eggs is increasing at an alarming rate. In the last 20 years most new diseases that have emerged are of animal origin. These diseases have motivated writers and movie producers to include interesting scenes, stimulating global awareness. A movie entitled "Outbreak," based on a hypothetical devastating widespread human disease of animal origin, a Jack-in-the-box like scenario, has recently been released. But most important is the way writers bring public awareness to scientific genetic manipulation as in the "Jurassic Park" novel of Michael Crichton. Another subject to be examined is the impact of livestock and agriculture on the environment and its subsequent effect on public health in order to raise the concern and awareness of politicians, scientists and the general public.

Operational plans need to be developed and fine-tuned to effectively manage human health and environmental hazards of agricultural production. If the human disease hazards are not found until people get sick or die, then it often takes days, weeks or months to trace back all the possibilities, conduct laboratory testing, and decide on the origin of the health hazard. We must do better than this; otherwise, we will be unable to sell agricultural products for domestic consumption and also for the export market. This presentation will outline our true potential for international production of wholesome, healthy, safe and delicious vegetables, meat, milk and eggs, and the regulatory measures and intersectoral actions that need to be implemented to protect the environment and human beings from problems of agricultural and animal origin.

## 2. Livestock and Agriculture Production. Its Importance in the Americas

The statistics presented in the Yearbook of the Food and Agriculture Organization (FAO) showed that in 1993 slightly more than 45% of the world's population was engaged in agriculture. This data alone makes a strong statement of the importance of agriculture.

However, huge differences in the percentage of the population in agriculture exist among the different countries in the Americas—from as high as 61.8% in Haiti to low as 2.1% in the United States in 1993. Some selected countries in the Americas and the corresponding percentage of the population engaged in agriculture are: Canada, 2.8%; Puerto Rico, 2.9%; Bahamas, 5.5%; Barbados, 6.0%; Jamaica, 25.7%; Mexico, 28.1%; El Salvador, 35.0%; Guatemala, 49.4%; and Honduras, 53.3%. Those differences have been and will be associated with the political systems, the economy, access to technology, climatic conditions and the management of natural resources. World

response to the challenge of agriculture production and trade has been shown as a greater interdependence of the countries, including adoption of common policies and norms and a restructuring of international trade.

In the last 10 years, there have been slight changes in the sources of food production. From 1985 to 1993 in North and Central America, there was a decrease in crops and cereals production; and this was offset by huge increases in livestock production. In South America during the same period, significant increases have occurred in the production of all of these items. On a worldwide basis, crop production and cereal production increased by 11% and 7%, whereas in North and Central America production decrease by 9% and 21% respectively. Food and agriculture production increased by 21% and 17% in South America, far exceeding the 15% and 14% increase worldwide. Livestock production indices increased between 1985 and 1993 on a worldwide basis by 17%, as compared to 10% and 29% increases for North and Central America and for South America, respectively.

Another way to dramatize the relative importance of the livestock industry to agriculture in North, Central, and South America is to calculate what percentage of the world's livestock can be found in the Americas. In 1993, cattle in the Americas totaled 443.0 million, representing 35% of the world's total. Of the 5.57 billion people in the world in 1993, North and Central America's 0.442 billion represented only 13.5% of the total. Thus 13.5% of the world's human population existed where 35% of the world's cattle were raised. In that year, there were 84.2 million head of cattle slaughtered in the Americas, representing 34.6% of the world's total in an area with fewer than 14% of the world's population.

## 3. Food Production, Distribution, and Losses

On a worldwide basis, per capita food production indices were 104, 106, and 103 for the years 1985, 1990 and 1993, respectively. For North and Central America the indices were 102, 95, and 89, significantly lower than the world values for the same years. In South America, food production indices were increasing for the same three years at 103, 105 and 106, respectively. World per capita livestock products were the same for each of the years 1985 and 1993. In North and Central America, livestock products declined slightly from 1985 to 1993, whereas in South America, there was a clear and steady increase of 9.5% in livestock products from 1985 to 1993.

