ASIA-PACIFIC ECONOMIC COOPERATION

2000 APEC CHINA SEMINAR

Public Health Issues in Animal Production/Animal Products

Oct. 15 - 19, 2000

Friendship Hotel, Beijing, P. R. China

- 2000 APEC CHINA SEMINAR -

Public Health Issues in
Animal Production/Animal Products

(October 15-19, 2000, Beijing)

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Ministry of Foreign Trade and Economic Cooperation (MOFTEC)

China Agriculture University (CAU)

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- 2000 APEC CHINA SEMINAR -

Public Health Issues in Animal Production/Animal Products

October 15-19, 2000, Beijing, China

Summary Report

1. The APEC Seminar of Public Health Issues in Animal Production/Animal Products was held at Scientific Conference Hall of Friendship Hotel in Beijing, China from October 15-19, 2000 with jointly sponsorship by APEC, the Ministry of Foreign Trade and Economic Cooperation (MOFTEC) of China, the Ministry of Agriculture Feed Industry Center (MAFIC), China Agricultural University (CAU).
2. The Organizing Committee for APEC China 2000 included: Chairperson--Dr. **Shaogang Zhang** (MOFTEC), Executive Chairperson--Prof. **Defa Li** (MAFIC), Secretary General--Dr. **Xiangshu Pia**o (MAFIC), Secretary--Mr. **Yuan Rao** (MOFTEC). The Seminar was attended by 13 representatives from the following member economics: Prof. **Mary Barton**, Australia; Prof. **B.Y. Chang**, China; Prof. **D.W. Chen**, USA; Prof. **W.W. Gao**, China; Prof. **In K. Han**, Korea; Prof. **M.H. Lee**, Korea; Prof. **D.X. Lu**, China; Prof. **Lynn McMullen**, Canada; Prof. **I.K. PaiK**, Korea; Prof. **J.M. Tong**, China; Prof. **Metha. Wanapat**, Thailand; Prof. **H. Yano**, Japan; Dr. **YuYu**, Hongkong, China. Also in attendance: Dr. **S.G. Zhang**, President of APEC, China; Prof. **Defa Li**, Chairman of Organization Committee, China; Mr. **Y. Rao**, Secretary of the President of APEC, China; Dr. **X.S. Piao**, Secretary General of the President of APEC, China; Mr. **Hon-Chung Thomas, SIT**, and Mrs. **H.K. Ellen**, official of Department of Food and Environmental Hygiene, Hongkong, China; Mr. **S.R. Jiang**, president of China Agricultural University, China; Mrs. **Geralddine S.M.**

Luk, technician of Castle Peak Veterinary Laboratory, Hongkong, China; Mr. **ABD.L.H. Nasi**, official of Department of Agricultural Bandar Seri Begawan, Brunei; Prof. **K.Y. Zhang**, Animal Nutrition Institute of SiChuan University, China; Mrs. **X.H. Zhao**, official of Ministry of Agriculture, China.

3. The opening ceremony of the Seminar in charge of Prof. H. Yano, was held at Scientific Conference Hall of Friendship Hotel in Beijing on Oct. 15th. Government officials from MOFTEC , President of CAU, Post President of WAAP as well as scholars from CAU and MAFIC presented the opening ceremony.
4. In his opening address, Prof. Defa Li, the Chairman of Organization Committee, also the dean of MAFIC, extended warm welcome to all the participants at first. Then he pointed out that with the quick development of international animal husbandry, animal pollution has become one of the most important issues all around the world. Prof. Li emphasized that both the animal pollution and drug residues in animal products was a world-wide issue concerning Public Health. The main purpose of this Seminar, therefore, was to arose the public attention, thus promoting the sustainable development of animal husbandry in all-over the world.
5. Government official of MOFTEC, Mr. S.G. Zhang, the President of APEC China, then welcomed all participants and invited speakers. Mr. Zhang explained that the history of APEC and illustrated one of the objectives of this Seminar was to build up partnership between the other member countries of APEC and China. He further thanked APEC for the sponsorship, which has increased the accessibility of the Seminar for APEC sustainable development of animal husbandry.
6. President of CAU, Mr. S.R. Jiang made a Congratulatory Speech. In his speech, Mr. Jiang thanked the work had been done by the Organizing Committee for APEC 2000 in China. He believed that public health

concerning animal production and animal products should arose the world-wide attention, not only in Asia-Pacific area. He hoped the achievements of the Seminar.

7. Prof. In K. Han, the Post President of AAAP, also made Congratulatory Speech during the opening ceremony. Concerning the theme of the Seminar, Prof. Han emphasized that not only for animal health, but also for human health, nutritional manipulation should be made to reduce the animal production in environmental pollution and drug residues in animal products should be taken into more consideration. Then the future of the animal husbandry would be perspective and sustainable.
8. During the five-day-seminar, 13 speakers from 7 nations and region (Australia, Canada, Japan, Korea, Thailand, USA, Hongkong China, and China) have submitted their presentation on "Public Health Issues in Animal Production/Animal Products". The main part of the Seminar included: 1. Public Health Issues in Animal Production; 2. Public Health Issues in Animal Products.
9. The first speaker, Prof. I.K. Paik, gave his presentation on "the main sources of animal pollution: nitrogen, phosphorus and pharmacological level minerals". His report related to the microbial phytase that has been used to control P excretion. The activity of natural phytase in certain plant feedstuffs is also high enough to be considered in feed formulation. Nitrogen control could be achieved through amino acids supplementation and protein restriction in the diet. Supplementation with carbohydrases reduces output of excreta as well as N. Ammonia release from the manure could be reduced by using a low protein diet along with the supplementation with probiotics products. Excretion of minerals used at pharmacological level can be reduced by using chelated forms. Cu and Zn in the form of methionine chelate have been successfully used in the broiler and pig diet.

10. Prof. D.W. Chen, the second speaker, made a speech on "environmental challenges of animal production and the role and task of animal nutrition in environmental protection". In his reviews, he figured out the position of animals in the food chain of human beings. On the average, about 20% feed proteins and 15%feed energy could be converted into edible nutrients for humans. The rest of proportion of feed nutrients is exposed to the environment. Nutrients overloading, green house gases, inefficient utilization of natural resources and potential unsafety of animal products to human health are all critical environmental issues. Improving the conversion efficiency of nutrients in the food chain is the fundamental strategy for solving environmental issues. For animal production, the strategy includes the improvements of animal genotypes, nutritional and feeding management, animal health, housing systems and waste disposal programs.
11. The third speaker, Prof. In K. Han made his presentation about "feeding and management system to reduce environmental pollution in swine production". In his manuscript, several effective feeding and management systems to reduce environmental pollution in swine production have been briefly introduced. The first step is to reduce the excretion of nutrients in manure. When more digestible or available feedstuffs and the supplementation of enzymes (e.g., phytase), β-agonists and porcine somatotropin are used, the excretion of N and P can be reduced. Synthetic amino acids is one of the effective ways to reduce pollutants from swine manure. Regarding feeding strategy, he emphasized that phase feeding regimen (also includes split sex feeding) could be used to reduce pollution. He pointed out that proper combination of feeding regimen and environment-friendly diet formulation through nutritional approach would be more effective to reduce nutrient excretion in swine production system compared to single approach to do so.

12. Prof. D.X. Lu, the fourth speaker, gave a speech on "advances in enhancing nutrient utilization for ruminants by nutritional manipulation to reduce environmental contamination". With introduction of the recent understanding of the dietary nutrient utilization in ruminant animals, Prof. Lu introduced some up-to-date advances in such field made by his lab, such as urea slow release technique, optimum amino acids pattern, peptide production and absorption in the rumen, mitigation of methane emissions, metabolizable glucose, improving utilization of low quality roughage, and organic trace minerals. He suggested that the first principle for designing and using these technique must lie in synergism among the other techniques. There ear needs to carry out more research works before application of an integrative and systematic technique in ruminant production.
13. The fifth speaker, Prof. M. Wanapat, made a presentation about "nutritional control to reduce nitrogen excretion from cattle". In his speech, Prof. Wanapat spent much time explaining the nitrogen fermentation and metabolism in the rumen and its impact on ruminant utilization. He suggested that manipulating N sources and levels in the rumen and available carbohydrates would improve rumen ecology and fermentation. The practical uses of local feed resources have been found to improve the feeding systems especially under small-holder farming context.
14. Prof. H. Yano, the sixth speaker made a speech on "nutritional control to reduce phosphorus excretion from monogastric animals". In his report, Prof. Yano tried to dephytinize soybean meal using fermentation with *Aspergillus usami* and phosphorus availability in the fermented soybean meal was studied in chicks. He also compared the efficacy of yeast phytase with that of phytase from *Aspergillus niger*. Prof. Yano suggested that alternative phytase are preferably investigated with regard to stability in the stomach before feeding trials.

15. The seventh speaker, Dr. YuYu gave his presentation on "reduction in animal waste through effective nutritional manipulation". Dr. YuYu pointed out that the aim of animal production is now changed from maximum, optimum, to consumer level. Nutritionists are more care of the taste that carcass quality and growth performance. In his report, he mainly figured out the efficacy of use of rendered protein and fat in both broiler and pig diets.
16. After 20 minutes coffee break, a warm discussion began. The speakers who had given their speeches were being asked questions. The discussion lasted for whole hour. And the aura of the discussion was much exciting.
17. In afternoon of Oct. 17th, all participants were picked up by the Organizing Committee to visit China Agricultural University and MAFIC (Ministry of Agriculture Feed Industry Center). And all participants praised highly on the achievements of MAFIC not only for it's the leading role in the Feed Industry of China, but also among other research institutes all around the world.
18. The Section 2 Public Health Issues in Animal Products of 2000 APEC Seminar began on Oct. 18.
19. The eighth speaker, Prof. M.H. Lee made a speech on "public health risks: drug and antibiotic residues". Prof. Lee illustrated two major areas of concern over the presence of residues of antibiotics in animal-derived foodstuffs with regard to human health. The first is allergic reaction. The second is development of antibiotic resistance in gut bacteria of human. His topic covered classification and usage or sources of chemical residues, their adverse effects, and chemical residue status of some countries. Prof. Lee also expanded his topic to residue detection methodologies, toxicological and pharmacokinetic backgrounds of MRL and withdrawal time establishments, and the importance of non-governmental activities with regard to reducing chemical residues in food.

20. Prof. Mary Barton, the ninth speaker, gave a presentation about "public health risks: antibiotic resistance". She mentioned that antibiotic resistance in human pathogens has been identified as one of the most serious problems facing human medicine. Much of the resistance stems from overuse and misuse of antibiotics in hospitals and community practice but in the case of some human enteric pathogens there is evidence for transfer of resistance bacteria and resistance genes via the food chain from animal to human.
21. The tenth speaker, Prof. W.W. Gao made a speech on "development and application of Chinese Herb Medicines as feed supplements". In her report, Prof. Gao introduced some animal-use herbal medicine in China. Although the herbal extracts could be used as long term feeding supplements, the potential effect of such supplements on the immune function of the livestock should be considered. At the same time, to improve the quality control of the production, the active ingredients of certain herbal extracts whose therapeutic effects have been proven should be elucidated. To achieve this goal, the previous experiment with Chinese Herbal Medicine used for human would be of help.
22. Prof. Lynn McMullen, the eleventh speaker made a speech about "HACCP for control of microbial contamination". Prof. Lynn McMullen introduced what and why HACCP means by illustration of foodborne disease in Canada before HACCP. She also introduced how to develop a HACCP Program and what the principle of HACCP is. She suggested that anyone producing food for human consumption should have a HACCP plan.
23. Prof. B.Y. Chang gave the last but one speech on "regulatory analytical methods for veterinary drug residues". Prof. Chang mentioned that the drug residue analyses related to public health, international trade or environmental problem and as powerful tool for regulation purpose have to be performed fast, reliable and within a limited budget. In her report,

Prof. Chang illustrated the characteristics of the drug residues analyses and integrated strategic approach. She also described the methods used in multi-step programs, general performance criteria for residue analytical method and the criteria for quality assurance and quality control of regulatory analysis.

24. The last speaker, Prof. J.M. Tong made his presentation on "feed antibiotics and feed safety". Prof. Tong reviewed the use of feed antibiotics in China. Although the mechanisms of the growth promoting antibiotics are still not fully understood in detail, Prof. Tong listed a number of reports have enlightened this area. He pointed out that endogenous antibiotics and Chinese Herbal Medicine would be the important sources from which to develop antibiotic replacements as feed supplements.
25. Prof. Defa Li made a closing remark. On behalf of the organizing committee, Prof. Li showed his special thanks again to Asia Pacific Economic Cooperation and Ministry of Foreign Trade and Economic Cooperation of P. R. China. He said that pollution is a world-wide issue. Not only to be the problem for scientists, but also for governments of each nations. He hoped this seminar would raise public and government awareness of the effects of food sanitation and food safety concerning the animal products on human health. And from now on, each government, research institutes, and animal production producers, among Asia-Pacific Economic Cooperation would impact great strength on this issue. Prof. Defa Li advocated that in order to achieve a sustainable development, we should do something right now.
26. All participants expressed their sincere appreciation to MOFTEC, MAFIC and CAU for the warm hospitality and also the excellent arrangement made for the Seminar.
27. "2000 APEC Seminar on Public Health Issues in Animal Production/Animal Products" has achieved a complete success.

AGENDA

Oct. 15 (Sunday)

09:00~17:00 Registration
12:00~14:00 Lunch Break
18:00-20:00 Opening Reception   Reception invited by Prof**. Defa Li**

Oct. 16 (Monday)

08:30~12:00 Registration

Chairperson : Dr. H. Yano (Japan)
09:00~09:15 Opening Address Dr. **Defa Li** (Chairman of Organization Committee)
09:15~09:30 Welcome Remark Mr. **S. G. Zhang** (President of APEC, China)
09:30~09:40 Congratulatory Speech Mr. **S. R. Jiang** (President of CAU)
09:40~09:50 Congratulatory Speech Prof. **In K. Han** (Past President of AAAP)

Section 1. Public Health Issues in Animal Production

09:50~10:40 **Speaker 1 (Prof. InK Paik, Korea)**
10:40~11:00 Coffee Break
11:00~11:50 **Speaker 2 (Prof. D.W.Chen, USA)**
11:50~12:00 Take Picture
12:00~13:30 Lunch Break

Chairperson : Prof. M. Wanapat, (Thailand)
13:30~14:20 **Speaker 3 (Prof. InK Han, Korea)**
14:20~15:10 **Speaker 4 (Prof. D.X. Lu, China)**
15:10~15:30 Coffee Break
15:30 ~16:20 **Speaker 5 (Prof. M. Wanapat, Thailand)**

Oct. 17 (Tuesday)

Chairpersons : Prof. InK Paik (Korea)

09:00~09:50 **Speaker 6 (Prof. H. Yano, Japan)**
09:50~10:40 **Speaker 7 (Dr. YuYu, Hongkong, China)**
10:40~11:00 Coffee Break.
11:00~11:50 **Discussion**
11:50~13:30 Lunch Break
13:30~17:00
Tour : Technical field trip for overseas participants will be organized APEC at free of charge.
Hotel → Ministry of Agriculture Feed Industry Center, MAFIC→Tiananmen→ Hotel

Section 2. Public Health Issues in Animal Products

Oct. 18 (Wednesday)

Chairperson : Dr. J. M. Tong (China)
09:00~09:50 **Speaker 8 (Prof. M. H. Lee, Korea)**
09:50~10:40 **Speaker 9 (Prof. Mary Barton, Australia)**
10:40~11:00 Coffee Break
11:00~11:50 **Speaker 10 (Prof. W.W. Gao, China)**
11:50~13:30 Lunch Break

Chairperson : Dr. Mary Barton (Australia)
13:30~14:20 **Speaker 11 (Prof. Lynn McMullen, Canada)**
14:20~15:10 **Speaker 12 (Prof. B. Y. Chang, China)**
15:10~15:30 Coffee Break
15:30~16:20 **Speaker 13 (Prof. J. M. Tong, China)**
16:20~17:10 Closing Remark **(Prof. Defa Li)**
18:00~20:00 Closing Reception

Oct. 19 (Thursday)
09:00~16:30
Hotel→China Agricultural University→China Academy of Agriculture Science →Hotel

List of Speakers

1. **The Main Sources of Animal Pollution: Nitrogen, Phosphorus and Pharmacological Level Minerals**
Dr. In K. Paik (Korea)
Department of Animal Science
Chung-Ang University
Korea
E-mail: ikpaik@cau.ac.kr

2. **Environmental Challenges of Animal Production and the Role and Task of Animal Nutrition in Environmental Protection**
Prof. D.W.Chen
USA
E-mail: cdaiwen@hotmail.com

3. **Feeding and Management System to Reduce Environmental Pollution in Animal Production**
Prof. In K. Han
Department of Animal Science & Technology
College of Agriculture & Life Sciences
Seoul National University, Suweon 441-744, Korea
Korea
Tel: 82-331-292-0898, Fax: 82-331-291-7722
E-mail: inkhan@kornet.net

4. **Advances in Enhancing Nutrient Utilization for Ruminants by Nutritional Manipulation to Reduce Environmental Contamination**
Prof. D. X. Lu
President, National Society of Animal Nutrition
China Association of Animal & Veterinary Sciences
Inner Mongolian Academy of Animal Sciences
PR.China
E-mail: nmxky@email.nm.cninfo.net

5. **Nutritional Control to Reduce Nitrogen Excretion From Cattle**
Dr. M. Wanapat
Dept. of Animal Science, Faculty of Agriculture
Khon Kaen University
Thailand
E-mail: metha@kku1.kku.ac.th

6. **Nutritional Control to Reduce Phosphorus Excretion From Mmonogastric Animals**
Prof. H. Yano
Department of Animal Science
College of Agriculture , Kyoto University, Kyoto 606
Japan
Tel : 81-75-721-4738, Fax : 81-75-753-6344

E-mail: yanoh@adm.kais.kyoto-u.ac.jp

7. Reduction in Animal Waste Through Effective Nutritional Means

Dr. YuYu
National Renderers Association, Inc.
Hongkong, China
E-mail: nrahkg@compuserve.com

8. Public Health Risks: Drug and Antibiotic Residues

Dr. M. H. Lee
Laboratory of Biochemistry
College of Veterinary Medicine, Seoul National University
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9. Public Health Risks: Antibiotic Resistance

Dr. Mary Barton
School of Pharmcy and Medical Sciences
University of South Australia
GPO Box 2471 Adelaide SA 5001
Australia
Tel:618-8320-2933, Fax:618-8320-2389
E-mail: mary.barton@unisa.edu.au

10. Alternatives to Drug Use: Chinese Herbs

Prof. W. W. Gao
Chinese Herbs Research Institute
PR. China
E-mail: tjming@public.fhnet.cn.net

11. HACCP for Control of Microbial Contamination

Dr. Lynn McMullen
Department of Agriculture, Food and Nutrition Science
2-06J Agriculture-Forestry Building
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Canada
Tel:1-780-492-6015
E-mail: lynn.mcmullen@ualberta.ca

12. Detecting and Measuring Drug Residues

Prof. B. Y. Chang
China Academy of Agri. Sci
PR. China

13. Strategies to Reduce Drug Use: Disease Prevention and Quality Assurance

Prof. J. M. Tong
Animal Husbandry Research Institute
PR. China
Tel: 86-10-62816061
E-mail: tjming@public.fhnet.cn.net

WELCOME ADDRESS

- From the organizing committee -

Ladies and Gentlemen:

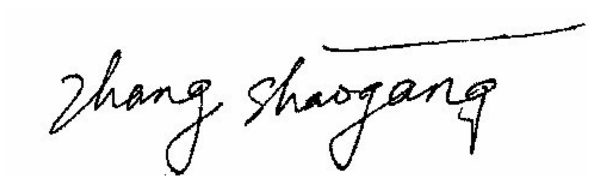
On behalf of the Organization Committee, it is my great pleasure to invite you to attend the 2000 APEC China seminar on "Public health Issues in Animal Production / Animal Products " held in Beijing, China from October 15-19, 2000.

Feed is the in-direct food of human beings. While relating to domestic animal's health directly, feed is related to human's health in-directly. The purpose of the seminar is to increase safety of food by arousing relevant enterprises' attention to public health and by improving their knowledge and skills on food management.

The purpose of the seminar is also to enhance environmental protection by arousing relevant enterprises' attention and public's concern to environmental protection with the introduction of current research on feed management. Through a series of nutrient strategies, the environmental pollution of manure could be reduced.

We sincerely hope that the seminar will make greater contributions to the further development of animal industry, to the strengthening of friendship and to the improvement of human health in the 21th century through our joint efforts.

Beijing, the capital of China, possesses a wealth of historical monuments and tourist sites. We wish you enjoyable and fruitful 2000 APEC China Seminar in Beijing.



Zhang ShaoGang
Deputy Director
Department Of International Trade and Economic Affairs
Ministry of Foreign Trade and Economic Cooperation

WELCOME ADDRESS

FROM THE ORGANIZING COMMITTEE

Ladies and Gentlemen:

On behalf of the organizing committee, I am privileged to welcome you all to APEC seminar on "Public health issues in animals production /animal products ". I would like to extend a warm greeting to the experts and distinguished speakers invited from all over the world. We are truly very pleased that you are contributing your expertise through oral and poster presentation .I am sure that we all will enjoy exciting and thought–provoking topics during the sessions and will return to our work refreshed and reinvigorated.