Poverty is a significant and persistent problem in developing countries. It gives rise to lack of food security, poor health and nutrition, and lack of education. The number of people living in poverty in developing countries reaches 700 million. In March 1995, delegates from over 140 countries gathered in Copenhagen for the United Nations World Summit for Social Development, chaired by Juan Somavia, UN

ambassador from Chile. The Summit was faced with issues such as that the wealthiest 20% of the world population controls 84.7% of the gross national product, while the poorest 20% controls barely 1.4%, a per capita ratio of 1:61 today compared to a ratio of 1:30 only three decades earlier. For the poorest 20% of the world's population, obtaining sufficient food is the greatest factor in their lives; the UN assessment classifies all as at risk of malnutrition.

According to FAO, "Traditionally hunger and malnutrition were geographically defined in areas of droughts, flooding or other natural disasters which caused widespread crop and livestock production failures; today life and health threatening malnutrition are still geographically defined but increasingly are dispersed among the urban poor and landless rural laborers."

The countries of the Americas, although all are classified by the UN on an index that weighs life expectancy, education and standard of living as at high and medium development, face the poverty/malnutrition discrepancy along with other countries worldwide. As they are above the level of countries of low development, the vision of all countrie of the Americas should be the active and successful raising of levels of food protection to ensure that all people have sufficient amounts of safe food and water. This vision is definitely not impossible to achieve.

For many developing countries, agriculture is the most essential and frequently the only available source of income to the people. Alleviation of poverty requires a sustained growth strategy where agriculture is the key to economic growth. Rural poverty, exacerbated by the lack of technology, also causes environmental degradation and soil erosion. Food losses from faulty storage and handling and problems of food distribution also contribute to an increase in poverty.

In tropical and subtropical climates, food grains and legumes become plentiful in rural areas at seasonal harvest time; landless laborers may or may not have access to this abundance. Seasonal harvest times have become fewer and less distributed in many areas where the rainy season has been drastically shortened and intensified by regional deforestation. Improper application of agricultural chemicals may result in the accumulation of hazardous residues in products, causing rejection on the market. In the United States alone, during 1991-1992, a total of 10,237 shipments of food products originating in countries of this Region were rejected because of chemical residues. The losses were in excess of $320 million. Storage inadequacies in rural areas lead to heavy losses. The increase in harvest yields of grains which achieved in the Green Revolution of the 1960's through the 1980's has not entirely benefitted rural populations, as rats and other rodents attacked inadequately protected grains while weevils destroyed the softer kernel maize and other grains.

In urban areas residents are almost totally dependent on food grains and legumes brought in from rural areas or imported, with multiple steps and persons who do not know each other in the chain, leaving consumers with little or no direct control over the quality of these foods. It has been estimated that a 27% of these products are lost in cities, as a consequence of poor handling and conservation.

WHO estimates that on a worldwide basis food losses annually decrease the available food supply of grains and legumes by 10%, fish and seafood by 25%, and vegetables, fruits and non-grain staples by 50%.

Deforestation and degradation of agricultural lands and waters is an international problem, and this is certainly true in the countries of this hemisphere where agricultural production was reduced as a consequence of these problems. Between 1950 and 1984, world grain production expanded 2.5-fold, outpacing population growth, but between 1984 and 1993, per capita grain harvested decreased by 11%. This has impacted severely on both food availability and quality.

Regarding food of animal origin, milk is our most perishable food, losing quality and safety after two hours without refrigeration or processing, followed by meats which lose quality and safety after five hours without refrigeration or processing and then by eggs which lose quality and safety in their intact shells after three days without refrigeration.

Milk from healthy cows, chilled and transported under sanitary conditions, will have a low bacterial count. Pasteurization followed by packaging and refrigerating under sanitary conditions produces a quality product with a long safety period. However, pasteurization is not available in all milk-producing areas. It is estimated that 40% of the milk in Latin America and the Caribbean is still consumed raw, because of the absence of pasteurization facilities.