As most of you may already know, with the speeding development of world husbandry, the pollutants from animal production to the environment, food of people, and water are becoming heavier and heavier, and more and more people become caring about the pollution. The theme of this seminar is about "Public health issues in animals production /Animal products", and the purpose of the seminar is to raise public awareness of the effects on their health of antibiotic residues in domestic animal products and to explore ways of reducing antibiotic use in animal diets. The purpose of the seminar is also to raise public awareness of environmental pollutants resulting from animal production and to introduce current research on feed management that can reduce that pollution, and how to develop a sustainable husbandry is also a purpose of this seminar.

I appreciate all participants for making this seminar meaningful. Special thanks are extended to financial sponsors-Asia Pacific Economic Cooperation, Ministry of Foreign Trade and Economic Cooperation. We wish you enjoyable and fruitful APEC Seminar in Beijing .

Defa Li (Ph.D)

Chairman of Organization Committee APEC Seminar
on "Public Health Issues in Animal Production /Animal Products"
China Agricultural University
Director of Ministry of Agriculture Feed Industry Center. .

CONGRATULATORY SPEECH

2000 APEC China Seminar on Publich Health Issues
in Animal Production / Animal Products

October 15～19, 2000 Friendship Hotel, Beijing, China

Dr. Defa Li, Mr. S. G. Zhang, Mr. S. R. Jiang, ladies and gentlemen. On behalf of the World Association for Animal Production (WAAP), I am much honored to deliver a congratulatory speech at the opening ceremony of 2000 APEC China Seminar on Public Health Issues in Animal Production and/or animal products. Although foods of animal origin were able to improve significantly health status of human beings in the past and consequently, have resulted in considerable extention of life span. For example, average life span of world population has increased 14 years in last 40 years time from 52 years in 1960 to 66 years in 2000. During the same period, the animal protein intake per person per day has also been increased from 20 g to 27 g. However, we should pay a great deal of attention to public concerns related to animal products and animal production systems, since the quality and safety of animal products have direct effects on human health. One should realize that public awareness of the negative effects on their health of antibiotic residues, some heavy metals contamination and environmental hormone residues in domestic animal products. Similarly, there has been public critics on environmental pollution resulting from animal feeds, animal feeding and management systems. Therefore, it would be a very important issue that we should be able to produce clean, antibiotic and environmental hormone free foods of animal origin through sustainable animal production in the 21st century. In these senses, the APEC 2000 China Seminar is timely organized to discuss how to develop sustainable animal agriculture through the collaborative technical programs among the member countries of the APEC.

Many congratulations for the successful 2000 APEC China Seminar on public health issues in animal production and/or animal products which is held on October 15～19, 2000 here at beautiful and historical city of Beijing. I do sincerely hope that all speakers will discuss how to solve the public health issues related to antibiotic residues and environmental pollution from animal production. Thank you very much for your kind attention.

In K. Han (Professor)

Immediate Past President of
World Association for Animal Production (WAAP)

CLOSING REMARKS

Ladies and Gentlemen,

"2000 APEC Seminar" has been held on Oct.15th,2000 in Beijing, China. 13 speakers from 8 nations and region (Australia, Canada, Japan, Korea, Thailand, USA, Hongkong China, China, Brunei) have given their presentation on "Public Health Issues in Animal Production /Animal Products". Over 70 person joined the seminar.

On behalf of the organizing committee, I am privileged to show my special thanks to Asia Pacific Economic Cooperation and Ministry of Foreign Trade and Economic Cooperation of P. R. China.

Public health and environmental pollution is a world-wide issues. Not only to be the problem for scientists, but also for governments of each nations.

I hope this seminar would raise public and government awareness of the effects of food sanitation and food safety concerning the animal products on human health.

To achieve a sustainable development, what should we do now? I think we do know how and what to. As we all know, we have only one earth. And the earth belongs to everyone, not only to human beings, but also to other species.

"2000 APEC Seminar on Public Health Issues in Animal Production/Animal Products" had made great achievement. I wish that, from now on, each government, research institutes, and animal production producers, among Asia-Pacific Economic Cooperation would impact great strength on this issues.

At last, I would appreciate all participants for making this seminar meaningful.

Thank you!

Defa Li (Ph.D)
Chairman of Organization Committee

The Main Sources of Animal Pollutions: Nitrogen, Phosphorus and Pharmacological Level Minerals

I. K. Paik

Department of Animal Science, Chung-Ang University,
Ansung-Si, Kyonggi-do, 456-756,Korea

Abstract
In order to prevent pollution from animal waste, P, N, and pharmacological level minerals should be properly managed. Microbial phytase has been used successfully to control P excretion. Activity of natural phytase in certain plant feedstuffs is high enough to be considered in feed formulation. Nitrogen control can be achieved through amino acid supplementation and protein restriction in the diet. Supplementation with carbohydrases reduces output of excreta as well as N. Ammonia release from the manure could be reduced by using a low crude protein diet along with the supplementation with probiotics products. Excretion of minerals used at pharmacological level can be reduced by using chelated forms. Cu and Zn in the form of methionine chelate have been successfully used in the broiler and pig diet.

Ⅰ. Introduction

The animal industry must be environmentally sound to ensure its long-term sustainable growth. Livestock wastes, mostly manure, can be a valuable resource as a fertilizer or soil conditioner. But it can be a potential hazard to environment as well. Environmental concerns relate to water quality, soil degradation, air pollution and rural-urban interface issues. Land application of excessive quantities of nutrients is subject to surface run-off and leaching that may contaminate ground or surface waters. Nitrate leaching has been considered a major nitrogen (N) pollution concern with livestock farms. Ammonia toxicity to fish and altered effectiveness of chlorination are other concerns. Phosphorus (P) entering surface waters can stimulate growth of algae and water plants. Decomposition of them results in an increased oxygen demand, which may interfere with the well-being of fish and wildlife. Excessive contributions of some minerals from animal manure can create high salt concentration in the soil. High concentration of copper in the pig diet can cause accumulation of copper in the soil. Manure can be a major source of methane and nitrogen oxides which contribute to the accumulation of greenhouse gas. Volatilization of ammonia causes acid rain which results in forest dieback in western Europe (ApSimon et al., 1987). Emissions of nitrous oxide (N_2O) during nitrification and denitrification cause depletion of the stratospheric ozone layer (Christensen, 1983). Manure can be a source of odours which contribute to friction between urban and rural residents.

As described above, animal manure can be a valuable resource while it can be a major obstacle in the future development of animal industry if the impact on environment is not properly controlled. Major efforts are required to adopt all best available technologies capable of reducing excretion of pollutants from animal industry before further restrictive legislation is enacted to control the problem. There are a number of possible solutions to this problem.

The first option of manure management is developing an 'environmentally sound'

nutritional management, that is, feeding program and feeds to result in less excreted nutrients that need to be managed. Once the manure is produced it can be best utilized as a fertilizer or a soil conditioner. In many countries the amount of manure that can be spread on land depends on the nutrient requirements of the crop being grown. The laws specify maximum application rates and not animal stocking rates. Farmers who reduce the N and P component of manure can release pressure on the environment without having to reduce the number of animals. There are alternative systems for housing and manure treatment which generate manures that are easier to handle and have less pollutants or more economic value. Treated animal wastes may also be used as a feedstuff or fuel source.
The present paper reports the results of experiments conducted at author's and some other laboratories regarding to the nutritional management to control environment pollution from animal production.

Ⅱ. Phosphorus control

1. Microbial phytase

In broiler chickens, phytase supplementation at a level of 1,000 U/kg diet increased the bioavailability of P and Ca by 60% and 26%, respectively (Simons et al., 1990). The beneficial effects of phytase supplementation were illustrated by Zyla and Korelski (1993). The performance of birds fed available P deficient diets was improved by the addition of phytase to the diets. The *in vitro* activity (i.e. ability to dephosphorylate phytate) was also demonstrated, confirming the proposed mode of action of this enzyme. The direct benefits of dietary phytase supplementation on bone mineralization have been shown by Farrel and Martin (cited by Annison and Choct, 1993) who reported that tibial ash deposition was enhanced in birds fed phytase supplemented diets. Simons and Versteegh (1993) summarized the results of several experiments conducted in Netherlands. A microbial phytase product from *Aspergillus niger* was added to broiler feed with a low inorganic P level. The availability of total P could be increased up to 70%. In comparison with feed with increased levels of inorganic feed phosphates, a significantly larger amount of the P consumed was absorbed. Improved utilization of P decreased its excretion by 40% or more. Growth and feed conversion ratios were comparable with feed to which inorganic feed phosphate was added. In layers the degradation of phytate and the absorption of P was slightly decreased by higher amounts of Ca in the diets (4.0% vs. 3.0% Ca in feed), nevertheless at both levels the efficacy of phytase addition was satisfactory. In broilers up to 500 units of phytase per kg feed, 250 units phytase was equivalent for P absorption with 0.5 g monocalcium phosphorus (MCP) P per kg feed. Addition of up to 300 units phytase per kg feed for laying hens resulted in a minimal equivalency of 0.3 g MCP P per 100 units phytase.
In a feeding trial with laying hens the effectiveness of microbial phytase in diets based on corn-soya and wheat-soya was tested (Peter and Jeroch, 1993). The supplement of phytase (500 U/kg diet) or inorganic P (0.1% of diet) had a positive effect on the performance of the corn-soya group but no effect on that of the wheat-soya group. The highest breaking strength of the egg shell was recorded with hens that received the phytase supplement in the corn-soya group. Mineralization of the tibia bone was also improved with phytase addition. Provided phytate P content and plant phytase activity are taken into account, it should be possible to mix layer diets which require minimum amount of supplementary inorganic P with 250 U phytase supplemented (Um et al.,

1998) or do not require supplementary inorganic P sources with 500 U phytase supplemented (Um and Paik, 1998).

Although microbial phytases have shown an ability to enhance P availability in many varied situations, several technical problems still exist that prevent the universal application of such enzymes. These include instability to gastric pH and a severe loss in activity at elevated, present day processing temperatures. Such difficulties present a challenge to producers of microbial phytases, which the tools of biotechnology can address (Power, 1993).

Table 1 and 2 shows summary of the feeding trials conducted with microbial phytases in author's laboratory.

Table 1. Effects of supplemental phytases on the productivity and P excretion of laying birds

Experiment	Level of NPP[1], %	Supplemental phytase, unit	Egg production	Feed/egg mass	P excretion
1	0.37	0	100	100	100
	0.37	500	102.2	99.6	88.5
	0.24	500	100.4	100.4	70.5
	0.12	500	100.4	100.4	59.0
2	0.27	0	100	100	100
	0.22	250	100.3	100.5	88.5
	0.16	250	101.4	98.6	67.3
	0.11	250	99.1	100.3	57.7
3	0.25(Ca 4%)	0	100	100	100
	0.25(Ca 4%)	300	103.1	99.8	94.4
	0.25(Ca 3%)	0	102.1	96.1	102.8
	0.25(Ca 3%)	300	104.5	91.6	86.1
	0.15(Ca 4%)	0	97.6	130.4	86.1
	0.15(Ca 4%)	300	97.2	101.6	72.2
	0.15(Ca 3%)	0	100.6	89.9	83.3
	0.15(Ca 3%)	300	101.5	95.0	80.6

[1]Nonphytate phosphorus

Table 2. Effects of supplemental phytase on the productivity and P excretion of broiler

Experiment	Level of NPP[1], %		Supplemental	Performance index		
	Starter	Finisher	phytase, unit	Gain	Feed/gain	P excretion
1	0.45	0.40	0	100	100	100
	0.34	0.31	600	101.0	98.7	76.2
	0.23	0.21	600	99.3	101.3	54.8
	0.13	0.12	600	96.7	103.3	40.5
2	0.45	0.35	0	100	100	100
	0.35	0.25	0	89.4	100.6	84.8
	0.25	0.15	0	60.5	108.7	51.5
	0.25	0.15	600, Phyt-A[2]	82.2	109.3	39.4
	0.25	0.15	600, Phyt-B[3]	78.9	109.3	45.5
3	0.45	0.35	0	100	100	100
	0.45	0.35	500	99.9	100	107.4
	0.35	0.25	0	87.3	102.5	85.2
	0.35	0.25	500	97.0	100.6	70.4
	0.25	0.15	0	57.3	101.2	81.5
	0.25	0.15	500	65.1	108.1	55.6
4	0.45	0.35	0	100	100	100
	0.45	0.35	600	100.6	100	92.7
	0.35	0.25	0	92.5	103.0	78.6
	0.35	0.25	600	100.5	101.2	72.9

[1]Nonphytate phosphorus, [2]Crude phytase A(soup + cell), [3]Crude phytase B(soup)

2. Plant phytase

It is generally accepted that approximately one third of phosphorus in the plant origin feedstuffs are available to monogastric animals. However, proportion of phytate P of total P varies from 12% in tapioca to 83% in wheat bran. Natural phytase content also varies widely from almost none in corn to 2395U in wheat bran (Table3). Such differences should be considered in calculating available P content of diets.

Table 3. Total P, phytate P content and phytase activity of plant origin feedstuffs

Ingredients	Phytate-P ㎎/100g	Total-P ㎎/100g	Phytate-P % of total P	Phytase activity, U/㎏
Corn	60	182	32.7	0.2
Lupin	55	307	17.8	3.2
Tapioca	7	59	11.9	18.8
Wheat	199	295	67.5	1120
Sesame meal	542	816	66.4	3.0
Soybean meal	286	577	49.6	7.5
Cottonseed meal	303	678	44.7	2.4
Cocunut meal	204	539	37.8	350
Corn germ meal	32	130	24.4	12.6
Corn gluten meal	287	536	53.5	170
Corn gluten feed	896	1099	81.5	14.8
Rapseed meal	535	1016	52.7	103
Wheat bran	742	893	83.1	2935
Rice bran	1201	1886	63.7	-
Rice bran (fat-free)	1077	1899	56.7	114

Characteristics of wheat phytase and microbial phytase were compared. Both of them showed similar characteristics at varying pH and temperature. Maximum activities were achieved around pH5.5 and 50°C (Fig 1 and 2). Considering these characteristics, plant phytase may be as effective as microbial phytase to the animals.

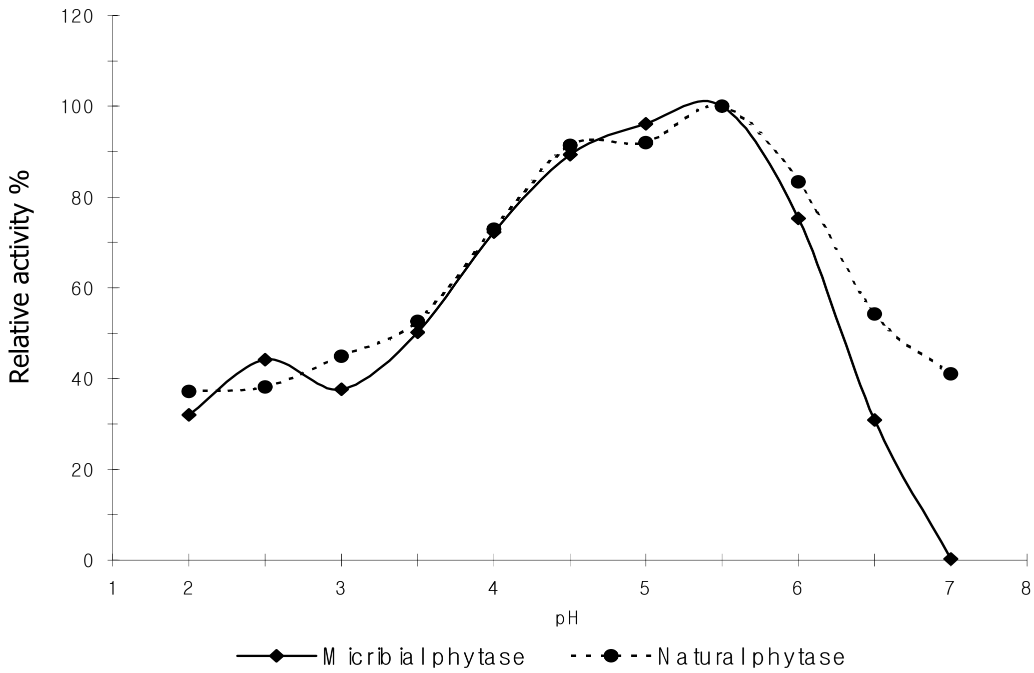


Fig 1. Activity of microbial and plant origin natural phytase at different pH

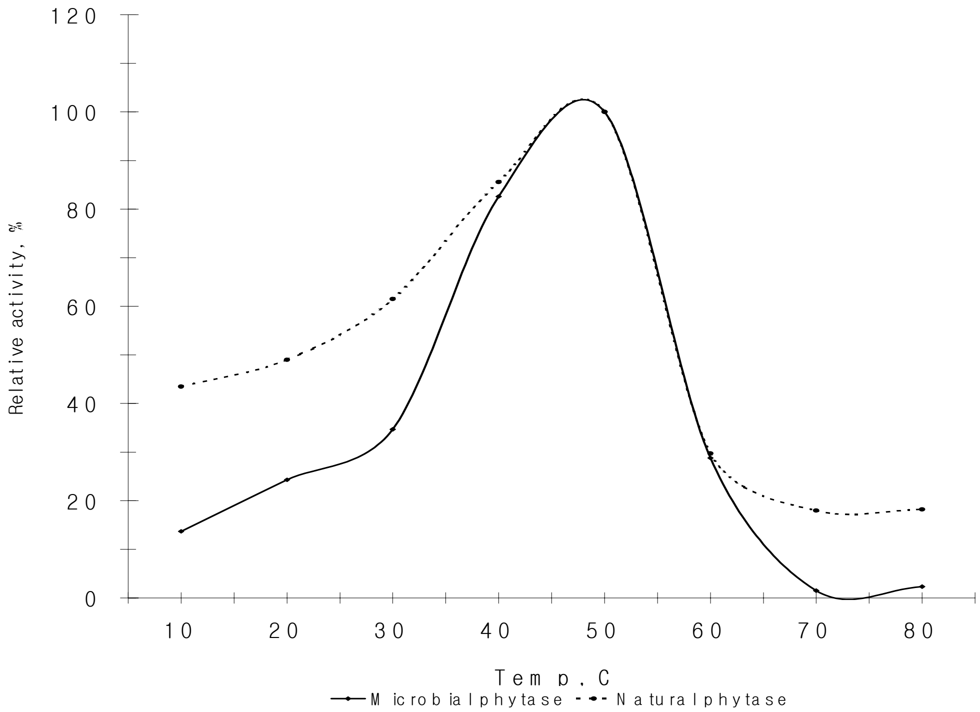


Fig 2. Activity of microbial and plant origin natural phytase at different temperature

Ⅲ. Nitrogen control

1. Amino acids supplementation and protein restriction

Table 4 shows the effect of dietary protein levels and enzyme supplementation on daily N output in broiler. Broilers fed reduced protein diets supplemented with amino acids performed as well as, if not better than, the broilers on the control (normal) protein diets and showed a significant reduction in daily N ouput (24% at 2 wk and 17% at 5 wk).

Table 4. The effect of dietary protein and enzymes on the growth performance and daily N output of broilers

Diet description			Weight gain		Feed intake		Feed conversion		Daily N output (g/bird)	
Protein	Phytase	Pentosanase	2 wk	5 wk	2 wk	5 wk	2 wk	5 wk	2 wk	5 wk
Control[1]	no	no	643	2272	758[ab]	2942	1.27[b]	1.81	0.67[abc]	2.12[a]
Control	yes	no	626	2277	794[a]	2907	1.37[a]	1.76	0.73[ab]	1.66[bc]
Control	yes	yes	641	2326	793[a]	2959	1.33[ab]	1.76	0.80[a]	1.80[bc]
Control	no	yes	642	2325	761[ab]	2961	1.28[b]	1.77	0.63[bcd]	1.92[ab]
Average			638	2300	777	2942	1.31	1.78	0.71	1.88
Reduced[2]	no	no	635	2230	747[ab]	2882	1.27[b]	1.82	0.58[bcd]	1.91[ab]
Reduced	yes	no	608	2138	735[b]	2765	1.31[ab]	1.81	0.53[cd]	1.74[bc]
Reduced	yes	yes	598	2106	754[b]	2747	1.36[a]	1.82	0.48[d]	1.39[cd]
Reduced	no	yes	646	2250	758[ab]	2894	1.26[b]	1.80	0.56[cd]	1.56[bcd]
Average			622	2181	749	2822	1.30	1.81	0.54	1.65

(Jacob, et al. 2000)

[a,b,c,d] $P<0.05$.

[1]The protein levels of control protein diet were 23% CP in starter and 21% CP in grower.

[2]The Protein levels of reduced protein diet were 21% CP in starter and 17.5% CP in grower. Reduced protein diets were supplemented with synthetic amino acids to meet their requirements.

A similar experiment with laying hens indicated that reducing crude protein levels from 17% to 13.5% with supplementation of synthetic amino acids significantly reduced the daily N output (24.8% and 35.6% in collection 1 and 2, respectively) with no significant effect on egg production except one treatment with phytase (Table 5).

Table 5. The effect of dietary protein and enzymes on the egg production and daily outputs of dry matter and nitrogen of laying hens

				Daily output (g/layer)			
Diet description			Egg production	DM		N	
Protein	Phytase	β-glucanase	%	Collection 1	Collection 2	Collection 1	Collection 2
17	no	no	85.8[a]	28.99[a]	31.40[a]	1.21[a]	1.38[ab]
17	yes	no	86.9[a]	26.47[ab]	26.17[ab]	1.13[abc]	1.21[b]
17	yes	yes	89.1[a]	30.24[a]	30.92[a]	1.36[a]	1.45[a]
17	no	yes	86.6[a]	28.74[a]	29.25[a]	1.30[ab]	1.38[ab]
Average			87.1	28.61	29.44	1.25	1.36
13.5[1]	no	no	85.0[ab]	26.79[ab]	26.17[ab]	1.06[bc]	0.98[c]
13.5	yes	no	78.4[b]	21.34[c]	18.67[c]	0.91[c]	0.78[c]
13.5	Yes	yes	82.6[ab]	21.92[c]	22.53[bc]	0.86[c]	0.94[c]
13.5	No	yes	84.9[ab]	23.78[bc]	22.51[bc]	0.92[c]	0.79[c]
Average			82.73	23.46	22.47	0.94	0.87

(Jacob, et al. 2000)

[a,b,c] $P<0.05$. [1] 13.5% CP diets were supplemented with synthetic amino acids to meet their requirements.

2. Carbohydrase supplementation

Non-starch polysaccharides (NSP) in some feed grains (e.g. pentosans or arabinoxylans in wheat and rye, and b-glucans in barley and oat) are soluble fibers. Their presence can either block digestion of other nutrients (e.g., protein and starch), or can seriously inhibit absorptive capacity. Therefore, the digestibility of NSP is low in monogastric animals (Table 6).

It was found that the results of using enzymes (xylanase or b-glucanase) did not stem from complete hydrolysis of the non-starch polysaccharides but that relatively minor hydrolysis altered the ability of the medium to form a viscous solution and act as a barrier to endogenous enzyme activity.

In the past few years a number of different feed enzymes have been developed. The use of multi-enzyme preparations in traditional wheat-based poultry diets was examined (Graham, 1992). The results demonstrated that with a diet based on 60% wheat, a mixed enzyme preparation was capable of increasing the rate of live-weight gain (+17%) and at the same time reducing feed conversion ratio (1.46 to 1.29). There was also an increase in the N utilization percentage (37.4 to 45.3%). Such improvements were attainable even after pelleting which in itself was capable of solubilizing starch (Pettersson et al., 1991). A commercial multi-enzyme preparation from *Trichoderma viride* contained 11,150 U/g cellulase, 27,600 U/g glucanase and 37,150 U/g xylanase. This multi-enzyme product was tested with layers fed a barley-based diet (Brufau et al., 1994) and a wheat-based diet (Um et al., 1998). The results showed that barley and wheat can replace corn as an energy source in layer diets if the enzyme is properly supplemented.

For the better utilization of enzymes in feed industry, commercial enzyme preparations should be customized depending on the animal species, age of animals and major feed ingredients. Enzyme products which contain β-glucanase and xylanase in different proportion were produced from *Trichoderma longibrachiatum* and *Bacillus subtilis.* They were used with different diets (wheat-based or barley-based) in different animal species of different ages (poultry, starting pigs or growing-finishing pigs). Enzyme products supplemented to the respective diets reduced the viscosity caused by non-starch polysaccharides and increased amino acid availability as well as energy and P availability (Creswell, 1994). Low and Longland (1990) reported that N retention of pigs was slightly increased by enzyme supplementation.

Contents of moisture and N were lower in the litter of birds given diets supplemented with β-glucanase. Measurement of ammonia release from the litter indicated that when a second flock of birds was raised on the same litter, the presence of a glucanase in the diet reduced the level of ammonia release by 80% (Williams and Kelly, 1994).

An experiment was conducted to test the possible interaction of an enzyme complex and feed antibiotics on growth and metabolic parameters of broilers. The basal diet contained barley at a level of 40%. Both supplements, when added together in the diet, had almost an additive effect on growth parameters, and energy, fat and N utilization (Vukic Vranjes and Wenk, 1993).

Overall nutritional management can result in the reduction of manure output. A proven and more direct method is enzyme supplementation. Reducing the DM content of the digesta in the intestinal tract with supplemental feed enzymes has a marked impact on excreta volume and composition. In a trial offering wheat or wheat/barley-based diets to broilers, excreta weight was reduced by 17 - 28% in fresh or 12 - 15% in DM by supplementation of a multi-carbohydrases enzyme product (Table 7). The direct production benefits of lower excreta output and reduced fecal DM are seen in some broiler trials where observations on the frequency of hock lesions and breast blisters are recorded. Reductions in manure output and water content will improve litter quality, and possibly decrease carcass downgrade.

Table 6. Content of non-starch polysaccharides (NSP) in feedstuffs and digestibility of NSP in young chickens

Feedstuffs	NSP, %DM	Digestibility, %
Barley	15	14
Wheat	10	12
Soybean	20	0
Pea	22	18
Bean	23	19
Rapeseed	24	7
Wheat bran	34	9
Sunflower seed	28	17
Rice bran	25	3
Grass	28	5
Corn gluten feed (20%)	31	17

(Cited by Charlton, 1996)

Table 7. Excreta output of broilers fed wheat or wheat/barley-based diets with and without multi-enzyme (carbohydrases) supplementation at 19-21 days of age

	Wheat Control	Wheat +Enzyme	Wheat/Barley Control	Wheat/Barley + Enzyme
Fresh Excreta, g	221	184	258	185
Excreta DM, %	42.4	45.2	39.8	47.3
Dry Excreta, g	94.0	83.0	102	87.0

(Lakeside Research Center, Canada cited by Wyatt, 1995)

An layer experiment was conducted to evaluate the effect of a microbial enzyme (Roxazyme-G), a multi-carbohydrases preparation, supplementation to the wheat-based layer diets. Diets were formulated to include different levels of wheat replacing yellow corn on isocaloric and isonitrogenous basis. The energy value of wheat in the enzyme supplemented diets was adjusted (spec-modified) to have 5% more ME than the wheat in diets without enzyme. A total of 864 Hy-Line brown layers were assigned to 4 dietary treatments: 10% wheat (T1), 25% wheat (T2), 25% wheat (spec-modified) + 0.01% Roxazyme-G (T3), and all wheat (spec-modified) + 0.01% Roxazyme-G (T4). Overall performances are shown in Table 8. Hen-day egg productions of T1 and T4 were significantly ($P < 0.05$) greater than that of T2 but not different from T3. Hen-housed egg production of T4 was significantly ($P < 0.01$) greater than those of T1 and T3 but not different from T2. Egg weights of T1 and T2 were significantly ($P < 0.01$) greater than that of T4. Feed consumption of T2 was significantly ($P < 0.01$) lower than other treatments. Feed conversion ratio (feed/egg mass) was not significantly different among treatments. Eggshell thickness of T1 was significantly ($P < 0.01$) greater than other treatments but ratio of broken eggs was not significantly different among treatments. Haugh unit of T4 was significantly greater ($P < 0.05$) than that of T2. Egg yolk color was significantly ($P < 0.01$) influenced by treatments in which enzyme treatment potentiated the yolk pigmentation. It was concluded that a multi-carbohydrases supplementation enables complete replacement of yellow corn with wheat without loss of productivity and major egg quality parameters.

Table 8. Overall performance of laying hens fed experimental diets during 20 to 40 wk of age

Parameters	Treatments[1]				SEM
	T1	T2	T3	T4	
Egg production (%, hen-day)	72.7	72.0	71.8	73.4	2.04
Egg production (%, hen-housed)	67.1	67.7	66.2	68.7	2.69
Egg weight, g	59.8	59.7	59.5	59.2	0.58
Feed consumption (g/hen/day)	127.2	125.0	126.9	128.0	1.72
Feed conversion (feed/egg mass)	2.93	2.92	2.97	2.95	0.067
Mortality (%)	7.84	6.05	7.84	6.38	1.979

[1]T1: 10% wheat, T2: 25% wheat ＋ 5 ppm Carophyll Red, T3: 25% spec-modified wheat ＋ 0.01% Roxazyme-G ＋ 5 ppm Carophyll Red, T4: spec-modified wheat(no-restriction) ＋ 0.01% Roxazyme-G ＋ 5 ppm Carophyll Red ＋ 25 ppm Carophyll Yellow.

3. Ammonia control

Ammonia release from animal manure should be controlled to avoid air pollution and conserve N in the manure for use as fertilizer. The smell of pig slurry has four times the intensity of cattle, broiler and poultry manure (Pain, 1990). In terms of odour control, ammonia reduction may only play a contributory role since Schaefer (1977) correlated odour intensity with the concentrations of volatile fatty acids (C2 -C5), phenol, *p*-cresol, indole, skatole and ammonia, the highest correlations were obtained with *p*-cresol. Conservation of N in manure is important because P or K usually limit use of poultry manure for crop production and other sources of N are needed when the manure application is limited to needs for fertilizer elements. Ammonia release from manure can be limited by using additives, by drying and by acidic conditions.

Research into minimizing air pollution from animal wastes is continuing and taking many different paths. In the Netherlands, for example, they have identified a microorganism (aerobic denitrifier) which, under aerobic conditions, converts the nitrogen of ammonia and other nitrogen containing compounds into nitrogen gas. Nitrogen gas can be released into the atmosphere without causing pollution problems. Adding such bacteria to manure would reduce the emission of ammonia and reduce the nitrogen content of the manure. They are looking at the possibility of adding these bacteria to the feed (Holthuijzen, 1993).

The ammonia-binding properties of the *Yucca* extract have been widely studied. The earlier reports on the action of a *Yucca* extract to prevent the accumulation of ammonia erroneously attributed its action to an inhibition of urease by its component three steroid saponins, i.e. sarsapogenin, smilagenin and hecogenin. But Headon et al. (1991) reported that the *Yucca* extract does not inhibit urease activity and that saponin-free De-Odorase had an ammonia-binding capacity similar to that of the unfractionated De-Odorase. Recent work by Headon and Power (unpublished, cited by Leek, 1993) demonstrated that the binding agents in the *Yucca* extract are glycocomponents. Because the ammonia-binding action starts to decline slowly from fourth day onwards, atmospheric ammonia levels within the houses can be significantly reduced by including this product in the diet.

Zeolite products have been used at a level of 1 to 2% of the diet to improve pelleting quality. It is also believed that zeolite may improve the litter condition and environment of the barn. Due to a high ion-exchange capacity, it is expected that zeolite may bind ammonium ion in the litter (Moon et al., 1991). However, dietary supplementation of zeolite or top dressing of zeolite on the broiler litter did not significantly influence the level of ammonia produced from the broiler litter (Blair and Jacob, unpublished).

Table 9 and Fig 3 are summaries of an experiment conducted to reduce ammonia level in the broiler barn. Diets were formulated to have different protein level with or without supplementary amino acids (arginine, threonine and tryptophan) and a probiotic product (*Bacillus subtilis* and *Lactobacillus*).

Table 9. Feed intake, weight gain, feed/gain and mortality in broiler chickens fed different protein level diets for 35 d

Diets	Feed intake	Weight gain	Feed/gain	Mortality
	(g)		(g:g)	%
T1 (21.5% CP)	2869.8	1636.0a	1.76b	3.60
T2 (21.5% CP+BIO-21[1])	2879.9	1626.8a	1.77b	2.00
T3 (18.5% CP+AA[2])	2794.5	1518.6b	1.85a	0.40
T4 (18.5% CP+AA+BIO-21)	2859.3	1511.6b	1.88a	2.00
SEM	32.74	12.09	0.02	1.31
	Main effects			
CP				
21.5 %	2874.9	1631.4a	1.76b	2.80
18.5 %	2826.9	1515.1b	1.87a	1.20
BIO-21(SP)				
0 %	2832.1	1573.8	1.80	2.00
0.1 %	2869.6	1572.7	1.83	2.00

[1]BIO-21 is a commercial probiotics containing *B. subtilis*, *Lactobacillus* and yeast
[2]AA: amino acids supplement of arginine, threonine and tryptophan
[a-b]Values with different superscripts in the same column are significantly different($P<0.05$)

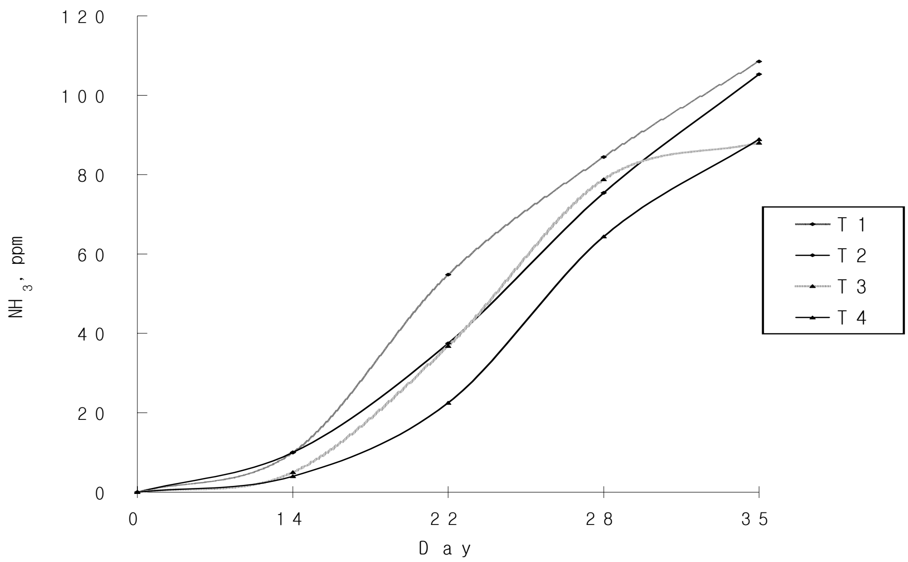


Fig 3. Ammonia level at the litter of broiler barn, determined in the air collected for 60 sec using trapping box of 36 ㎝ L × 27 ㎝ W × 18 ㎝ H.
T1; 21.5% CP, T2; 21.5% CP+BIO-21, T3; 18.5% CP+AA, T4; 18.5% CP+AA+BIO-21

Ⅳ. Mineral control

1. Chelated minerals

Some micromineral supplements are produced in the form of protected forms. Metal amino acid chelate (Ashmead, 1992), metal proteinate and metal polysaccharide complex are protected minerals. The protected minerals may be more available and not react with digesta due to both their chemical (electrically neutral, ligand and metal make up) and physical structures (size and ligand source). If this is the case, we could use less to achieve the same result. This would be excellent as potentially it would save world resources and reduce pollution.(Lowe, 1993).

High levels of copper sulphate have been widely used as growth promotants in pigs and broilers. Copper polysaccharide complex (sequestered Cu) at a level of 62.5 ppm of Cu was as effective as 200 ppm Cu in the form of copper sulphate in weanling pigs and broilers (Paik and Kim, 1993). The performance enhancing effect of methionine-Cu complex at a level of 100 ppm Cu was greater than that of copper sulphate at a level of 200 ppm Cu in broilers. The excretion of copper was significantly less in the methionine-Cu treatment than in the copper sulphate treatment (Min et al., 1993, 1994).

Table 10 shows summary of feeding trials conducted in author's laboratory to test effects of chelated copper sources on the performance of broiler chickens and pigs.

Table 10. Effects of supplementary copper chelates

Experiment	Animals	Source and level of Cu, ppm	Difference from the control, % Gain	Feed intake	Feed/gain
1	Broilers	CuSO4, 200	3.8	-0.2	-4.0
		SQM-Cu, 63.5	2.6	0.6	-3.5
		SQM-Cu, 127	3.5	-0.2	-4.0
		SQM-Cu, 191	3.8	1.7	-2.0
2	Pigs	CuSO4, 200	6.4	4.0	-3.1
		SQM-Cu, 63.5	4.1	0.9	-3.5
		SQM-Cu, 127	7.5	3.1	-4.8
3	Broilers	CuSO4, 200	-0.9	-0.6	0.0
		Met-Cu, 200	2.5	-0.5	-3.3
		SA-Cu, 200	1.1	-0.3	-1.6
4	Broilers	CuSO4, 200	0.3	-2.0	-2.2
		Met-Cu, 200	2.1	-0.5	-2.2
		FM-Cu, 200	0.2	-1.4	-1.7
	Rats	CuSO4, 200	-7.0	-5.3	1.9
		Met-Cu, 200	-7.5	-3.7	3.8
		FM-Cu, 200	-6.3	-3.0	3.4
5	Broilers	CuSO4, 200	4.3	-1.4	-5.7
		Met-Cu, 200	6.3	3.1	-3.2
		Met-Cu-Zn-Fe, 200	2.2	0.0	-1.9
		FM-Cu, 200	2.0	1.2	-0.6
6	Pigs	CuSO4, 200	7.5	-5.9	-3.8
		Met-Cu, 100	10.1	0.4	-1.9
		Met-Cu, 200	8.2	9.6	0.0
7	Pigs	CuSO4, 200	5.5	2.6	-4.6
		Met-Cu, 200	17.8	-7.2	-9.8
		FM-Cu, 200	0.0	-16.4	-4.6
8	Broiler	CuSO4, 250	-1.5	-2.2	-0.6
		Met-Cu, 125	4.6	2.3	-2.5
		Met-Cu, 250	4.0	2.4	-1.8

The effects of copper sources were compared with the results of non-supplemented control groups. In broiler chickens, supplemental copper sulfate at the level of 200 ppm was effective for increasing weight gain in Exp 1 and 5 but not in Exp 3, 4 and 8. Supplementation of chelated coppers (SQM-Cu and Met-Cu) had always positive effect on broiler performance. Supplementation of copper sources had detrimental effect on rats. Met-Cu, SQM-Cu, and copper sulfate had better effect on weight gain in pig than in broiler chickens. The effect of Met-Cu on the performance of broiler chicks was high compared to those of fish meal-Cu (FM-Cu) or sodium alginate-Cu (SA-cu). Considering the results of experiments 6 (pig) and 8 (broiler chickens), it appears that dietary level of 100~125 ppm copper in chelated form is enough to improve the performance of pigs and chickens. This will result in reduction of fecal Cu excretion to the environment. Growth-stimulating action of dietary Cu has been attributed to its antimicrobial actions (Fuller *et al*., 1960; Vogt *et al*., 1981). However, the antimicrobial hypothesis alone can not fully explain the effects of Cu. It has been demonstrated that intravenous injection of Cu stimulates the growth of weanling pigs (Zhou, *et al*., 1994). The results of this experiment indicated that Cu acts systemically to influence the growth regulatory system in many ways. Kratzer and Vohra (1986) reported that metal ion chelated with low molecules of peptide such as amino acid or organisms have more stable, neutral electrocity and therefore, chelated minerals is easier to pass through intestinal wall than natural minerals.

Table 11 shows the effects of supplemental chelated zinc in weanling pigs. Chelated zinc had a similar solubility with chelated copper. In experiment 1, dietary levels of methionine chelated zinc at 100 and 200 ppm and zinc oxide at 100 ppm in zinc increased weight gain and feed intake compared to the control (100 ppm of Zn in ZnO) but only 200 ppm of zinc in the form of chelated zinc improved feed to gain ratio compared to the control. In experiment 2, 1,000 or 2,000 ppm of dietary zinc in zinc oxide increased weight gain and feed intake but high dietary level of Zn (1,000 and 2,000 ppm) in the form of methionine chelate had diminishing effect on weight gain and feed intake compared to 100 ppm of Zn in the form of methionine chelate. One hundred ppm of Zn in the form of methionine chelate showed highest weight gain and feed intake.

Table 11. Effects of supplementary zinc oxide and Zn chelates in weanling pigs

Experiment	Source and level of Zn, ppm	Difference from the control (ZnO, 100 ppm), %		
		Gain	Feed intake	Feed/gain
1	ZnO, 200	8.3	9.6	0.5
	Met-Zn, 100	3.0	3.0	0.5
	Met-Zn, 200	18.8	15.1	-3.8
2	ZnO, 1000	10.0	9.2	-1.4
	ZnO, 2000	11.0	12.8	1.4
	Met-Zn, 100	15.6	15.9	0.0
	Met-Zn, 1000	6.5	12.2	7.6
	Met-Zn, 2000	-2.0	9.4	11.7

Footnotes: Met-Zn; methionine-Zn chelate

Table 12, 13 and 14 show the effect of supplementary Zn, Cu and Mn chelated with methionine in laying hens. One hundred ppm Cu in the form of methionine chelate was most effective in improving egg production, feed efficiency and egg shell quality. Zn-Met and Mn-Met + Zn-Met did not improve laying performance and egg quality. Combination of Zn-Met + Mn-Met + Cu-Met did not have any additive effects in the performance of layers.