Although Latin America and the Caribbean slaughter about 56.4 million head of cattle, 23.2% of beef and veal of the world, only 28% of this amount is inspected by the relevant public health authority. The products inspected are usually destined for export. The poultry industry has increased and progressed in an integral manner so that most poultry meat is processed in adequate installations and under sanitary conditions, reducing losses in quality by contamination.

The production of meat for export may lower the quality and safety of local supplies when the select products are tagged for export, the products not meeting standards of quality or safety; e.g., containing hazardous chemical residues, which are rejected by importing countries, are distributed and sold locally.

Seafood and fresh-water fish have received attention far below their importance; even countries with extensive fishing as a natural resource have limited regulations for the sustainable extraction of these products.

On a worldwide basis, 16% of animal protein was estimated by the UN in 1993 to have been from fish and shellfish; for the regions of the Americas, the estimates were 6.6% - 8.2%. Management of the marine fishing grounds of the world is chaotic and disastrous for long term maintenance. World marine catches peaked in the mid 1980s at over 80 million tons but have declined since, and desired marine species in several important fishing grounds; e.g., cod off Nova Scotia, have been reduced to economic extinction. Although the per capita world catch of all fish and shellfish, including those raised in aquaculture is about 18kg., the reality is that the distribution is very uneven, with a continually increasing proportion of the dwindling supply entering markets in developed countries and being sold at ever rising prices.

## 4. Human Disease Hazards of Livestock and Agriculture Products

The health of food source animals is a main factor in product safety. Diseased animals may be sources of zoonotic diseases to consumers; eg. *Mycobacterium bovis* and *Brucella* through milk, or Taeniasis through beef or pork. Animals may be inapparent carriers of zoonotic pathogens which could infect their products; eg. *Salmonella dubling and Coxiella burnetti* transmitted through milk, *Toxoplasma gondii* and *Trichinella spiralis* transmitted through pork, and *Salmonella enteritidis* transmitted through eggs. Animals which are intestinal carriers of zoonotic pathogens may be the sources of contamination of their products; eg. *Salmonella typhimurium* and *Campylobacter jejuni* contaminating milk or the shells of eggs, or *Yersinia enterocolitica, Escherichia coli* 0157:H7 and *Cryptosporidium parvum* transmitted through pork or beef. Human pathogens may directly contaminate milk, meat or eggs from diseased or carrier persons handling these products on farms or in slaughtering places and processing plants. Examples are *Staphylococcus aureus, Shigella dysenteriae*, hepatitis A virus and Norwalk virus.

Many of the foodborne hazards in fish and shellfish are indigenous to their marine environments, but the growing human waste pollution of the seas is responsible for much of the increasing occurrence of human foodborne diseases. Traditionally, consumption of raw seafood dishes like "*Ceviche*" has characterized the safety of sufficiently pristine marine sources; more recently, epidemics of *Vibrio cholerae* and *Vibrio vulnificus* infections and increases in occurrence of hepatitis A and *Shigella dysenteriae* infections in the Americas have removed this confidence.

Important seafood and fresh water fish and shellfish borne diseases in the Americas are caused by:

- Flatworms (trematodes); i.e., *Paragonimus* from crayfish or crabs, *Opisthorchis* from freshwater fish, *Echinostoma* from clams, *Chlonorchis* from fish, and *Gastrodiscoides* from snails;

- Tapeworms (cestodes); i.e., *Diphylobothrium* from marine or fresh-water fish;

- Roundworms (nematodes); i.e., *Angiostrongylus* from crabs, prawns, shrimp or snails, *Anisakis* from marine fish, *Gnathostoma* from frogs or fresh water fish, and *Dioctophyma* from frogs or fish;

- Bacteria which live as marine saprophytes and contaminate seafood; i.e., *Vibrio vulnificus* and *V. parahemolyticus*;