Table 12. Result of laying performance of hens fed mineral-methionine chelate diets for 8wks (96～103 wks of age)

	Treatments*					SEM
	Control	Zn-Met	Cu-Met	Zn-Met + Mn-Met	Zn-Met + Mn-Met + Cu-Met	
Hen-day egg production, %	69.97[ab]	67.13[c]	72.57[a]	68.37[bc]	71.67[a]	2.702
Hen-housed egg production, %	68.80[bc]	65.61[d]	72.57[a]	67.48[cd]	70.82[ab]	2.821
Egg weight, g	70.27[ab]	70.77[a]	69.33[c]	69.72[bc]	70.04[abc]	0.717
Feedintake, g/hen/day	127.9[ab]	127.3[ab]	129.2[ab]	126.9[b]	130.4[a]	2.965
Feed conversion ratio, g/100g egg mass	2.62[ab]	2.71[a]	2.58[b]	2.68[ab]	2.60[ab]	0.103

* Mineral-methionine chelate was supplemented at the level of 100ppm of each mineral

Table 13. Result of eggshell quality of hens fed mineral-methionine chelate diets for 8wks (96～103 wks of age)

	Treatments*					SEM
	Control	Zn-Met	Cu-Met	Zn-Met + Mn-Met	Zn-Met + Mn-Met + Cu-Met	
Albumin hight, mm	6.305	6.259	6.375	6.296	6.382	0.172
Haugh unit	74.96	97.05	75.46	74.63	75.77	28.448
Specific gravity	1.0845[b]	1.0851[b]	1.0864[a]	1.0847[b]	1.0851[b]	1.136
Eggshell strength, kg/cm^2	0.540[c]	0.546[bc]	0.573[a]	0.562[ab]	0.562[ab]	0.018
Eggshell thickness, ㎜	0.366	0.375	0.374	0.376	0.369	0.010
Soft egg production, %	0.59[ab]	0.78[ab]	0.31[b]	1.07[a]	0.60[ab]	0.495
Broken egg production, %	3.81[c]	4.76[bc]	4.71[bc]	6.90[a]	5.59[ab]	4.465

* Mineral-methionine chelate was supplemented at the level of 100ppm of each mineral

Table 14. Result of IgG, gizzard erosion index and mineral contents in liver of hens fed mineral-methionine chelate diets for 8wks (96～103 wks of age)

	Treatments*					
	Control	Zn-Met	Cu-Met	Zn-Met + Mn-Met	Zn-Met + Mn-Met + Cu-Met	SEM
IgG, mg/mℓ	25.3	20.8	32.0	24.0	22.7	4.68
Gizzard erosion index	0.30[c]	0.50[bc]	1.25[a]	0.90[ab]	1.35[a]	0.18
Mineral contents in liver						
Zinc	99.5[ab]	104.5[a]	96.4[ab]	95.1[ab]	82.8[b]	6.38
Copper	12.6	12.3	14.9	12.8	14.1	2.18
Manganese	10.3	10.1	10.3	10.3	11.3	0.72

* Mineral-methionine chelate was supplemented at the level of 100ppm of each mineral

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Environmental Challenges of Animal Production and the Role and Task of Animal Nutrition in Environmental Protection

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Abstract

Animals are one of the important memberships of the food chain. The low-efficiency rule of nutrient transfer from one member to the next in the food chain determines the low efficiency of animal production for human food. On the average, about 20% feed proteins and 15% feed energy can be converted into edible nutrients for humans. The rest proportion of feed nutrients is exposed to the environment. Environmental pollution,therefore, is inevitable as animal production grows intensively and extensively. The over-loading of the environment by nutrients such as nitrogen, phosphorus from animal manure results in soil and water spoilage. The emission of gases like CH_4,CO_2,SO_2,NO,NO_2 by animals are one of the contributors for the acidification of the environment and global warming. The inefficient utilization of natural resources and the probable unsafety of animal products to human health are also a critical environmental issue. Improving the conversion efficiency of nutrients in the food chain is the fundamental strategy for solving environmental issues. Specifically in animal production, the strategy includes the improvements of animal genotypes , nutritional and feeding management, animal health, housing systems and waste disposal programs. Animal nutrition science plays a unique and irreplaceable role in the control of nutrient input and output in either products or wastes. Several nutritional methods are proved to be effective in alleviating environmental pollution. A lot of nutritional issues ,however, remain to be further researched for the science of animal nutrition to be a strong helper for sustainability of animal agriculture.

Key Words: Food Chain Animal Production Environment Animal Nutrition

Introduction

The environmental issues related to modern animal production are of global concerns and interests .The objective of animal production has been shifted from one goal of high yield of animal products into the multiple goals including high yield of safe animal products, high utilization of natural resources and minimum environmental pollution. Animal nutrition plays an important role in realizing the new objective of animal production. The role, however, may be limited because animal production itself is a process of low efficiency of nutrient conversion and many other factors are related to the process. This overview is intended to explain the inevitability of environmental pollution by intensive animal production and the dependence of alleviating environmental risk on all the related factors being taken into accounts at the same time, with emphasis on the role and future task of animal nutrition, one of the factors related to animal production. The specific nutritional management for minimizing environmental pollution , which has been extensively reviewed in literatures (Backus,1998;Kornegay,1996; Kephart,1996; Honeyman, 1993), will not be covered in this overview.

Position of Animals in the Food Chain

Plants and animals are the major and basic constituents in the food chain. Plants absorb solar energy and convert simple nutrients from soil and air into complex nutrients by photosynthesis. Animals and humans are unable to live on simple nutrients directly as plants do. Photosynthesis products are their fundamental food source (Figure 1). Therefore, both animals and humans are consumers in the food chain.

Energy and nutrients are transferred relatively inefficiently from one member to the next in the food chain.The exchange efficiencies are only about 10% for energy and 25% for nutrients (Lanyon,1996). Consequently, the number of organisms that can be supported by the food chain becomes less and less as each transfer is made along the food chain. It is estimated that only 1% of total solar energy reaching on the earth is captured by plants and only 5% of the captured energy is transferred into edible foods for humans. The number of people sustained directly by grains produced in one hectare land is five times as that by animal products after the grains are consumed by animals (Gillespie, 1987)。 Therefore , low efficiency of nutrient transfer down the food chain is a basic natural rule. "Eating lower on the food chain" is a way for greater energy efficiency. However, There are a large number of decomposer organisms in the food chain which are able to recycle the "wasted" nutrients back into the food chain(Figure 1).

In terms of human food production, both plants and animals are food producers. Plants contribute 84% calories and 66% protein of total human food demands, animals cover the rest of the percentage(Table 1). Despite the smaller proportion, animal products play a unique role in human life, which plant products can not.

Table 1. Contributions of plant and animal products to the world food supply

Food source	calories(%)	protein (%)
Plant products	84	66
Cereals	49	43
Roots,tubers,pulses	10	10
Nuts, oils, vegetable fats	8	4
Sugar and sugar products	9	2
vegetables and fruits	8	7
Animal products	16	34
Meat	7	15
Eggs	1	2
Fish	1	5
Milk	5	11
Other	2	1

From Pond,.2000.

There are several important issues related to the food chain which people are or will be facing and have to deal with properly.

Whether the food chain goes well and efficiently is a main determinant of ecosystem equilibrium. The rapid increase of population and human activities requires the parallel increase of food production, which means the food chain will be over-loaded. The over-loaded food chain and the inefficiency of nutrient transfer in the chain will result in the inevitability of environmental deterioration and the deletion of unrenewable natural resources. Consequently ,the food chain, and therefore together with the ecosystem equilibrium will be broken. Avoidance of such disastrous result is an extremely hard and long-term task.

Animals, as a consumer in the food chain, will compete with humans for food. There are some options to solve this problem. For example, animals as the member of food chain have to be kept, but animals as a human food producer could be limited so that the use of grains for animal consumption could be shifted to a direct consumption by humans. If the amount of animals raised have to be globally limited in general, either increasing productivity or utilizing high proportion of nutrients that are directly inedible to humans, or both are the right direction for animal agriculture to go. In this case it will be probably more difficult to solve environmental issue in animal agriculture than ever before.

As a human food producer, animals must be fed and managed in such a way that their products must be safe to human health. Food problems such as bovine spongi form encephalopathy (BSE), salmonella, E.coli.0157 must no longer appear. Animal agriculture will be subject to more strict legislative control (Bateman,1998; Cooke,1998;Thomas,1998).

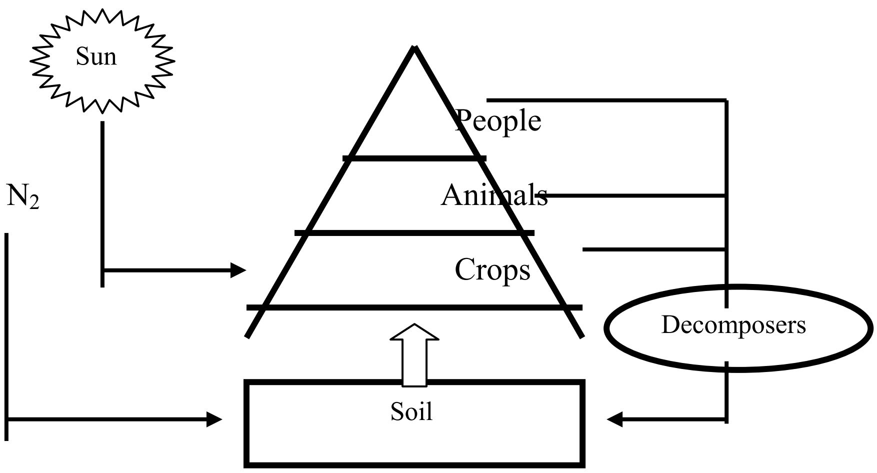

Figure 1. Primary Food Chain
(From Lanyon,1996)

Efficiency of Animal Production

The position of animals in the food chain determines the low efficiency of animal production. For example, a 100-kg-liveweight pig consumes totally about 8 kg nitrogen, the amount retained in the body is less than 2.5 kg . Energy excreted into the environment accounts for 80-85% of total consumption, phosphorus for 70-80%, trace mineral for 95-98% (NRC,1998).

For a dairy cow producing 22.7kg of milk , about 35% of carbon and energy consumed are excreted as feces and urine, 40-44% as CO_2, 5% as CH_4. Only 18-20% of consumed carbon and energy is converted into milk (Van Horn,1994). About 17.6g carbon and 171.8 kcal energy are lost in form of methane per kg of milk production(Chandler,1996).

Animals, as a food producer of humans, are characteristic of low efficiency to transfer feed nutrients into edible nutrients for humans. On the average, the efficiency is about 20% for proteins and 15% for energy (Table 2). This means approximately 80% proteins and 85% energy consumed by animals will be exposed to the environment. When the amount of "exposed" nutrients exceeds the amount of "recycled" nutrients, environmental pollution is inevitable no matter how properly they are handled.

Table 2 Conversion efficiency of feed nutrients into human food by animals

species	energy efficiency（%）	protein efficiency（%）
laying hens	18	26
broilers	11	23
turkeys	9	22
dairy cows	17	25
beef cattle	3	6
hogs	14	14
lambs	2	5

From Gillespie, 1987.

Impacts of Animal Production on the Environment

The low efficiency of animal production determines the inevitability of the negative impact of intensive animal production on the environment. The negative impact includes, broadly speaking, three aspects. First, animals themselves and the activity of animal production produce wastes or manure (including feces, urine,sloughed hair and skin, waste substances such as feed, water, bedding), exhaled gases such as CO_2 and CH_4 , noise , offensive odour, and dust on which there may exist pathogens and toxins to some extent, all of which are referred to as pollutants and directly contribute to the environment deterioration (Stehman,1996). Secondly, animal production consumes inefficiently the existing environmental resources. Theoretically, animals, together with other consumers, can delete the unrenewable resources. Renewable resources may be renewed at the rate not enough to meet the total needs. Thirdly, There exists a safety issue of animal products to human health.

Nutrients in manure are not balanced for crop requirements. Manure nitrogen is not adequate because ammonium nitrogen which accounts for approximately 50% of the total is easily lost by volatilization, and phosphorus and potassium exceed the crop requirements (Bannon,1997). Application of manure at a rate to meet the nitrogen requirement of crops would result in the accumulation of phosphorus and potassium in soil. On the contrary , application of manure based on phosphorus and potassium requirements of crops would need large area of land to dispose the manure. When enough land is not available, the situation that heavy application of manure in a certain area must occur, which means the environmental pollution in that area is inevitable.

Water pollution is the biggest problem in animal agriculture because of the limited availability of freshwater and the long time of turnover of water in the globe(Table3). The most common impacts are nitrate contamination of groundwater , which is the primary source of drinking water for humans(Jacques,1989), and phosphorus contamination of surface water, which is the primary source of fisheries,recreation, industry ,and drinking in some area, and toxic metal contaminations.

Table 3 Location and turnover time of the global freshwater resources

Storage location	% of total	turnover time
Ice sheets and glaciers	85	8000 years
Groundwater	14	280 years
Surface water	1	
Late, reservoirs	0.5	7 years
Soil moisture	0.3	1 year
Atmospheric vapor	0.05	3 months
Rivers	0.004	3.5 months

From Jacques,1989.

Animals can emit a lot of gases like CH_4,CO_2,SO_2,NO,NO_2 , which are believed to be associated with the acidification of the environment and global warming(greenhouse effect). The presence of CO_2 in the atmosphere results in the retention of solar radiation. CH_4,on the molecular basis, is sixty-five times more efficient in absorbing infra-red radiation than CO_2. The buildup of CH_4 in the atmosphere is considered to contribute 15% to the global greenhouse effect (Williams,1994). It is estimated that the global methane emission from livestock industry accounts for 10-30% of total emission, some counties reaching as high as 50%(Van't Klooseter,1998).

It should not be neglected that the environmental pollution within animal housings may be more severe than that outside housings. Workers who are exposed to animal housings are prone to health problems resulting from toxic gases and pathogen-containing dust. Animal health and productivity are also affected by the pollution. Therefore, more attention should be paid by priority to workers and animals within housings from standpoints of human and animal welfares and animal productivity.

Animals of different species or different physiological conditions have different potentials for environmental pollution. In order to make calculations and comparisons, animal population unit(APU) and animal pollution equivalent(APE) are employed by Taiganides(1987). APU is defined as 100 kg of total live weight (TLW) of animals. APE is a pollutant parameter based on the biochemical oxygen demand(BOD) of the waste compared to the BOD of human waste. 1 APE is defined as 0.075 kg BOD. Table3 shows the APE of each head animal and each APU for different species of animals. The larger the physical size of animals , the higher the APE for each head animal; while the smaller the physical size of animals, the higher the APE for each APU.

Table 3 Animal population units(APU) and the water pollution equivalents (APE)

Animal	Description and age	Mean TLW Kg/animal	APU /animal	No. of animal/APU	APE /animal	APE /APU
Beef cattle	Cows 2 y and older	500	5	0.2	8.5	1.7
	Heifers 1-2 y old	400	4	0.25	6.8	1.7
	Feeder calves	200	2	0.5	3.4	1.7
	Steers 1 y and older	300	3	0.33	5.1	1.7
Dairy cattle	Cows 2 y and older	700	7	0.14	16.8	2.4
	Heifers 1-2 y old	500	5	0.2	12	2.4
	Heifer calves	300	3	0.33	7.2	2.4
Pigs	Piglets	10	0.1	10	0.3	3.0
	Growers	40	0.4	2.5	1.2	3.0
	Porkers	70	0.7	1.4	2.0	2.8
	Gilts,sows and boars	100	1.0	1.0	2.9	2.9
Poultry	Pullets---not laying	1	0.01	100	0.05	5.0
	Pullets---laying	1.5	0.015	67	0.07	4.7
	Hens---laying	2	0.02	50	0.10	5.0
	Broiler	1	0.01	100	0.05	5.0
	Ducks	2	0.02	50	0.10	5.0
	Turkey---heavy	7	0.07	14	0.34	4.8
Turkey	light	4	0.04	25	0.19	4.8
Sheep	Lambs---ewe and ram	40	0.4	2.5	0.48	1.2
	Wethers	50	0.5	2	0.60	1.2
	Ewes---1 y and older	80	0.8	1.2	0.96	1.2
	Rams	100	1.0	1.0	1.2	1.2

From Taiganides,1987.

Environmental Pollution from Animal Production Will Continue to Exist

Environmental issue from animal agriculture will continue to exist or even to be more serious simply because animal agriculture will continue and be expanded although animal production is characteristic of low efficiency. Several reasons may support this idea. First, animals are the important membership of ecosystem. Animals are not only the contributor of environment pollution,but also a protector of the environment. There are a large array of processing byproducts and inedible food wastes from plant products. If these byproducts were not utilized by animals as feeds, they would contribute to disposal problems and environmental pollution. Second, animals consume enormous quantities of harvested and grazed forages which is of little nutritional value to humans and is produced in the area of little economic value for other agricultural activities. So animal production itself is also a way to increase transfer efficiency of the food chain and utilization efficiency of natural resources. As a result, animal production has much higher conversion efficiency in terms of human edible nutrients than of total nutrients (Table 4). Third, animal products are valuable food for human health. In the developing counties consumption of animal products has been steadily increasing as their economic status improves. Even in the developed countries in which the per-capita consumption of total protein tends to plateau as family incomes rise, animal protein consumption continues to rise (Pond,2000).

It is reasonably believed that animal agriculture will continue to be developed to meet the increasing demands for humans. It is also predicted that a number of changes will take place in animal agriculture in such aspects as the distribution and size of animal farms, the shift of feed resources from conventional to more nonconventional, animal facilities and management model, waste disposal , animal welfare and legislative supervision on the whole process. Therefore, environmental pollution and the endeavors against the pollution will not only continue but also tend to be more intense in the future.

Table 4 Inputs and returns of animal production

	Total energy and protein				Human edible energy and protein			
	Energy		protein		energy		protein	
Product	input Mcal	return %	input Kg	return %	input Mcal	return %	input Kg	return %
Milk	19960	23.1	702	28.8	4555	101.1	111.5	181.4
Beef	20560	5.2	823	5.3	1869	57.1	39.9	108.8
Swine	1471	23.2	66	37.8	588	58.0	29.0	86.0
Poultry	23.2	15.0	1.2	30.0	11.2	31.0	0.48	75.0

Inputs are calculated as digestible energy and digestible protein and include cost of maintaining breeding herds and flocks.
From Pond, 1995.

Strategies for Alleviating Environmental Pollution

The activity of the food chain and its member is a matter of ecological, economical, technical and social issues. The essence of alleviating environmental pollution is to combine all the issues into the activity of the food chain or its member and make them well balanced and harmoniously developed, which is the exact concept of sustainability. Maintaining the sustainability of agriculture (including crop and animal production) is one of the greatest challenges for the humans in the coming decades .

In order to reach this goal , more and more artificial strategies are applied to increase the energy and nutrient transfer efficiency nowadays (Figure2). Crops are grown in one location, animals raised in another, and humans live far away from crop and animal production sites. At the same time, fertilizers and renovated farming systems are applied for greater crop production, animals do not live directly on crop produces, instead on commercial feed from feed mills which can balance the nutrient demands by animals and nutrient supplies by crops according to the achievements of the science of animal nutrition and feeds, and people, on the processed products from crops and animals by food processing industries.

In terms of animal agriculture, the most important ways to increase productivity and decrease environmental loading include enhancing animal genetic potential of production by breeding and selection, improving performance and feed conversion efficiency of animals by nutritional managements, improving animal health by veterinary managements and developing proper waste disposal programs. Any animal farms that either exist already or are going to be built have to take into account all the aspects related to environmental risks such as animal species or breeds and density raised, feed requirements, manure output, nutritional managements , facility for manure collection and treatments, where and how to dispose manure , land area needed for application. Only the comprehensive action is taken could the environmental risks be minimized.

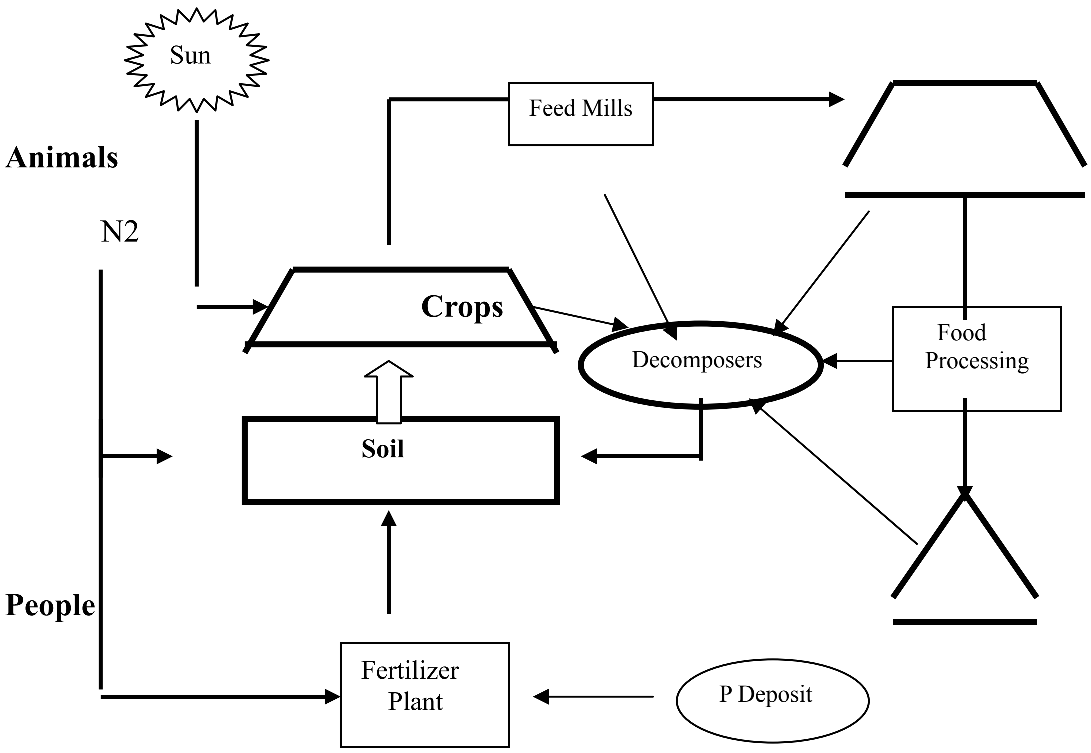

Figure 2 Remodeled Food Chain
(Based on Lanyon,1996)

The role of biotechnology in alleviating environmental pollution needs to be emphasized. Biotechnology has been playing and will continue to play an important role in the following aspects related to animal agriculture.

At first, more and more genetically modified crops are or will be available for animal feeds. Many of the disadvantages of these original crops, for example, high content of anti-nutritional factors, low content of lysine,can be overcome by biotechnology in various extents (Anderson,1998). These new crops have higher nutritional value and feeding value than their original breeds(Anderson,1998).It is much easier than before to balance a diet when they are used as feed ingredients The amount of excretion, therefore, is expected to be declined considerably.

Secondly, recombinant DNA technology can produce mass quantities of biologically active proteins for animal production, such as hormones, enzymes, amino acids,vaccines. When used as feed additives or growth promotants or disease preventers , animal health and the efficiency of animal production or the quality of products can be improved ,while environmental loading, decreased dramatically.

Thirdly, transgenic technology can not only help to elucidate the molecular mechanisms of nutrient metabolism, making it possible to meet exactly nutrient requirements for animal production, but also produce animals with particular metabolic functions. A good example is that transgenic pigs that have high blood growth hormone(GH) level and, moreover, express GH in peripheral tissues in addition to in the pituitary gland have been produced (Pond,2000). Many nutritional disorders may be eliminated or at least alleviated by gene therapy. Therefore , transgenic animals have tremendously high genetic potential for production.

At last, biotechnology can directly play a role in waste disposal. Great break-throughs in the purification of animal wastes and farm environment, and the recycling of animal wastes as plant fertilizers or animal feeds will be made in the near future by means of biotechnology.

It should be clear that the successful application of all the strategies does not mean, at least in the present, that the inefficiencies of nutrient transfer in the food chain can be reversed . Indeed, the more extensive and intensive the animal production and human activities are, the larger the amount of wasted nutrients is, and the higher the risk of environment deterioration would be. At the same time, It should be remembered that comprehensive manipulations have to be employed to minimize environmental risk but not all manipulations are cost effective in terms of animal production.

Roles and Tasks of Animal Nutrition in Solving Environmental Issues

Animal agriculture has negative impacts on the environment in many aspects. Animal nutrition plays a role in 1) improving utilization efficiency of natural resources by animals, 2) controlling nutrient intake and excretion by animals , and 3) ensuring the safety of animal products to humans. All the three roles lie during animal production rather than pre- or post-production. The ultimate goal of animal nutrition science is to make animal agriculture to go well under such nutritional management system that is, in general, environmentally, economically, and socially sound.

Based on the current knowledge of animal nutrition science, the following options can be taken to reduce the environmental pollution by animal production.

1. Figure out the accurate nutrient requirements of the specific genotypes of animals.
2. Apply the most precise database of nutrient availabilities of feedstuffs for animals.
3. Use new feed ingredients with high availability of nutrients.
4. Formulate diets based on bio-available nutrients rather than total nutrients to just meet the needs of animals.
5. Reduce crude protein level by applying ideal protein principle or supplementing synthetic amino acids.
6. Supplement diets with feed enzymes ,especially phytase,polysacchridases and proteases.
7. Use growth promoters
8. Improve feed processing facilities and technology
9. Apply phase feeding and sex-split feeding systems
10. Execute all the regulations and laws concerning feed hygiene,food safety and environmental protection.
11. Recycle animal manure as animal feeds.

Nitrogen and phosphorus excretions can be decreased up to 50% by the above strategies. However none of the above aspects is clearly understood up to now. There is a long way for the science of animal nutrition to go to realize its ultimate goal.

Understanding nutrient metabolism and its efficiency in animal body in molecular basis is the prerequisite to improve utilization efficiency of nutrients. Very little has been known in this area up to now. Animal nutrition must be transferred from traditional population level into a new branch of molecular level.

Nutrient requirements of animals need to be refined and reevaluated. The current nutrient requirements are established mainly based on the optimum performance of animals ,with little care about the environmental loading. As shown in Figure 3, as nutrient intake increases , animal performance enhances and reaches a plateau at the level of B. But when nutrient intake reaches a certain level (A), further increase would result in a gradual decrease of the marginal utility of performance, and dramatic increase of environmental loading although the absolute performance continues to rise. Nutritionists need to discuss this question: which point (A or B or a point between A and B) as shown in Figure 3 is the reasonable nutrient recommendation taking all the three factors of animal performance, environmental risk and resource utilization into account? In other words, do we need to match nutrient allowances to the genetic potential of animals or to balance the genetic potential with environmental pollution potential and utilization efficiency of resources? Even though the optimum absolute performance is still considered as the criterion for establishing nutrient recommendation, the current recommendation based on performance has to be reevaluated because some experiments show that the recommendation for some nutrients may be higher than(B in Figure 3) needed for optimum performance(Keshavarz,1999;Satter,1999).

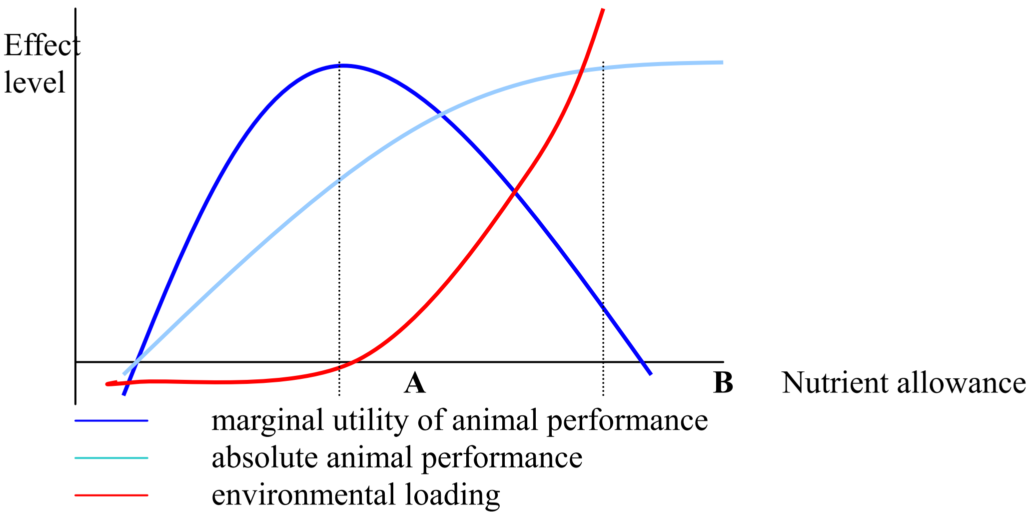

Figure 3 Relationships of nutrient allowance with animal performance and environmental risk

Establishing the accurate database of available nutrient contents in feed ingredients is important for alleviating environmental risk. Feed evaluation in the future should focus on the improvement of methodology and the refinement of the current data of nutritional values on the basis of nutrient availability. It is very likely that the proportion of nonconventional feeds and genetically modified crops for animal feeds will be increased to a large extent. Data for these feeds are almost exclusively deficient in the present time. Nutritional evaluations on these new feed resources will be the predominant task for feed scientists in the near future.

Feeding system is one of the factors influencing nutrient conversion efficiency. Many studies indicate phase feeding is effective to reduce nutrient excretion. Liquid feeding is superior to solid feeding in terms of environmental risk. All these feeding systems, and other probable systems need to be further studied.

The efficacy and the mechanisms of additives for animal production and their possible impacts on environment protection remain to be evaluated. Feed additives are classified into two categories according to their effects. One is those which have efficacy of promoting animal performance or improving product quality and have little detrimental impact on human health and the environment. The other one is those which have both efficacy of promoting animal performance or improving product quality and detrimental potential on human health and the environment. Most of the current commonly-used additives belong to the second category, such as antibiotic, arsenic, high level copper and zinc. It is predicted that these additives will be under more strict control and eventually prohibited for food-producing animals in the globe. The most significant consequence of prohibiting these additives is a noticeable reduction of animal resistance to diseases and animal performance. Nutritionists have to seek alternative products or methods to keep the similar animal performance to that in the present , when the second category of additives is still employed widely.

There are increasing legislative constraints on animal agriculture, some of which have close relationships with nutritionists(Cooke,1998;Thomas,1998). For example, the ban of antibiotics as growth promotants, the prohibition of bone meal or even animal proteins as animal feeds in European Union, the increasing outdoor feeding of some animals to meet the animal welfare are all great challenges for nutritionists to improve further the production level and efficiency by the same nutritional programs employed before theses laws are brought into action .

Conclusion Remarks

The environmental issue resulting from animal agriculture is ,as a matter of fact, an issue of nutrient transfer efficiency along the food chain and is beyond a technical issue. Many options, however, are indeed available, from the technical standpoints, to alleviate environmental risks by animal agriculture to a certain extent. The application of science and technology in animal nutrition is no doubt one of the most important options in the present. The future progress of science and technology in animal nutrition in the area of nutrient metabolism, nutrient requirement , nutritional evaluation of feedstuffs and the application of metabolic modifiers, will play much greater role in the sustainability of future animal agriculture.

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Feeding and Management System to Reduce Environmental Pollution in Swine Production

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SUMMARY

In this manuscript, several effective feeding and management systems to reduce environmental pollution in swine production have been briefly introduced. It is logical that reducing the excretion of nutrients in manure should be a first step to reduce the environmental impact of pig production. It is evident that the excretion of nitrogen and phosphorus can be reduced when more digestible or available feedstuffs are used. Also, It is well known that proper feed processing can reduce anti nutritional factors (ANF) and improve nutrient digestibilities. Supplementation of effective feed additives can reduce excretion of nitrogen and phosphorus due to efficient feed utilization. These include enzymes (e.g., phytase), β-agonists and porcine somatotropin. One of the most effective ways to reduce pollutants from swine manure is to use synthetic amino acids in feed manufacturing. Many studies showed that reduction of 2 to 4% unit (U) of dietary protein with supplemental amino acid (AA) could reduce dramatically (15 to 20%) nitrogen excretion. Regarding feeding strategies, it has been recognized that phase feeding regimen could be used to reduce nitrogen and phosphorous excretion by feeding pigs in better agreement with age and physiological state. Feeding barrows and gilts separately, known as split sex feeding, can also decrease excretion of nitrogen and phosphorus. With the increasing concern on the negative impact of animal production systems on the environment, animal nutritionists and producers should be aware that sustainability of animal agriculture is as important as high production performance. Therefore, some feeding and management strategies described in this manuscript will help to reduce environmental pollution in swine production. Proper combination of feeding regimen and environment-friendly diet formulation through nutritional approach will be more effective to reduce nutrient excretion in swine production system compared to single approach to do so.

INTRODUCTION

With the increasing concerns on the negative impact of livestock production systems on the environment, it is evitable that the animal industry should be environmentally sound to ensure its long-term sustainable growth. In the past, dietary adjustments to animal requirements were aimed at maximizing production performance without special concern for nutrient (especially protein and amino acids) oversupply and environmental pollution. However, the recent environmental constraints have forced animal nutritionists to figure nutrient feeding not only in terms of nutrients retained in animal but also in terms of nutrients excreted.

On the average, finishing pigs produce approximately 4.5 L of manure (excluding flush water or water wastage) per pig each day. This equals a total of 9.5 kg of nitrogen and approximately 6.8 kg of phosphorus per pig per year. Methods to reduce the environmental impact of pig production may be focused on different processing techniques of manure after its production. However, this is one of factors to make swine production cost high. Therefore, reducing the excretion of nutrients in manure should be a first step to reduce the environmental impact of pig production. A large part of the nitrogen losses are associated with inefficiencies of digestion and metabolism. The retention of nitrogen and phosphorus in the pig body as a percent of intake is relatively low. It has been recognized that typically only 20～50% of the nitrogen and 20～60% of the phosphorus consumed is retained in the body (Table 1; 1). This illustrates the potential for reducing nutrient excretion through nutritional means.

Table 1. Digestion and retention of nitrogen and phosphorus by different classes of pigs

Nutrients	Nursery	Finishing	Gestating	Lactating
Nitrogen				
Digested, %	75～88	75～88	88	-
Retained, %	40～50	30～50	35～45	20～40
Phosphorus				
Digested, %	20～70	20～50	30～45	10～35
Retained, %	20～60	20～45	20～45	20

(Adapted from Kornegay and Harper, (1))

Several nutritional strategies have been considered to be possible for reducing nutrients excreted. Therefore, this manuscript will briefly introduce some possible nutritional ways to reduce environmental pollution from swine production, with the aim of hoping that swine industry could be sustainable in the 21 century.

Nutritional approach to enhance nutrient availability

1) Choice of high available ingredients

To improve nutrient availability, it is very important to take the digestibility of nutrients of nutrients in consideration when formulating diets. It is evident that the excretion of nitrogen and phosphorus can be reduced when more digestible or available feedstuffs is used. Also, to provide dietary nitrogen or phosphorus in accordance with the animals' need, adequate knowledge about the digestibility of amino acids or phosphorus in feedstuffs is required. Ileal digestibility would be more appropriate.

New sources of highly digestible feedstuffs are being developed by crop breeders, either using classical breeding techniques or through genetic modification of crops. Examples of such products are low-phytate corn and low-stacchyose soy. Recently, low-phytate corn has been shown to substantially reduce phosphorus excretion when diets are formulated on an available phosphorus basis (2).

2) Proper feed processing

It is recognized that the digestibility could be improved through technological treatments of the feeds. For each 1% improvement in digestibility, nitrogen waste produced per kg of meat produced decreases by 1.4%.

Examples of technological treatments include particle size reduction (grinding, roller milling), pelleting, and expanding. Wondra et al. (3) demonstrated that a uniform particle size of approximately 400 microns leads to a better nutrient digestibility than coarsely ground material (although ulcers may increase with fine particle size). For practical purposes, Kansas State University (KSU) recommends a particle size of 700 microns (4).

It is also well known that proper feed processing can reduce anti nutritional factors (ANF). Most legume seeds, such as soybeans, contain different ANF, i.e. protease inhibitors, lectins, tannins, and amylase inhibitors. Digestibility and absorption of protein is compromised when these ANF are present. Thus, elimination of ANF from the feed and better processing conditions can improve nitrogen utilization in pigs which will reduce nitrogen excretion.

3) Use of feed additives

Supplementation of feed additives can also reduce excretion of nitrogen and phosphorus due to efficient feed utilization. One of the most representative feed additives to reduce nutrient excretion from animal manure is enzymes. The carbohydrate fraction of feed ingredients consist of starch, sugar and non-starch polysaccharides (NSP), soluble dietary fiber fraction, like cellulose, hemicellulose, pectins and oligosaccharides. These NSP are resistant to digestive enzymes but digestibility of these fibrous feeds can be improved by treatment with enzymes that are capable of hydrolyzing the NSP to monosaccharides. Xylanases and β-glucanases are enzymes that are used to degrade NSP present in cereals such as wheat and barley. The pig does not secrete these enzymes and does not have the capability to digest and use NSP, resulting in a loss of usable energy from the diet. Because these NSP can trap other nutrients, such as protein and minerals, they also increase mineral excretion. The addition of xylanase and/or β-glucanase to cereal-containing diets can improve digestibility and feed efficiency. Graham and Inborr (5) reported a 9% improvement in the ileal digestibility of protein in a wheat/rye diet due to enzyme addition. Recently, with the advancements in enzyme-producing technology as well as a better understanding of the role of enzymes in animal nutrition, the use of enzymes in pig diets will be more widespread and contribute to reduce environmental pollution from animal manure.

Phytase (described in more detail later) has been reported to increase the phosphorus availability dramatically (6). Also, the use of β-agonists (7) or rpST (8) could reduce nitrogen and phosphorus excretion through the improvement of feed efficiency.

4) Phosphorus excretion control by microbial phytase

The most important ANF in swine nutrition, as it relates to nutrient management, is phytate. The major ingredients in pig diets are seeds (cereal grains) or products from seeds (oilseed meal and grain byproducts). However, 60-80% of the phosphorus in these feedstuffs is present in the form of phytate, a compound that pigs do not use well. Bioavailability estimates of phosphorus in corn and soybean meal for pigs range from 10-30% (1). This phytate phosphorus must be hydrolyzed by an enzyme, phytase, into inorganic phosphorus before it can be used by pigs. Four sources of phytases have the potential to degrade phytate within the digestive tract of pigs: 1) intestinal phytase in digestive secretions 2) endogenous phytase present in some feed ingredients 3) phytase originating from resident bacteria and 4) phytase produced by exogenous microorganisms. Unfortunately, all of these potential sources have proven to have negligible phytase activity for improving phytate availability in nonruminant animals (1).

However, recently several types of microbial phytases has initiated a new era in the battle to reduce nutrient excretion. From the many studies (9, 10, 11), it has been recognized that it breaks down most of the phytate complex, releasing the phosphorus in it as well as other nutrients (such as zinc and amino acids) bound by it. As a result, it is possible that the total phosphorus levels in the diet are reduced, the efficiency of retention improved and excretion of P into the environment is decreased. Effects of using phytase in diets for pigs on growth performance and nutrient excretion are summarized in Table 2.

Table 2. Effects of phytase on growth performance and nutrient utilization in pigs

Range (FTU[1])	Age or weight	ADG (%)	Gain/feed (%)	Utilization (%)			Ref.
				DM	N	P	
800	45.0 kg	-	+2.86	+2.86	-	+73.27	1
500	20.7 kg	+11.94	+6.10	-	-	+23.00	2
1000	20.7 kg	+20.90	+6.11	-	-	+33.00	2
500	10.2 kg	+15.56	+9.76	-	+7.46	+12.86	3
1000	37.0 day	-	-	-0.24	+13.63	+54.41	4
1000	18-74 day	+8.49	+1.49	-6.3	-	+26.00	5
500	47-74 day	+7.24	+3.62	+3.62	-3.11	+20.29	5

[1] 1FTU is equal to 1 μ mol of otho-phosphate liberated from 1.5 mmol of Na-phytate within 1 min. at 37℃ and pH 5.5. (Han et al., 2000)

1=Mroz et al., (12); 2=Cromwell et al. (9) ; 3=Young et al. (13) ; 4=Simons et al. (14) ; 5=Kwon et al. (6) .

Currently, the addition of phytase does not appear to add more cost to the diet because it is offset by the savings associated with reducing phosphorus and calcium in the diet. Therefore, the use of phytase will be more common in diet formulation for the pigs with increasing concerns on negative impact of swine production systems on the environment.

5) Use of synthetic amino acids for diet formulation

One of the most effective ways to reduce pollutants from animal manure is to use synthetic amino acids in feed manufacturing. Basically, the concept of a low-pollution diet originated from the protein sparing effect. An excess of dietary protein or a deficiency in calories from carbohydrates and/or fat will cause a proportion of proteins to be used for energy. In either case, protein will be broken down and carbon used for energy, thus nitrogen will be excreted as urea in mammals or as uric acid in poultry. Protein and other dietary nitrogenous materials that resist or escape digestion in the intestinal tract are excreted in faeces. A large part of the nitrogen losses are associated with inefficiencies of digestion and absorption but more generally in protein synthesis after absorption, so the excretion of nitrogen in faeces and urine may be influenced by dietary manipulation. Providing diets with highly digestible amino acids such as synthetic amino acids may improve absorption and protein synthesis. This will reduce the amount of nitrogen in the diet, which will in turn reduce nitrogen excretion. A simple means of improving dietary amino acid balance is to partially replace some of the standard protein sources (e.g., soybean meal) with purified synthetic amino acids. If these diets are properly formulated and produced, they should support at least the same levels of performance as compared to corn-soybean based diets (15).