- Bacteria of human origin which contaminate marine and fresh water fish and shellfish through sewage pollution; i.e., *Vibrio cholerae, Shigella dysenteriae* and *Salmonella*;

- Viruses of human origin which contaminate marine and freshwater fish and shellfish through sewage pollution; i.e., hepatitis A and Norwalk virus;

- Marine toxins originating when fish or shellfish accumulate toxic products found in dinoflagelates alga they consume. Several marine-borne intoxications have been recognized in the Americas: Ciguatera, paralytic shellfish poisoning, diarrheic shellfish poisoning, neurotoxic shellfish poisoning and amnesic shellfish poisoning.

In addition we must be concerned not only about pathogenic microorganisms but also pesticides, drugs, food components, growth promoters and other production-enhancing practices that increase human health hazards. A few chemicals used in animals might remain unchanged or their metabolites concentrated as residues in tissues of animal products, becoming hazardous to the consumer.

Different types of pesticides are used in agriculture and livestock. Some of them have been forbidden because of their toxicity in developed countries, but are still used in the developing countries. Importer and farmer awareness is urgently needed to ensure proper handling of agricultural chemicals. Companies which label agricultural chemicals according to the laws applied in the country of production may feel no compulsion to include all of these instructions and warnings on these chemicals when packaged for export to countries without stringent labeling requirements. In addition, when confronted with new regulations or halting of production of chemicals found to be public health hazards in countries where they are produced, manufacturers may feel no obligation to not distribute these chemicals in countries with lesser restrictions. The treatment of

grains and legumes with organophosphate or chlorinated hydrocarbon insecticides or the coating of the insides of storage containers with these chemicals to prevent damage by weevils and other pests can create serious public health hazards. When the contamination of grains and legumes with agricultural chemicals or molds reaches a level detectable by smell or sight, blending to dilute odors or discoloration can be done at various pre-sales points, and consumers may be helpless to avoid purchasing such adulterated food.

Where grains are being stored for periods of months at levels of humidity which support the growth of molds, the productions of aflatoxin occurs. These toxins, which over long time consumption lead to increased occurrence of liver and other cancers, have been long time problems, but are being increasingly recognized as of public health importance.

The use of human sewage for irrigation of vegetables, fruits in rural as wells as in semi-urban gardens, or the use of nonpotable water to wash the produce constitute important causes of contamination and a human health hazard. Cysticercosis of *Taenia solium* is an example of this method of contamination.

Canning does not imply safe food. Occasionally Clostridia and other anaerobic bacteria might grow into the canned food if there is not adequate handling and levels of sugar, salt or heat.

Thirty to 55% of the people of developing countries still drink microbiologically and/or chemically contaminated water. Furthermore, it is estimated that at least 1.5 billion people experience foodborne diseases annually. Up to 70% of childhood diarrheas, which kill 4-5 million children under 5 years of age, are now considered to be due to foodborne pathogens. Surveillance data, inadequate though they are, serve as the basis for the Centers for Disease Control and Prevention (CDC) to estimate that 2.5% to 12.8% of the people of the United States experience foodborne illness annually at an economic cost in medical care and loss of productivity up to US$23 billion. Calculations for cases, death and costs from seven major foodborne illnesses are shown in Annex A.

## 5. Impact on the Environment

Someone said that protection of the environment is a responsibility of everybody. It does not exclude agricultural producers. There are still problems that we do not know how to solve without increasing production costs. We know how to design, construct and manage intensive production units where thousands or millions of animals produce meat, milk and eggs at costs so low they could not have been imagined only a few years ago. But the damage these intensive production units are inflicting on the environment and to human health may be greater than the cost-savings. Are the policymakers concerned about these problems?

Few years ago WHO/FAO/UNEP joined efforts to convene a panel of experts on environmental management for vector control (PEEM). One of the subjects was sustainable livestock development in developing countries, which is understood as follows: *"Sustainable development is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable."*

This sustainability in agriculture and livestock production cannot be achieved if there is not considerable international cooperation with all countries accepting their responsibilities to the rest of the world, in a long-term commintment.