Table 3. Effects of synthetic amino acid supplementation on growth performance, feed conversion and nutrient excretion in pigs compared to control diets

CP level C-L[1] (%)	Added (%)				Weight (kg)	ADG (%)	G/F (%)	Excretion (%)*			Ref.
	Lys	Met	Thr	Trp				DM	N	P	
18-16	0.10	-	-	-	9-25	+2.8	+1.5	-16.7	-10.6	-14.7	1
18-16	0.20	-	-	-	9-25	-1.3	+0.0	-22.5	-17.7	-20.9	1
18-16	0.40	-	-	-	9-25	+1.5	+1.0	-16.3	-4.0	-15.8	1
14-14	0.15	-	-	-	25-30	+14.5	-	-	-33.7	-	2
14-14	0.30	-	-	-	25-30	+36.0	-	-	-31.7	-	2
14-14	0.45	-	-	-	25-30	+42.3	-	-	-38.5	-	2
16.9-15.6	0.24	-	-	-	44.2	-	-	-	-13.9	-	3
14.6-13.5	0.22	-	-	-	84.1	-	-	-	-19.3	-	3
16-12	0.34	-	0.16	0.07	22.3	-3.6	-4.0	-4.4[2]	-29.3	-	4
18-15	0.28	-	-	-	14-26	-8.7	-7.1	-0.1	-6.7	+1.6	5
18-15	0.28	0.04	-	-	14-26	-7.1	-6.2	-1.1	-7.6	-0.6	5
18-15	0.28	-	0.12	-	14-26	-3.5	-3.5	-4.7	-11.0	-1.4	5
18-15	0.28	0.04	0.12	-	14-26	+0.2	-1.0	-7.3	-17.2	-0.6	5
18-15	0.28	0.04	0.12	0.02	14-26	+0.6	-1.0	-7.9	17.7	-0.6	5

*Compared to control treatment.

[1] Control high protein diet - Low protein diet.

[2] Energy excretion ; [3] Corn-soybean meal based diets ; [4] Wheat-barley-soybean meal based diets.

1=Han et al.(16); 2=Hahn et al. (17)[3]; 3=Gatel et al. (18)[4]; 4=Kerr and Easter. (19)[4]; 5=Jin et al. (20)[3].

Effects of synthetic amino acids on the growth and nutrient excretion reported in the literature over the last two decades are summarized in Tables 3. This summary shows that reduction of 2 to 4 % unit (U) of dietary protein with supplemental amino acid (AA) can reduce dramatically nitrogen excretion. Lenis (21) reported that lowering dietary crude protein level for growing-finishing pigs by 2 percentage U reduced nitrogen excretion by approximately 20%. In a review of literature, Lenis and Jongbloed (22) concluded that even larger reductions in dietary protein level are possible if appropriate levels of amino acids are supplemented to low protein diets.

In addition, more recently, Lenis and Jongbloed (22) stated that reducing dietary crude protein levels with the supplementation of amino acids can reduce nitrogen excretion as well as manure volume. Because reduced dietary protein levels usually involve a reduction of the dietary level of soybean meal in the diet, and because soybean meal contains approximately 2.0 to 2.2% potassium, this will result in a significant decrease of the dietary potassium level and consequently in a lower potassium excretion. The lower dietary levels of protein and potassium may also lower water intake when available *ad libitum* to the pigs, which will reduce manure volume.

It should be noted that there have been some results showing negative effect on growth performance and carcass characteristics when even lower crude protein (CP) diets with supplemental AA were fed to pigs. Cromwell et al. (23) showed that pigs can perform optimally at 4 percentage units crude protein reduction with supplementary amino acids, but carcass leanness was reduced. Tuitoek et al. (15) also found increased fat content in the carcass and reduced gain and feed efficiency in pigs fed diets with protein levles reduced by 4 percentage U even when the low protein diets with synthetic amino acids (lysine, threonine, tryptophan, isoleucine, and valine) were fed to meet ideal amino acid ratios.

The use of synthetic amino acids to lower CP diets is associated with cost factor as well as potential reduction of nitrogen excretion. When some of the soybean meal is replaced with lysine · HCl, both feed cost and nitrogen excretion are reduced. But there may be a limited economical feasibility of using various amino acids to reduce dietary protein levels. The potential of the use of synthetic amino acids is likely to be closely related to prices of the soybean meal and synthetic amino acids.

Feeding management

1) Feed waste control

The reducing feed waste can be the first step to control nutrient excretion. Poor feeder design and presentation of feed can lead to the wasting of animal feed. Gonyou and Lou (24) reported that feed wastage was typically 5 to 6% but much larger ranges have been reported for field conditions (1.5 to 20%). Although little research has been performed to evaluate the effect of feed wastage on environmental pollution, it cannot be ignored.

Feed waste is strongly influenced by the presentation of the feed. Mash feed tends to cling to the animal's chin and nose, ultimately leading to waste. Gonyou and Lou (24) determined that each time the pig leaves a feeder it takes 1.5 grams of feed with it. Given that the pig typically accesses the feeder 60 times per day, this theoretically could amount to wasting 90 grams of feed. Pigs also tend to root through the feed, which in poorly designed feeders lead to the waste of 3.4% of the feed (24).

. Since wasted feed generally falls into the manure storage areas, its contribution to waste can be estimated by making some assumptions. For example, if feed wastage is 5% on average during the grow-finish phase (which is a low estimate), and the animal utilizes approximately 30% of the nitrogen fed, then feed wastage contributes 7.5% of the nitrogen in manure.

2) Phase feeding

Recently, it has been recognized that phase feeding could be used to reduce nitrogen and phosphorous excretion by feeding pigs in better agreement with age and physiological state (25, 26). In a conventional feeding system a growing animal is given free and continuous access to a feed. As the live weight of a pig increases from 30 to 110 kg, the concentration of amino acids and phosphorus in the feed decreases. Jongbloed and Lenis (25) reported that growing pigs use only about 30 to 35% of ingested nitrogen and phosphorus. These are important information to emphasize the need of phase feeding strategies to allow providing dietary nitrogen and phosphorus in close accordance with the animals' requirement. The introduction of one or more additional feeds will avoid over or under feeding condition for growing-finishing pigs and help balance amino acids and digestible phosphorus in the diet to the requirements of the pig, as a results, less nitrogen and phosphorus are excreted. Namely, when diets are precisely formulated to meet the nutrient requirements (especially protein and amino acids) of pigs, nitrogen excretion can be reduced due to decreased dietary excess and improved nutrients utilization.

Lenis (21) calculated the reduction in nitrogen excretion by changing from one feed system that is common in Europe to a two phase feeding regimen. Koch (27) reported that by matching the feed's nutrient composition to pigs' requirement at a given age and weight through phase feeding system, nitrogen excretion could be reduced by 14% and nitrogen retention could be improved by 10%. Lenis (21) reported that nitrogen and phosphorus excretion could be reduced 6% by two phase feeding compared to single phase feeding.

Recently, our research group has conducted a series of experiments to determine optimal number of phases for finishing period and evaluate effects of phase feeding on growth performance and nutrient excretion of finishing pigs. Lee et al. (28) have compared four phase feeding regimens by using four different dietary protein patterns (16% CP, one phase feeding; 16% and 12% CP, two phase feeding; 16%, 14% and 12% CP, three phase feeding regimen; 16%, 14.7%, 13.4% and 12% CP, four phase feeding, respectively). The results revealed that three phase feeding regimens resulted in 12% lower nitrogen and dry matter excretion than one phase feeding regimen without any deterioration of growth performance and carcass characteristic. In continuous study, Lee et al. (unpublished data) conducted an experiment to investigate the effects of different dietary protein sequences (17-15-13% CP, 16-14-12% CP and 15-13-11% CP) on growth performance of finishing barrows and gilts. They reported that there was no interaction between sexes and dietary CP levels on growth performances and suggest that 16%-14%-12% dietary CP sequence is desirable in the sense of economics and environment for practical three phase feeding regimen for finishing period . In another study, Lee et al. (unpublished data) investigated the effect of low CP diet supplemented synthetic amino acids on growth performance and nutrients utilization of finishing pigs under three phase feeding regimen and to determine the safety margin for dietary protein level to minimize nitrogen excretion without sacrificing performance of pigs (55 to 105 kg). Dietary treatments were as follows; 1) control (16-14-12% CP), 2) Con+L (15-14-13% CP with identical lysine levels with the control), 3) Con+LMT (14-12-11% CP with identical lysine, methioine and threonine levels with the control) and 4) Con+LMTT (13-11-9% CP with lysine, methionine, threonine and tryptophan levels with the control). As shown table 4, for the overall period (55 to 105 kg), Con+L group showed similar growth performance to the control group, but resulted in 13.4% lower nitrogen excretion compared to the control group. Con+LMT and Con+LMTT groups also resulted in much less nitrogen excretion (18.8 and 21.6% reduction, respectively) compared to the control, but resulted in significant reduction of growth performance. This results indicate that reducing dietary CP level by 1% U and supplementing only lysine at each phase could obtain similar growth performance compared to control and could be very beneficial feeding strategy for finishing pigs under three phase feeding regimen in both environmental and economical aspects.

The results from our studies suggest that phase feeding regimen which enable pigs to closely meet their nutrient requirement without over-feeding is a very effective method to reduce pollutant excretion without affecting animal growth performance.

Table 4. Effects of dietary treatments on growth performance and the nutrient utilization of finishing pigs

Items	Control	Con+L	Con+ LMT	Con+ LMTT	SE[1]
Growth performance					

Initial weight (kg)	55.79	55.73	55.76	55.76	0.65
Final weight (kg)	107.08	106.04	104.03	103.64	1.07
Average daily gain (kg)	0.827[a]	0.812[ab]	0.778[bc]	0.772[c]	0.01
Average daily feed intake (kg)	2.61	2.56	2.51	2.52	0.03
Feed efficiency	3.15	3.16	3.22	3.26	0.02
Nutrient utilization					
Excretion (g/day)					
Dry matter	272.19	266.80	270.39	268.65	3.43
Urinary nitrogen	20.52[a]	17.01[b]	15.45[c]	15.20[c]	0.65
Fecal nitrogen	8.42	8.05	8.04	7.48	0.28
Total nitrogen	28.95[a]	25.06[b]	23.50[bc]	22.69[c]	0.76
Fecal phosphorus	4.65	4.57	4.39	4.24	0.07
Nitrogen intake (g/day)	50.61	47.64	44.20	42.82	-
Nitrogen retention					
Daily nitrogen, g	21.66	22.57	20.70	20.12	0.44
Nitrogen % of nitrogen intake	43.51	47.90	47.32	47.64	0.81

[1] Pooled standard error. (Lee et al., unpublished data)
[a,b,c] Values with different superscripts within the same row are significantly different ($p<0.05$).

3) Sex split feeding

Feeding barrows and gilts separately, known as split sex feeding, can also decrease excretion of nitrogen and phosphorus. It is also well known that barrows consume more feed and gain body weight more rapidly than gilts (29). Conversely, gilts are more efficient in converting feed to body weight gain and deposit a higher percentage of muscle and a lower percentage of fat tissue in their carcass than barrows (29, 30). Because gilts have a greater accretion rate of lean tissue and a lower feed intake than barrows, many researchers have suggested that gilts require a higher level of dietary CP (amino acids) than barrows to maximize rate and efficiency of growth and carcass leanness (30). Therefore, it is likely that penning barrows and gilts separately and feeding them diets that more closely meet their nutrient requirements are more effective feeding system for finishing pigs than a feeding system which barrows and gilts were mixed in the same pens.

CONCLUSION

Over the last decade, animal production has expanded significantly. However, with this expansion, environmental issue related to animal production has been increased. It is noted that controlling environmental pollutants from animal manure through the proper feeding and management strategy is very important to make animal industry sustainable in the 21 century. In this manuscript, several effective feeding and management systems to reduce environmental pollution in swine production have been briefly introduced. It is evident that several approaches described above are effective to reduce excretion of pollutants from animal manure. However, incessant study to figure out more effective ways to control excretion of pollutants from animal production should be needed.

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Advances in Enhancing Nutrient Utilization for Ruminants by Nutritional Manipulation to Reduce Environmental Contamination

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INTRODUCTION

The ruminant production in the world faces an environmental challenges. As we know, ruminant's nutrient metabolism and efficiency of conversion of dietary nutrients into animal products is an inefficient process, leading to uneconomic use of some dietary parts and a substantial contribution to environmental pollution. The environmental concern has stimulated an effort to develop some techniques for increasing the utilization of dietary nutrients and reducing environmental contamination, which is called as a green nutritional technique. To reduce this environmental pollution, we need a better understanding of why inefficiencies in dietary nutrient utilizations occur, and what ways to improve those utilizations. This paper will attempt to analyze the present understanding of the dietary nutrient utilizations in ruminant animals and introduce some recent advances in this field made by our laboratory.

DIETARY PROTEIN UTILIZATION

Nitrogen pollution of the environment will become more important in the future. Animal production will be called upon to do its part to minimize excessive nitrogen output in animal excreta. Meanwhile, protein is a costly item in ruminant diets; therefore, maximizing the efficiency of dietary protein utilization is very important. It is realized that ruminants have lower efficiency of conversion of dietary nitrogen into animal products. For example, between 20 and 50% of the daily N intake in forage-fed cattle may be released into the environment, and estimates of the costs from this waste approach 5 billion annually (Russell, 1993). Even in the high yielding dairy cow less than 20% of ingested protein is converted into saleable products (MacRae, 1996). Why the ruminant animals have lower dietary nitrogen efficiency involves several aspects in their digestion and metabolism processes.

Firstly, the asynchrony of release of dietary protein degradation products and energy to the conversion into microbial protein is an important cause. For example, fresh herbages have highly soluble proteins, which results in a rapid release of ammonia from dietary proteins degradation and exceeding the rate of release of energy mainly from structural carbohydrates. Therefore, a substantial proportions of the dietary protein are lost as ammonia absorption from the rumen, the rates of microbial protein synthesis and the availability of amino acids for tissue metabolism are reduced, and finally the amount of N excreted in the urine is increased.

Secondly, the marginal efficiency of protein retention per unit extra protein absorbed by ruminants is lower than by pigs (MacRca, 1996). The reasons for the low efficiency in ruminants are not yet fully understood; but two possible reasons are:(1) a large proportion of the absorbed amino acid distributes to splanchnic tissues and (2) There is a relatively poor retention of synthesized protein by muscle. Macrea and Lobley (1991) identified wool and certain gastrointestinal tract secretions as having the potential to create limiting amino acids situations for other tissues under certain condition. This is one of possible contributors to the inefficiency of absorbed amino acids.

Thirdly, the detoxification of the substantial amount of ammonia absorbed from the rumen in the liver not only requires more energy costs, but also can lead to increased amino acids catabolism, because in ureagenesis one of the two N atoms can come directly from the condensation of ammonia with bicarbonate, via carbamolyl phosphate, the another N has to come from aspartate.

Fourth, there is a large turnover of the endogenous proteins in the gastrointestinal tract of ruminants. Compared with nonruminants, turnover and lost amounts of the endogenous proteins are much greater (Lu De-xun, 1994). This may also cause lower efficiency of dietary protein in ruminants.

In view of those four reasons, there are four ways to improve dietary N utilization in follows:

(1) To reach synchrony of release of dietary protein degradation products and energy in the rumen and to optimize rumen microbial growth.
(2) To maximize P/E (protein/energy) ratio in nutrients from the rumen and to reduce the loss of the endogenous protein in the gastrointestinal tract.
(3) To optimize the amino acid pattern in the digest flowed into the duodenum.
(4) To optimize the partitioning of nutrients into products.

Urea Slow Release Technique

In our laboratory, Gao min et al (1995) Studied on effects of expanded urea-corn starch complex (ECUSE) on N utilization in growing-finishing sheep. The results are shown in Table 1.

Table1.Effects of ECUSE on N Utilization in growing-finishing sheep

	Control group basic diet	Treatment group Basic diet+ ECUSE
N intake (g/d)	15.41	15.02
Fecal N output (g/d)	6.61[a]	5.87[b]
Urinary N output (g/d)	6.16[a]	4.47[b]
Retained N (g/d)	2.64[a]	4.68[b]
Retained N/N intake (%)	17.13[a]	31.16[b]
Retained absorbed N (%)	30.06[a]	51.15[b]
Rumen microbial N production (g/d)	2.60[a]	3.61[b]

Note:(1) The Composition of basic diet was:(%): hays (64.61), ground corn (24.49), Soybean meal (2.89), Linseed meal (2.89), Wheat Bran (1.15), Urea+ground (3.83) and Na_2SO_4 (0.14).

(2) In the treatment group, Urea+ground corn(1:3) in the basic diet was replaced by ECUSE, which contained 75% ground corn and 25% urea and had expanding treatment after add of some N slow release agent.

The results in Table 1 showed that use of ECUSE, a Urea slow release product, could reduce the Urea degradation to ammonia and increase rumen microbial protein production and retained N amount as well as dietary N utilization by 38.8%, 77.3% and

81.9%, respectively. The conclusion we arrived at was that the urea slow release product resulted in the much lower N excretion in urine and faces of sheep.

Optimum Amino Acid Pattern

If there is an optimum amino acid pattern in ruminant animals has been a dispute point in the field of animal nutrition. Most evidences were from dairy cows, but there was little yet know in sheep. Wang Hong rong (1998) infused amino acid solutions with different AA profiles into the duodenum of the sheep. The amino acid profiles designed in the digest at the duodenum were: patterns for rumen microbial protein and for casein and modified amino acid pattern for muscle protein. The results in Table 2 showed that there were significant effect of different duodenal AA pattern on urine nitrogen excretion (P=0.05), retained N (P=0.04) and daily body gains (P=0.05), compared modified AA pattern treatment with other two AA patterns treatments, and the modified AA pattern treatment had the highest value. Glycine/other amino acids ratio in plasma was decreased significantly for modified AA pattern treatment. Also, it was found that RNA/DNA concentration in the liver was elevated significantly for modified AA pattern treatment. Meanwhile, a urea N and insulin concentrations in plasma were also improved by modified AA pattern treatment. To synthesize the all results obtained, It was concluded that the modified amino acid pattern was an ideal digestible amino acid pattern for growing sheep. The pattern was presented in Table 3.

Table 2. Effect of duodenal amino acid pattern on nitrogen balance, body gain and Glycine/other amino acids ratio in plasma as well as RNA/DNA Concentration in the liver of the sheep

	Treatment			
	Rumen Microbial protein pattern	Casein pattern	Modified muscle protein pattern	SEM
Plasma urea N (g/d)	7.16[a]	6.35[ab]	5.43[b]	0.445(p=0.05)
Retained N (g/d)	4.43[b]	6.28[ab]	8.41[a]	1.779(p=0.04)
Daily body gains (g/d)	60[b]	146.7[ab]	153.3[a]	6.88(p=0.05)
Glycine/other AAs	28.61[a]	22.93[ab]	18.36[b]	3.93(p=0.05)
Plasma urea (mg/dl)	16.28[ab]	18.62[a]	15.13[b]	1.23(p=0.05)
Plasma insulin (μIU/ml)	4.70[c]	8.20[b]	14.23[a]	5.63(p=0.04)
Liver RNA/DNA	0.26[b]	0.26[b]	0.32[a]	0.09(p=0.04)

Table 3. Comparision of the ideal amino acid patterns proposed by different researchers (as lysine %)

	Amino Acids pattern (as Lysine %)									
	Lys	Met+Cys	Thr	His	Arg	Leu	Ileu	Val	Phe	Trp
Wang H.R (1998)	100	39.37	76.17	40.51	72.25	157.54	81.47	104.75	81.02	12.94
MaCame et.al (1978)	100	39.77	46.94	32.65	62.24	73.47	46.94	48.98	39.78	13.27
Fraser et al (1991)	100	46.38	55.34	38.04	49.94	128.83	71.29	85.15	63.69	17.91
Storm et.al (1983)	100	42.39	63.04	22.83	57.61	86.96	63.04	63.04	57.61	16.30

Note: Wang Honoring (1988)----Modified muscle protein AA pattern; McCanc and widdowson (1978)----muscle protein AA pattern; Fraser et al (1991)----Casein AA pattern; Storm and Φrskov (1983)---rumen microbial protein AA pattern.

Peptide Production and Absorption in the Rumen

As we knows, absorption of peptides from the forestomachs has been reported (Webb et al., 1992,1993;koeln et al., 1993). The forestomachs region of the gastrointestinal tract may be an important site of peptide absorption. The knowledge about peptide absorption in general and peptide absorption from the forestomachs and duodenum in particular may change some of the currently held views about protein utilization in ruminant animals and to develop techniques for improving rumen microbial growth rate and efficiency and then the efficiency of dietary N retention by the ruminant animal. Cheng Mao-ji (2000) studied on dynamics of production degradation, absorption, outflow and microbial uptake of oligopeptides in the rumen of sheep by using a pulse-continuous infusion of different peptides solution under once every two hours feeding conditions. Some results obtained are shown in Table 4.

Table 4. Dynamics of production, degradation, absorption, outflow and microbial uptake of different oligopeptides in the rumen of sheep

	Peptides source					
	Soybean peptides		corn peptides		rumen liquid peptides	
	(mgN/d)	(%)	(mgN/d)	(%)	(mgN/d)	(%)
Degredated peptides (1)	2035.68	59.83	968.88	44.78	3134.4	58.77
Absorbed peptides (2)	273.84	8.05	211.44	9.77	330.96	6.21
Outflowed peptides (3)	574.44	16.09	544.80	25.18	565.68	10.61
Microbial uptake of peptides (4)	545.52	16.03	438.48	20.27	1302.24	24.41
Principle production of peptides (1)+(2)+(3)+(4)	3402.48	100.00	2163.60	100.00	5333.30	100.0

The data in Table 4 indicate that the principle productions of soybean, corn and rumen liquid peptides are 3402.48,2163.60,5333.30 mgN/d, respectively; among them, corn peptides have the lowest value and rumen liquid peptides the highest one. It was also found that the absorption of peptides from different sources in the rumen of sheep was within the range of 211.44-330.96 mgN/d (6.21-9.77% as principle production %), which means the peptides absorbed from the rumen are an unneglectable part of dietary N compounds. A more thorough understanding of what impact the knowledge of peptide absorption may have on ruminant N metabolism awaits further experimentation.