Several important environmental considerations must be borne in mind. The degradation of agricultural lands in the tropics is a major concern, which includes, erosion, nutrient depletion, compactation, salinization and deterioration of pastures. During the period 1945-1994, total land degradation in the world was estimated at 1,965 million hectares with 244 million hectares in South America and 158 million in North and Central America. These numbers represent losses by overgrazing, deforestation and agricultural mismanagement. On the other hand industrialization and deforestation may already be producing climatic changes that could threaten agriculture, the ecological balance and even human health. The increase and accumulation of carbon dioxide, chlorofluorocarbons, methane, nitrous oxide and ozone in the atmosphere act as filters, returning the reflected radiation to the earth and causing a gradual rise in temperature (greenhouse effect). Some of these gases are produced both naturally and artificially (methane and nitrous oxide) but others are the result of human activity, as in the case of automotives, refrigeration, aerosols and solvents.

To be sustainable, all systems of pasture use must be designed to maintain or improve vegetal cover. Poor grazing management, including overstocking, leads to deterioration of pastures and consequently to decreased animal production.

Over-use of fertilizers, especially nitrogenous ones, although rare in developing countries, is also potentially harmful to the environment through pollution of surface and underground waters. It deserves special attention.

The large amounts of animal waste produced in concentrated production units cause odor, handling and disposal problems, very different from the value of wastes on small farms where they are valuable fertilizers applied on the soil that produces the feed for the small numbers of livestock. Water problems may be severe as very large

amounts of water are needed for these operations, reducing availability of potable water supplies to local residents and businesses. The flow or seepage of animal waste-contaminated water enters rivers, lakes or aquifers, increasing their organic loads, destroying fish breeding in surface waters, and polluting human water sources with pathogenic bacteria and viruses.

The next example is probably the most serious—contamination of groundwater with pathogens from food animals. In many areas underground aquifers are not protected by overlying rock strata. Microbes on the surface move quickly through the soil with the rain water and contaminate the groundwater. Well-water is not safe for animals or humans to drink unless it has been treated. Pathogen-free animals cannot be produced if the water they drink is contaminated. Intensive production units have produced massive volumes of manure and some carcasses from expected production mortality that are disposed of by spreading on land without composting. Some of this spread may contain pathogenic organisms, like *Cryptosporidium*, that may pass to the water supply causing disease in humans. In 1993, an outbreak of cryptoporidiosis in Milwaukee, United States, resulted in diarrheal illness in an estimated 403,000 persons. Later that year, outbreaks occurred in other counties through contamination of municipal water.

Problems of environmental degradation by large livestock production units for supplying food to nearby cities are magnified when these operations are for the production of meat, especially grass-fed beef cattle to supply the export market.

The creation of large ranges for food production is frequently done by cutting and burning of virgin rain forests, with devastating impact on the ecosystem; alternatively, land needed for local food production may be economically converted into production for export foods, reducing local supplies.

The contamination of the environment does not only result from microbiological or chemical contamination of water, soil or air. The growth of cities encompasses both human as well as animal populations, which include companion animals, birds, rodents and insects that are hazardous for public health and the environment.

The pet population in the United States has been estimated at 52 million dogs, 54 million cats, 12 million birds in captivity, 800,000 small rodents, and 94 million aquarium fish. There are companion dogs in some 38% of households. There are no statistics available in most developing countries on companion animal populations, but it is estimated that the ratio of dog to human populations is 1:7-10 and cat to human populations, 1:18-20 in cities. Animals in urban areas discharge their effluents directly into the open, contaminating the environment not only with their feces and urine, but also carrying zoonotic pathogens. A study conducted in the city of Houston, Texas, in the United States, with an estimated population of 500,000 dogs, showed that some 170,000