ENERGY UTILIZATION

In comparison with monogastric animals, ruminant animals have lower efficiency of dietary energy utilization (Table 5).

Table 5. Comparison of efficiencies of dietary energy utilization in swine with in ruminant animals fed a common practical diet (Church and podn, 1982)

	Swine	Ruminants
ME (as DE%)	75-90	50-87

ME Utilization for production (%)		
for body gains	75-80	30-62
for lactation	75-85	40-75

Several aspects in digestion and metabolism processes are involved in the inefficiency for ruminants. They are:

——Energy Losses in rumen fermentation.

——Inefficiency of acetate utilization, particularly in fermentation mode with acetate type in the rumen.

——Imbalance of glycogenic, aminogenic and lipogenic nutrients in the duodenum digesta or in the absorbed nutrient supply.

——The portal drained viscera (digestive tract, spleen and pancreas) tissues cost too much available energy, which was estimated to account for 15% of the ME (Lindsay, 1993).

——Poor utilization of low quality roughages, which occupy the most part of ruminant diets.

Mitigation of Methane Emissions

Methane is of environmental concern with respect to global warming, and also results in a loss of feed energy to the animal. It was estimated that cattle produced 73% of the livestock methane emissions, water buffalo 10%, sheep and goats 12%, camels and swine about 1% each and horses and donkeys about 2%(Johnson, et al, 1996). The data in Table 6 indicate that the estimated livestock gastrointestinal methane emissions in China make up about 10% of the world total value.

Table 6. Estimated gastrointestinal methane emissions by livestock in China in 1997

Species	Head ($\times 10^4$)	Annual methane emissions (kg/animal)*	Total emission (Tg)
Cattle	1411	35	4.90
Sheep	1343.6	5	0.67
Goats	1679.6	5	0.84
Swine	4664.7	1	0.47
Horses	906	18	0.16
Total	——	——	7.04

*Data from Leng (1993)

Reducing ruminant gastrointestinal methane emissions requires a comprehensive technique. Some common strategies are listed in Table 7.

Table 7. Methane mitigation strategies for ruminant animals*

Strategies	Technology availability	Capital requirements	Methane reduction (Per unit of Product)
Feeding processing			
Alkali/ammonia straw	current	Low	≥10%
Chopping straws	current	low	≥10%
Rice straw wrap	proposed	Low/medium	≥10%

Strategic Supplementation			
Molasses urea blocks	Current	Low	≤40%
Blocks plus escape protein	Current	Low/medium	≤60%
Mineral, protein supplements	current	Low	5-10%
Nutritional manipulators			
Defaunation	Future	Low	≤25%
Bovine somatotropin	Current	Low	10%
Anabolic implants	partial	Low	5-10%
Methane inhibitors**	Current	Low	6-14%

*After Johnson et al (1996); ** The data were provided by our labotorary.

Metabolizable Glucose (MG)

The limitation of current feeding systems based on measurement of energy metabolism is that DE or ME is not a nutrient per se, but the sum of a number of processes resulting in the assimilation of specific energy yielding nutrients. Today many nutritionists have recognized the need for feeding systems based on a clearer understanding of the role of specific absorbed nutrients and their metabolism in determining productive responses of farm animals (Reynolds, 2000). The nutrients for metabolism arise from the products of rumen fermentation and digestion of bypass nutrients and endogenous secretions, and from mobilized body tissues. The interrelationships among these sources are shown in Figue 1.

The evidence from trails proved that there was an optimum ratio of synthesis energy (C3+C6 energy) in ME requirements for ruminant animals (Φrskov, 1980). For example the ratio for lambs are 9.9-24.2%, for steers 9.9-23.2%, for dairy cows 9.9-39.0%. Therefore, there is a possibility to manipulate the ratio for improving efficiency of dietary energy utilization. To hit the target, we must develop a new index to evaluate the animal's glucose requirement and the relative feed characteristics. For this purpose, in 1996 Lu De-xun proposed a new technical term called metabolisable glucose (MG)(Sun Hai-zhou, 1999). It is defined as the total glucose available to the animal for metabolism after digestion and absorption of the feed in the animal's digestive tract. MG has two components:

——Glucose synthesized in the liver by propionic acid produced by the activities of the rumen microbes (Symbolized by POEG).

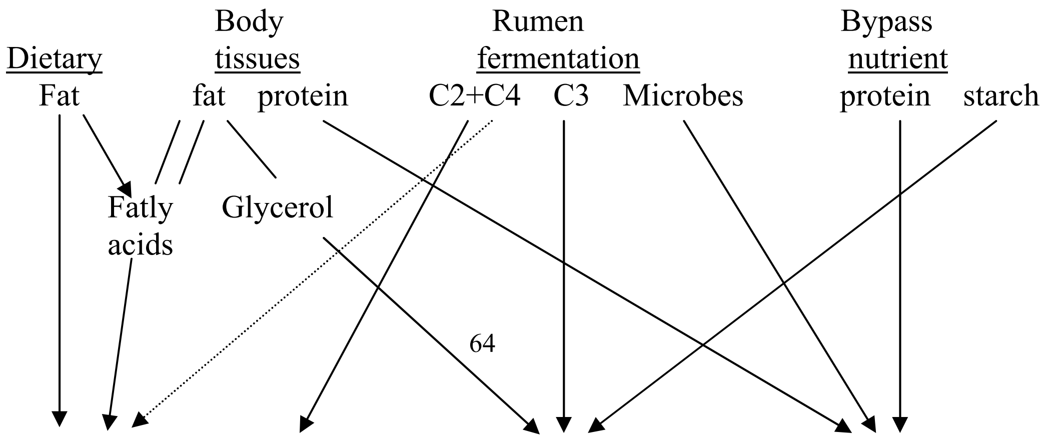
——Glucose provided by bypass starch and digested and absorbed in the lower intestines of the animal (Symbolized by BSEG).

According to the definition, MG (g/d)=POEG+BSEG

$$=0.09K_1*Pr+0.9K_2*BS$$

Where, Pr——pripionic acid production (mM/d)

BS——bypass starch (g/d)



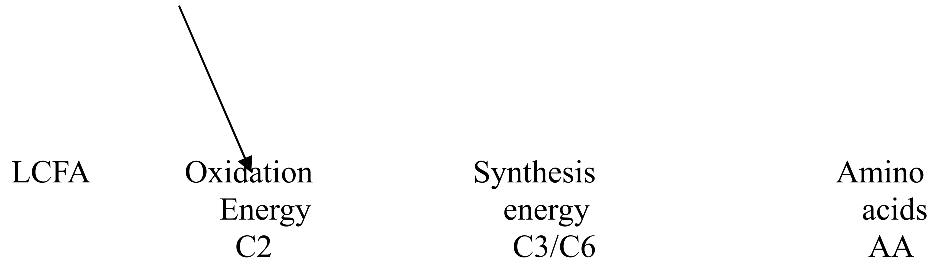


Figure 1.Origin of principal metabolites in ruminants (from Leng, 1987)

Based on the new term, Sun Hai-zhou (1999) Studied on dietary starch digestion, absorption and utilization and effects of different infusion levels of starch into the duodenum and on effects of different dietary MG/MP ratio on glucose nutrition of growing-finishing sheep fitted with permanent cannuals in the rumen and at the proximal duodenum and terminal ileum and with carotid artery, jugular vein, mesenteric and portal venous catheters. In Sun's ph.D thesis, he is the first person to determine the dietary MG value in growing-finishing sheep, and found that there was an optimum requirement for MG (131.6g/d, under 1.1M basic dietary condition). It was also found that there was significant correlation between dietary MG value (X) and total Liver glucose entry (Y). The regression formula is:$Y=-11.71+1.18X$ ($r^2=0.9782, n=20, P<0.01$)

This finding could be helpful to manipulate the ratio of C3+C6 energy in ME supply for better efficiency of dietary energy utilization. The MG term system has great potential to improve the current feeding system and to establish new feeding system for ruminants.

Improving Utilization of Low Quality Roughages

The potential of crop by-products as a feed resource for ruminants is being increasingly appreciated. So for, attention has been drawn to the considerable effort that has been directed towards improving the feeding values of crop by-products and other low quality roughages though a variety of processing. Obviously pretreatment processing can improve their feeding value by increasing its digestible energy content and/or by increasing feed intake, but all these pretreatment processing never can remove all of the important nutritional limitations to fermentation of low quality roughage by the rumen microbial population or limitations to metabolism in the tissues of the host animal. A great deal of evidence showed the optimal improvement of the feeding value of low quality roughages was only achieved with integrative manipulation technique (Preston and Leng, 1987;Lu De-xn, 1992). These multi-techniques are a kind of integrated and systematic one and focus attention on the 4 main aspects: increasing roughage intake; stimulating roughage DM fermentation in the rumen; optimizing the balances between absorbed nutrients; using nutritional status monitoring techniques (see Figure 2).

As shown in figure 2, a combination of 4 types of techniques is used in this technical programme. It is called as P plus 3M techniques, where P Stands for roughage processing; M1——nutritional manipulation through strategic supplementation; M2——nutritional managements, such as controlling feed particle size, optimizing feeding regime and using green forage as a catalytic supplement etc; M3——nutritional status monitoring which is much helpful to design supplementation strategy and to control the affectivity of the whole technical programme.

10 mature withers were used to study the effects of integrative nutritional manipulation (INM) technique on nutrient utilization of ammoniated wheat straw (Gao Min et al, 1991). The results shown on Table 8 indicated that 3.46, 4.74,7.04,3.05,4.08 unit increases in digestibilities of OM, CP, CF, NDF and ADF for the diet based on ammoniated wheat straw treated by INM technique were found, compared with for the control diet based on ammoniated wheat straw only. Utilization of the animals was increased from 35.33% in the control group to 42.92% in INM group with 2.35g more of daily N retention (P<0.05). Daily body gains of the animals in INM group were higher and the feed conversion was improved, too.

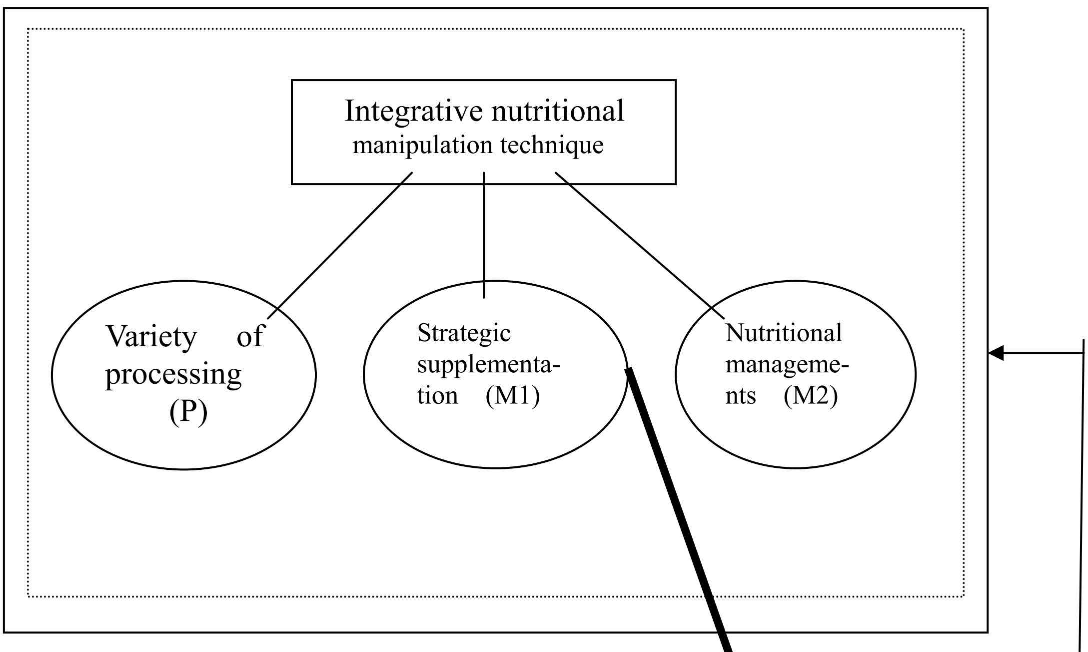
Table 8. Effects of INM technique on nutrient utilization of the diets based on ammoniated wheat straw

	INM technique	control
Digestibility (%)		
DM	65.18±1.72**	61.72±1.40
CP	67.57±2.03**	62.83±1.96
CF	64.68±1.84**	57.64±2.56
NDF	63.76±2.40*	60.18±1.80
ADF	55.80±2.22*	51.76±2.50
N retention (g/d)	8.49*	6.14
N utilization (as digestible N%)	63.54	56.22
Daily body gains (g/d)	83.3(128)	73.8(100)
Feed/body gain	10.2	11.8

* P<0.05 **P<0.01

Table 9. Effects of feeding ZnMet Chelate on Zn utilization in growing-finishing sheep

	treatment		
	Control	Zno+Methinine	ZnMet Chelae
Zn intake (mg/d)	33.33±2.10	43.37±3.06	48.39±0.55
Focal Zn output (mg/d)	22.59±3.32	29.88±3.35	29.41±2.25
(as Zn intake%)	67.78	68.90	40.78
Urinary Zn Output	2.31±0.69	1.69±0.34	2.40±0.62
(as Zn intake%)	6.93	3.90	4.96
Zn absorption (%)	32.39±7.45[a]	31.44±3.25[a]	39.21±4.89[a]
Zn retention (mg/d)	8.44±1.20	11.90±0.15	16.58±0.13
(as Zn intake %)	25.57±8.11[a]	27.47±2.40[a]	34.27±4.11[b]



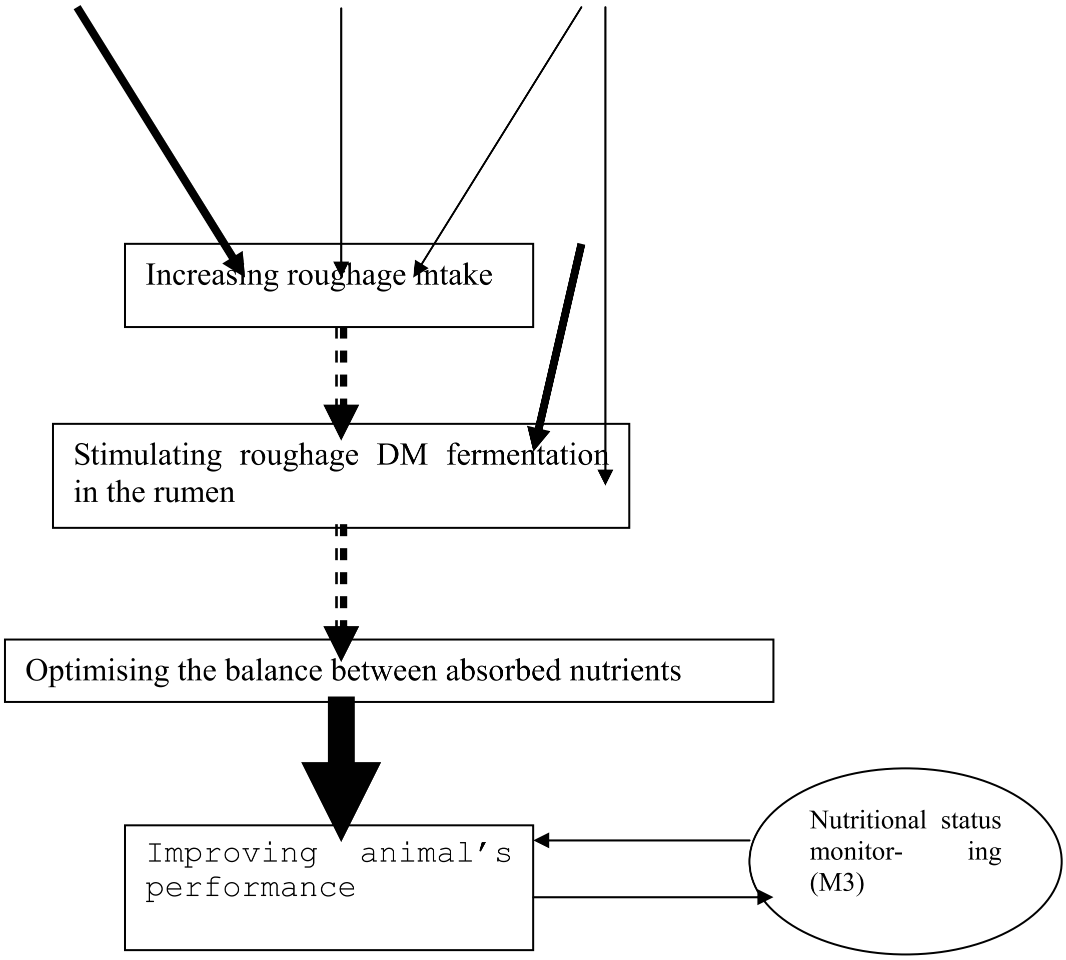


Figure 2:A Schematic Outline of the Intergrative nutritional manipulation technique for improving the utilization of low quality roughages

MINERAL UTILIZATION

In recent years, there has been increased environmental concern about the excretion of minerals by animals. In practice, there is not only excessive supplementation of minerals, but also the imbalance between dietary minerals for ruminants. Excessive mineral supplementation may cause a number of problems. The provision of minerals beyond the needs of an animal is economically wasteful and reduces the efficiency of mineral utilization and thus increases mineral excretion in feces and urine. The balance between dietary minerals is also an important factor affecting mineral utilization.

From an environmental standpoint, there are two ways both to optimize ruminant production and mineral losses in feces and urine. They are: (1) to refine current animal's mineral requirements;(2) to improve bioavailability of some dietary mineral sources.

Recently there has been considerable interest in use of organic trace minerals in ruminant diets. In our laboratory, Wang Hongrong et al (1998) studied on use of ZnMet in growing-finishing sheep feeding. The results in table 9 showed that ZnMet could significantly improve the bioavailability of dietary Zn and Zn retention and reduce fecal Zn excretion in the sheep.

CONCIUSION

For increasing the utilization of dietary nutrients and reducing environmental contamination, the nutritional manipulation has big potential. Settling at this specific goal, the development of the green nutritional techniques will likely increase in the future. Here, an emphasis is required that the first principle for designing and using these techniques must lie in synergism among the techniques. Until now, such nutritional technique has been in a stage for development of each individual technique. There are needs to carry out more research works before application of an integrative and systematic technique in ruminant production.

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Nutritional Control to Reduce Nitrogen Excretion from Cattle

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Introduction

As it has been established, the rumen has an important role and function in preparing fermentation end-products for biosynthesis processes of ruminants. It is therefore essential that the rumen is healthy and be able to establish an optimal ecology in order to perform well in regards to rumen microorganisms (bacteria, protozoa and fungi), pH, substrates (e.g. roughage, energy, effective fiber etc), fermentation end-products (NH_3-N, VFAs), and microbial protein synthesis. VFAs are major sources of energy, glucogenic and lipogenic compounds particularly propionate (C3), acetate (C2) and butyrate (C4) while NH_3-N is essential source of nitrogen for microbial protein synthesis, respectively(Orskov and Flint, 1989). Factors which contributed to the production and absorption of these compounds have been reported in a number papers. It was found that an established rumen be required and was affected by types and character stics of feeds, roughage to concentrate ratios, which consequently influenced on rumen microorganisms, fermentation pattern and rumen efficiency. It is therefore imperative to have an optimal rumen ecology for efficient use of feeds in the rumen especially the use of carbohydrate and protein for later use by the ruminants in order to control the use of nitrogen.

Nitrogen Fermentation and Metabolism in the Rumen and Its Impact on Ruminant Utilization

Dietary protein contains both rumen degradable and undegradable (by-pass) protein. Rumen degradable protein (RDP) and dietary non-protein nitrogen (NPN) especially urea will be solubilized and broken down into peptides, amino acids and NH_3-N in the rumen, respectively. While rumen undegradable protein will pass down to the lower-gut for later digestion and absorption. Rumen NH_3-N pool has been shown to be essential for optimal rumen microbes growth and as a source of microbial protein synthesis. Ranges of rumen NH_3-N has been reported to be 15-30 mg/dl for optimal rumen ecology (Leng, 1999,Wanapat and Pimpa 1999) . Excessive level of NH_3-N will be absorbed and be synthesized into urea in the liver through urea cycle. Urea will then be recycled into the rumen through rumen wall and a composition of saliva. The other route is being excreted in the urine. Amino acids and NH_3-N in the rumen will be transported into microbial cells and be synthesized into microbial protein. Efficient uses of amino acids and NH_3-N depend highly on the available carbohydrates especially non-structural carbohydrates to provide C-skelaton for microbial protein synthesis. Manipulating level of rumen degradable protein, the use of NPN and provision of NSC are essential approach and means in controlling the efficient use of N in ruminants /cattle. Imbalances of carbohydrates and nitrogen will result in excessive excretion of N in the form of urine and /or to induce urea toxicity (Fig1). Paper presented at the International Conference on Public Health Issues in Animal Production/Animal

Effects of Feeds on Rumen Ecology

Table 1 shows effects of different roughages on rumen ecology and fermentation end-products. It was found that urea-treated rice straw and mixed untreated and urea-treated rice straw improved rumen NH_3-N. These results suggest a better use of N to carbohydrate through the use of urea-treated rice straw (Wanapat , 2000).