kilograms of feces and 360,000 liters of urine are excreted daily into the open environment. These quantities of effluent surpassed the capacity of the urban services, giving rise to, in addition to disagreeable odor, rodents, and flies; death of grass and trees; and contamination of streams and bodies of water. In addition to this problem, prodigious quantities of waste constitutes a reservoir for *Toxocara* eggs and hookworm larvae in the environment, exposing humans, particularly children, to serious infections. The same study pointed out other additional problems of disposal of the carcasses of some 100,000 unwanted dogs that are destroyed annually. Pets also cause public hazards and physical injuries, such as vehicular accidents and dog bites. In Latin America, for example, the veterinary public health services report an annual average of 720,000 persons bitten by animals, who require medical attention.

In developing countries, the situation is complicated by populations migrating from rural to urban areas, bringing with them their domestic animals, such as goats, pigs and cattle, as source of food. In the absence of their usual grazing and confinement areas, these animals stray into the streets and scavenge in garbage dumps. In the province El Callao, close to Lima, Peru, for instance, human anthrax and brucellosis by *B. melitensis* has increased as a result of migration from rural areas, posing a significant animal and public health risk.

## 6. Conclusions

Although there are no complete answers to all the problems presented, there are enough answers for the development of agriculture and livestock production that is safe for public health and the environment. There will be a need to introduce procedures that we have ignored but which would work, and also to impose new regulations to protect everybody's interests. We need research to learn how to efficiently produce food free of hazardous pathogens, without contaminating the environment. Training is needed to make available personnel with expertise, knowledge, skills and abilities to provide solutions in the future to the problems we raise today.

There are starting points that we would like to suggest, as follows:

### 6.1 *Intersectoriality*

Agriculture production, human health and environmental protection are inextricately interwined. Bureaucratically it is the proverbial "hot potato" that has been rapidly tossed from one agency to another. Problems involved are much easier to pass on than to solve.

The Inter-American Meeting, at the Ministerial Level, on Animal Health (RIMSA) convened by the Pan American Health Organization every two years, provides

an excellent intersectoral forum to discuss these "hot" subjects—but not only to discus the problems but also to obtain commitments for appropriate actions.

If we know that food is being contaminated along the chain process, we should adopt methods to identify those hazard points and eliminate them. Recently, a Hazard Analysis and Critical Control Points (HACCP) method was developed. The HACCP is a specific hazard prevention approach. Basically HACCP identifies food hazards and their potential to enter a specific food chain; it pinpoints where in the food chain hazards may enter or originate. HACCP then sets up appropriate control procedures to prevent critical hazards and develops a continuous monitoring program to ensure that controls are effective. Because of its greater specificity and concentration on controlling more critical hazards than do traditional quality control procedures, HACCP provides a greater assurance of food safety. The system is proving as effective and economical in developing countries as in developed countries. However its implementation in the diverse food chains requires close intersectoral collaboration.

If we know of areas in the Hemisphere that do not have animal slaughter facilities and sanitary inspection of meat and meat products, we together—Health and Agriculture must make an effort to provide adequate, economical facilities and train the necessary personnel, even from the same community, in inspection services.

If we know that our agriculture and livestock is not sustainable because of high costs, contamination of the environment, soil erosion and animal and human stress, then we must look for an opportunity to discuss and define strategies to initiate solutions to specific problems. However, this is not only the responsibility of the health and agricultural sectors, but also the producer, the agroindustry, commerce, tourism, and other sectors.

The reduction of atmospheric contamination with noxious gases is the responsability of everybody, and solutions are available by simply reducing some commodities. One suggestion is the reduction of methane gas by the burning of crop residues and recycling of ruminants manure.

Other actions are underway but must be oustained to to be successful. Deforestation in the Amazon basin and other tropical regions is encountering new regulations and strategies for reforestation. Consumer preference for "naturally" produced food or "organic food" can be partially interpreted as an expression of dissatisfaction with production systems that use an excess of additives, such as antibiotics and hormones in animals and chemicals in crop production. The pressures to liberalize world trade predict profound changes in agricultural production systems in industrialized countries as subsidies and tariffs are gradually withdrawn.

Alleviation of poverty must be done in an intersectoral and programmatic way so as to increase access to safe water, adequate sanitation and health care, thus enabling the poor to better manage their natural resource base and to participate in the growth and development process. To achieve sustainable poverty alleviation it is necessary to create assistance programs for children, including feeding programs; facilitate credits and strengthening self-help capacities; provide investment in agricultural development in low-income developing countries and expand financial and technical support of agriculture and livestock research oriented to increase productivity; and avoid environmental degradation.

6.2 ***Research***

Research on the subject of sustainable agricultural production should envisage future events based on today's planning. Therefore there is a need to develop databases on water, land, air, other natural resources, and food needs for future generations. The development of long-term monitoring studies that incorporate geographic information systems and remote sensing and modelling will support livestock and agriculture management in intensifying and increasing productivity.

The identification of high-yielding sustainable ecosystems must be one of the first steps in any attempt to design new interventions. The products of such ecosystems must be able to serve as the principal inputs for integrated activities aimed at furnishing food, feed and fuel for immediate sale or consumption, while the by-products and residues should serve as inputs for livestock husbandry.

More research needs to be done with regard to the introduction of technologies for safe and productive feeding of small animal species, such a pigs, frogs, rabbits, turkeys and guinea pigs, with crop forage wastes or with large animal production wastes. Marketing systems for consumption of non-traditional species must be developed.

Diagnostic technology, based on monoclonal antibodies and recombinant DNA technologies, must aim to identify in infectious agents their changing or mutating characteristics and geographic distribution and to ensure efficient epidemiological monitoring, while research on immune responses will provide the basis for developing effective vaccines and delivery systems.

More should be known about the characterization of health hazards related to the rapid growth of cities and the implication of domestic as well as synanthropic animals on public health and the environment.

6.3 *Education*

Regarding food safety at retail level, there is a need for the education of retail operators in order to achieve food safety. Effective education is difficult, especially for small business operators with rapid personnel turnover and a clientele based more on personal relations than on sanitary appearance of shops and visible quality of foods. Education must be appropriate to specific operators, incorporating at least the following principles: (1) assessment of freshness and perishability of foods; (2) safe period for holding foods under prevailing conditions (e.g., perishable products like fresh meat in the absence of refrigeration must be moved rapidly from producer to consumer); (3) understanding environmental contamination of food and cleaning and sanitizing food contact surfaces; and (4) understanding human contamination of food and of protective measures, such as toilet hygiene, hand washing, appropriate clothing, and personal health. Certification of food handlers who have completed training courses can be very important in achieving desired education levels. Sanitary and operational inspections by government authorities, rewarding compliance, and achieving prompt correction of deficiencies can be very cost-effective in enhancing the public's health.

The education and inspection focus in food service establishments is similar to that in retail food markets, with the additional need for operators to understand and ensure the holding of cold and hot foods within a temperature range that prevents multiplication of pathogenic bacteria. Education and certification of street food vendors is truly needed. Practical food safety measures must be implemented in individual operations. This can be achieved as follows: (1) vendors should wear appropriate and clean clothes and shoes; (2) they should be healthy and practice healthful habits; (3) they should have an identified sanitary facility and permission to use it; (4) they should have a pail of water and soap specifically for hand washing; (5) they should have two additional pails of water, one for washing dishes with soap or detergent and one for sanitizing these dishes in a household bleach solution; (6) water should be changed in all three pails whenever a soapy layer forms on the surface; (7) all food contact and vending surfaces should be intact, impermeable, and maintained clean and sanitary; and (8) hot foods must be held in covered containers and for not more than two hours; if not sold within this time, they must be reheated before being sold.

Besides education addressed to food handlers, there is a need for awareness by the consumer, who stands at the end of the food supply chain. All microbiological, chemical and physical hazards which were acquired by the food during production, harvesting or slaughter, processing, distribution and sale will most likely be compounded at this point. During certain steps, bacteria and molds may be bestroyed, but in some others they might multiply. Education is the final focus for food safety for the customer, who needs to be aware: (1) that raw food entering the kitchen may carry pathogens; (2) that cleanliness and sanitation of all food contact surfaces are essential to

prevent further contamination; (3) that personal health, hygiene and cleanliness are essential to safe food handling; (4) that pathogens can be transferred from contaminated foods to other foods which are ready to eat; and (5) that contaminated foods can be made safe only by peeling, skinning or adequate cooking and cooked foods should be held hot until eaten.

Protection of the public from chemical residues requires multiple action and regulations. In reality, this is not easy to achieve, and there must be a general public commitment. Education about the proper use of agricultural chemicals in food production and the proper use of animal drugs in food animals are the most important targets; the increasing availability of these chemicals and drugs to both large and small producers means that the education program must extend throughout agriculture. These education programs should involve the policymaking group to illustrate to them the complexity of the problems of environmental and public health hazards in agriculture in order to enact adequate regulations covering all the hazardous stages in using pesticides. Policy research could improve databases and provide analysis to help policymakers anticipate and understand the probable consequences of their actions. This research should be concentrated on resources management, trade and macro-economics, technology policy, markets, institutions and tourist impact, among others.

## 7. The Role of Voluntary Organizations and Educational Institutions

Regional collaboration and coordination among agencies providing technical cooperation and financial aid to the countries are needed. Joint plans and projects with the participation of different agencies concerned with similar problems offer important opportunities to accomplish more with scarce resources.

Networking allows collaborating partners to pool scientific efforts on a regional basis in order to address problems of mutual interest more effectively, thereby avoiding a duplication of efforts.

There is always a starting point, although several institutions are already engaged with national institutions. The following aspects are suggested to develop joint collaboration:

- Define common concerns and initiatives;
- Identify national institutions with similar activities;
- Identify potential sources of improve technology,
- Harmonize institutional resources serving the purposes of common interest;
- Define an information exchange system;
- Develop periodic meetings of scientific groups;
- Develop explicit national commitments, indicating focal points;
- Mobilize resources for in-country activities.

The following agencies and organizations, among others, are suggested for the above purposes:

- Pan American Health Organization/World Health Organization (PAHO/WHO)
- Food and Agriculture Organization (FAO)
- Centre international de Recherches et Développement sur l'Elevage de la zone sub-humide (CIRDES)
- International Centre for Tropical Agriculture (CIAT). Colombia
- Inter-American Institute for Agriculture Services (IICA), San José, Costa Rica
- Institute for Land Improvement and Water Management. Switzerland.
- International Food Policy Research Institute (IFPRI)
- World Bank (WB)
- Inter-American Development Bank (IDB).

Universities may play a significant role in the administration of knowledge for the future sustainable agriculture and livestock production, food safety, and public health. A review of their programs of studies must be conscientiously done in order to introduce new concepts, methodologies and future strategies to improve agriculture and livestock production and productivity without harmful effects to public health and the environment.

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| Foodborne Disease in the U.S. | | | |
|---|---|---|---|
| **Organism** | Cases/Yr. | Deaths/Yr. | Cost/Yr. (Millions) |
| *Salmonella spp.* | 1,920,000 | 960-1,920 | 1,588 -1,888 |
| *Campylobacter spp.* | 2,100 | 120 - 360 | 907 - 1,016 |
| *E. coli 0157: H7* | 7,668 - 20, 448 | 146 - 389 | 299 - 610 |
| *Toxoplasma gondii* | 2,090 | 42 | 2,628 |
| *Listeria monocytogenes* | 1,526 - 1,581 | 378 - 433 | 209 - 233 |
| *Taenia spp.* | 1,104 | 0 | 0.3 |
| *Trichinella spiralis* | 131 | 0 | 0.8 |