Effect of Cassava Hay as a Protein Supplement on Dairy Cows

Cassava hay was used to supplement in lactating dairy cows as a source of protein (25% CP) and tannin-protein complex. Under this experiment, cassava hay supplementation improved fat protein, lactose percentages ($P<0.05$). Significant improvement of milk yield (3.5% FCM) was obtained in group supplemented with cassava hay as a result of efficient use of protein (Table 2) (Wanapat et al., 2000). It suggests that manipulating rumen NH_3-N and providing rumen undegradable or by-pass protein by the use of cassava hay could improve productivity.

Conclusions and Recommendations

Nitrogen or protein is an essential portion in ruminants/cattle feed. Manipulating N sources and levels in the rumen and available carbohydrates would improve rumen ecology and fermentation, Thus, it would enhance the overall use of N to reduce toxic potentiality and to reduce N loss in the urine and feces. Practical uses of local feed resources have been found to improve the feeding systems especially under small-holder farming context. Thus, the efficient use of N in feeding systems would reduce the loss in urine, feces and the environment.

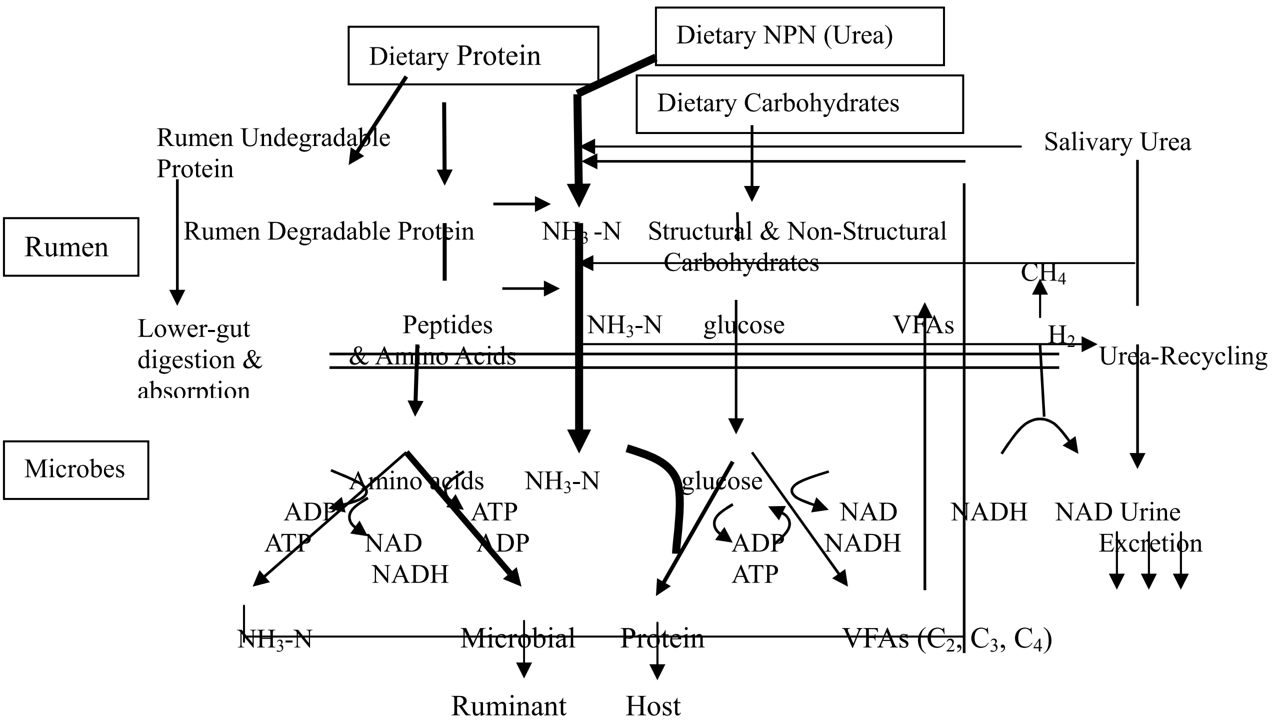

Fig.1.Interrelationships between carbohydrate fermentation, ammonia production and microbial protein synthesis in the rumen and nitrogen excretion in urine of ruminants

Table 1. Effects of roughages on rumen ecology and fermentation characteristics in cattle and swamp buffaloes

	URS	UTRS	MX	Buffalo	Cattle	SEM
Rumen						
pH	6.54	6.43	6.44	6.45	6.48	.05
Temp, ^{0}C	38.9	39.1	39.2	39.0	39.1	.04
NH_3-N, mg/dl	8.9[a]	15.2[b]	12.6[c]	12.6	12.5	.88
TVFAs, mM	72.1	96.2	86.1	82.3	87.3	3.43
C_2, mole/100 mole	73.4[a]	70.4[b]	70.9[ab]	72.2[c]	70.9[d]	.50
C_3, mole/100 mole	21.8	24.2	24.4	22.5	24.4	.57
C_4, mole/100 mole	4.8[ab]	5.5[a]	4.7[b]	5.2[c]	4.8[d]	.15
C_2+ C_4:C_3	3.7[a]	3.2[b]	3.2[b]	3.5	3.2	.09
TVFAs/ NH_3-N	8.0	6.3	7.1	7.2	9.0	.65
CH_4, mole/100 mole VFA	33.5	31.9	31.7	33.1	31.6	.39

Wanapat (2000). URS = untreated rice straw UTRS = urea-treated (5%) rice straw
MX = mixed URS and UTRS

Table 2. Effect of levels of chopped cassava hay on milk yield and compostion of Holstein Friesian crossbreds fed urea-treated (5%) rice straw on ad libitum basis

Item	Chopped cassava hay, kg/d			
	0	0.8	1.70	SEM
Concentrate DM intake, kg/d	5.53	5.00	4.03	0.25
Concentrate saving, kg/d (% control)	0	0.53	1.50	0.30
Milk yield, kg/d	12.50	12.12	12.62	0.57
3.5% FCM, kg/d	14.21[a]	15.70[b]	14.93[b]	0.67
Milk composition				
Fat,%	4.06[a]	4.15[b]	4.61[c]	0.19
Protein,%	3.40[b]	3.34[a]	3.50[c]	0.08
Lactose,%	4.64[a]	4.82[b]	4.62[a]	0.05
Solids-not-fat,%	8.74	8.80	8.81	0.09
Total solids,%	13.56	13.18	13.76	0.3

[abc] Values with different superscripts differ ($p<0.05$). Wanapat et al. (2000)

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Nutritional Control to Reduce Phosphorus Excretion From Monogastric Animals

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1. INTRODUCTION

In many areas with intensive animal production, the amount of phosphorus entering the environment with animal excreta can be Problem. Therefore, phosphorus excretion by animals should be decreased. Diets for swine and poultry contain high amounts of phosphorus in the form of phytate that has a low availability in these animals. Since the contents of available phosphorus from plant feeds are usually insufficient for pigs and poultry, additional inorganic phosphorus is supplies to the diets. There are two possible strategies to improve the availability of phosphorus in these feeds, i.e., the reduction of phytate contents in ingredients and dietary supplementation of phytase that degrades phytate in the digestive tract.

There have been trials to reduce phytate in feeds and foods using several methods, such as the degradation of phytate by extrusion cooking (Sandberg et al., 1987) by soaking to activate endogenous phytase in wheat bran (Morris and Ellis, 1980), by fermentation using yeast in wheat, or by soaking with microbial phytase that degrades phytate prior to feeding (widdowson, 1941), the removing phytate in soy protein by alkaline solution (Hartman, 1979) or ion exchange resin (Niiyama et al., 1992), the reduction of phytate content in soybean by the sand culture technique (Zhou et al., 1992), or the application of genetic modulation for reducing phytate in cormn (Spencer et al., 2000). Certain strains of *Aspergillus sp.* Are known to possess phytase activity and the fermentation with these microbes was reported to degrade phytate (Nelson et al., 1986). We tries to dephytinize soybean meal (SBM) using fermentation with *Aspergillus usami* and Phosphorus availability in the fermented soybean meal (FSBM) was studied in chicks.

Aspergillus phytase is well known to increase phosphorus availability in pigs and poultry fed corn and soybean meal based diets (Cromwell et al., 1993; Lei et al., 1993; Simons et al., 1990). Dietary microbial phytase mainly degrades phytate in the stomach of pigs (Jongbloed et al., 1992; Yi and Kornegay, 1996). *Aspergillus* Phtase showed maximal activity at pH 5.0 to 5.5 (Shieh et al., 1969; Simons et al., 1990). However, the digesta in swine stomach were reported to be at pH 4.5 (Dintzis et al., 1995) or Ph 3.8 (Yi and Kornegay, 1996). The avtivity of phytase from *Aspergillus* at pH 4 is reduced to less than half of the maximal activity (Engelen et al., 1994; Sandberg et al., 1995). A yeast strain of *Schwanniomyces occidentalis* also produces phytase may function more efficiently in the stomach of pigs than *Aspergillus* phytase. We studied the efficacy of different levels of yeast phytase in phosphorus utilization usting pigs. Additionally, we compared the efficacy of yeast phytase with that of phytase from *Aspergillus niger.*

(1) FERMENTATION OF SOYBEAN MEAL IMPROVED PHYTATE-

PHOSPHORUS AVAILABILITY IN CHICK.

1) Dephytinization of soybean meal by the fermentation with *Aspergillus usami*

Approximately 2*106 spores of *Aspergillus usami* were inoculated to 100g of steames SBM then fermented for 48 hours. Following the first fermentation, water was added to bring the product to 50 % content and it was fermented again for 12 hours (Ilyas, 1995). After the second fermentation, the product was dried and ground for analyses.

Aflatoxin B1 was not detected in FSBM. Crude protein, crude fiber, ether extract and crude fat concentrations were slightly increased by the fermentation with a concomitant reduction in nitrogen free extract (Table 1). By the fermentation, proteins in soybean meal were partly degraded and the molecular weights became less than 50 kDa. On the other hand, there was a slight diffderence in amino acid composition between SBM and FSBM, Approximately 55% of phosphorus in SBM was phytate phosphorus. Phytate phosphorus was not detected in FSBM. These results suggested that the fermentation almost completely degraded phytate in SBM without adversely affecting nutritional value of protein although easily fermented carbohydrates was partly lost. Therefore the fermented soybean meal in possibly used as a phytate-free protein source of monogastric animal feed.

Table 1. Chemical composition of soybean meal and fermented soybean meal (g/100gDM)

	SBM	FSBM
Crude protein	47.0	53.2±2.3[a]
Crude fiber	4.0	4.7±0.2
Ether extract	2.0	2.6±0.5
Crude ash	6.9	7.4±0.1
Nitrogen free extract	40.1	32.1±2.5
Phytate Phosphorus	0.40	ND

(2) THE AVAILABILITY OF PHOSPHORUS IN THE FERMENTED SOYBEAN MEAL IN CHICK

We examined the effect of the fermentation of soybean meal with *Aspergillus usami* on the phosphorus availability in chicks. Thirty 1-week-old male Leghorn-type chicks were divided into three groups and fed following each diet for 4 weeks:1) a diet containing soybean meal (SBM diet; total phosphorus, 5.2g/kg; non phytate phosphorus 2.3g/kg), 2) a diet containing soybean meal supplying inorganic phosphorus, (SBM+P diet; total phosphorus, 7.1g/kg; non phytate phosphors 4.0g/kg), or 3) a diet containing the fermented soybean meal (FSBM diet; total phosphorus, 5.8g/kg; non phytate phosphorus, 3.9k/kg). The excreta were collected in the last 5 days. The chicks were killed and the left femur was collected at the end of the feeding period.

Body weight gain was higher in the chicks fed FSBM diet and SBM+P diet than in those fid SBM diet during the 4-week feeding tuial (Table 2). Femoral dry weight, Phosphorus content, as well as specific gravity, were significantly greater in the chicks fed FSBM and SBM+P diets than in those fed SBM diet. Body weight gain and femoral parameters did not differ between the chicks fed FSBM diet and those fed SBM+P diet, In the last 5days of the feeding trial, Phosphorus excretion was largely lower in the chicks given FSBM diet than in those given the other diets. Retained phosphorus was more in the chicks given FSBM diet and SBM+P diet than in those given SBM diet and not differ between the chicks fed FSBM diet and those fed SBM+P diet. However, phosphorus retention (% of intake) was higher in the chicks given FSBM diet than in those given the other diets.

These results suggested that the fermentation improved phosphorus availability through degrading phytate in soybean meal. Dietary supplementation of inorganic phosphorus was not necessary for chicks fed FSBM. As a result, the application of FSBM can reduce phosphorus excretion in chicks.

Table 2 Body weight gain, femoral characteristics excretion in chicks given diets based on regular or fermented soybean meal

	SBM	SBP+P	FSBM
Body weight			
Initial (g)	88.0±0.5	88.9±0.4	88.5±0.4
Final (g)	436±6b	487±7a	472±9a
Gain (g)	348±5b	399±7a	383±9a
Femoral characteristics			
Dry weight (g)	2.05±0.04b	2.52±0.04a	2.44±0.05a
Specific gravity (g/cm3)	0.837±0.007b	0.880±0.006a	0.887±0.004a
Phosphorus content (mg)	163±6b	217±7a	214±11a
Phosphorus intake and retention			
Intake (mg/d)	307±7c	439±10a	349±10b
Excreted (mg/d)	240±7b	337±11a	234±14b
Retained (mg/g)	66±6b	95±6b	116±11a
Retention (% of intake)	21.5±2.0b	21.8±1.3b	33.2±3.2a

Means within a row with no common superscript differ significantly ($P<0.05$)
Means±SEM for 10 chicks

2. EFFECT OF DIETARY YEAST PHYTASE ON PHOSPHORUS AVAILABILITY IN PIGS

1)Effect on growth and bone characteristics

In this experiment, we evaluated the efficacy of phytase from yeast of *Aspergillus niger* in performance, tibial characteristics, and serum inorganic phosphorus concentration in crossbred barrows of 6 week old. Pigs were fed a phosphorus-adequate diet containing 0.34% non phytate phosphorus or a low-phosphorus diet containing 0.20% non phytate phosphorus for 6 weeks. The low-phosphorus diet was supplemented with 0, 1000, 2000 or 4000 phytase unit (PU; the activity at optimal ph, i.e., pH 4.2 for yeast phytase and pH 5.5 *Aspergillus niger* phytase)/kg of yeast phytase, or 1000-PU/kg phytase from *Aspergillus niger.*

The graded level of yeast phytase improved gain, tibial weight, tibial specific gravity, and phosphorus concentration in tibial cortex (Table 3). *Aspergillus niger* phytase also increased gain.

Serum inorganic phosphorus concentration, tibial specific gravity, and tibial phosphorus concentration. The pigs given 1000-PU/kg *Aspergillus niger* phytase showed greater tibial specific gravity than those given 1000-PU/kg yeast phytase. Gain and tibial phosphorus concentration were also tended to be greater in the pigs given 1000-PU/kg *Aspergillus niger* phytase, No measurements differed between the pigs given 1000-PU/kg *Aspergillus niger* phytase and those given 4000-PU/kg yeast phytase. These results suggested that yeast phytase improves availability of phosphorus in the diet for growing pigs but the efficacy of yaest phytase is less than that of *Aspergillus niger* phytase.

Table 3. Body weight gain, tibial characteristics and serum phosphorus in growing pigs given phytase

	Dietary phosphorus						
	Adequate	Low					
Phytase[a]	0	0	1000Y	2000Y	4000Y	1000Y	SE
Average daily gain[b] (g)	610^{e}	432^{f}	525^{e,f}	553^{e}	558^{e}	569^{e}	31
Average daily feed intake (kg)	1.26	1.01	1.13	1.17	1.26	1.12	0.11
Gain:feed (g/kg)	487	430	460	468	457	492	20
Serum inorganic phosphorus[b] (mg/l)	96.4^{e}	58.8^{f}	77.7^{g}	87.9^{e,h}	81.3^{g,h}	81.9^{g,h}	3.3
Serum calcium (mg/l)	114.5	118.5	117.7	113.1	116.2	117.0	3.0
Tibial dry weight (g)	85.3	71.7	77.5	78.4	85.3	81.8	5.5
Tibial specific gravity[c] (g/cm^3)	1.23^{e}	1.15^{f}	1.18^{g}	1.19^{g}	1.22^{h}	1.21^{h}	0.001
Phosphorus concentration in tibial cortex[d] (mg/g)	114.9^{e,f}	109.0^{f}	111.9^{e,f}	115.6^{e,f}	117.4^{e,f}	119.1^{e}	2.8

Data are means of three pens each containing three of four pigs.
Within a row, means lacking a common superscript letter differ (P<.05)
[a]Supplied per kg of diet: 1000Y, 1000-PU yeast phytase; 2000Y, 2000-PU yeast phytase; 4000Y, 4000-PU yeast phytase; 1000A, 1000-PU *Aspergillus niger* phytase
[b]Diet effect (P<.001). [c]Diet effect (P<.001). [d]Diet effect (P=.094).

2) Effect on apparent phosphorus absorption

Six male pigs (Gottingen) aged 11 months were allotted to a 6*6 Latin square design, Pigs were fed a diet containing a phosphorus-adequate diet or a low-phosphorus diet. The low-phosphorus diet was supplemented with 0,1000,2000 or 4000-phytase unit (PU)/kg yeast phytase, or 1000-PU/kg *Aspergillus niger* phytase.

Apparent absorption of phosphorus was increased by the supplementation with 2000 and 4000-PU/kg yeast phytase (Table 4). Although phosphorus absorption in pigs given 1000-PU/kg *Aspergillus niger* phytase did not differ from thoes given 2000PU/kg yeast phytase, the pigs given 1000-PU/kg *Aspergillus niger* phytase tended to absorb more phosphorus than did the pigs given 1000-PU/kg yeast phytase. Based on linear equation generated for the levels of yeast phytase and absorption of phosphorus, 1000-PU/kg *Aspergillus niger* phytase was equivalent to 2180-PU/kg yeast phytase, These results suggested that supplementation with yeast phytase increased phosphorus absorption in pigs. Hovever yeast phytase was less effective than *Aspergillus niger* phytase in pigs. These results were in agreement with the above experiment in which we estimated phosphorus availability by growth and bone characteristics in pigs given phytase.

Table 4. Phosphorus balance and plasma phosphorus concentration in pigs given phytase (g/day)

	Dietary phosphorus					
	Adequate	Low				
phytase^{a}	0	0	1000Y	2000Y	4000Y	1000Y
Intake						
	5.25±0.26	2.39±0.10	2.51±0.06	2.78±0.04	2.82±0.13	2.61±0.04
Fecal excretion						
	1.89±0.44^{a}	1.61±0.34^{ab}	1.41±0.38^{bc}	1.25±0.28^{bc}	1.09±0.28^{c}	1.22±0.20^{c}
Absorption						
	3.35±0.26^{a}	0.79±0.29^{d}	1.10±0.41^{cd}	1.52±0.29^{b}	1.74±0.36^{b}	1.39±0.21^{bc}
(% of Intake)						
	64.2±7.3^{a}	33.0±12.6^{c}	43.8±16.1^{bc}	54.8±10.1^{ab}	61.3±11.0^{a}	53.3±7.9^{ab}
Urinary excretion						
	1.37±0.39^{a}	0.08±0.04^{b}	0.17±0.13^{b}	0.20±0.13^{b}	0.20±0.09^{b}	0.26±0.21^{b}
Retention						
	1.99±0.48^{a}	0.71±0.29^{d}	0.94±0.45^{cd}	1.33±0.35^{bc}	1.54±0.38^{b}	1.13±0.36^{bcd}
(% of Intake)						
	38.3±10.8^{bc}	29.7±12.4^{c}	37.2±17.8^{bc}	47.8±12.5^{ab}	54.2±11.9^{a}	43.3±13.8^{abc}
Plasma phosphorus (mg/l)						
	65.9±6.62	61.4±4.17	62.0±7.60	60.5±6.13	63.8±3.68	62.9±2.43

Means±SD for 6 pigs

Means in the same line with different superscripts significantly differ ($P<0.05$)

[a]Supplied per kg of diet : 1000Y, 1000-PU yeast phytase; 2000Y, 2000-PU yeast phytase; 4000Y, 4000-PU yeast phytase; 1000A, 1000-PU *Aspergillus niger* phytase

It is not clear why yeast phytase is less effective than *Aspergillus niger* phytase. Yi and Kornegay (1996) suggested that approximately 60 % of supplied *Aspergillus niger* phytase was degraded in the stomach of pigs. We reported that only 20 % of dietary yeast phytase remained in the stomach of pigs 2 hours after ingestion (Tamura et al., 1998). Additionally, we showed that yeast phytase was less stable in acidic solutions with pepsin that simulated the gastuic conditions than *Aspergillus niger* phytase (Matui et al., 2000) Therefore, we consider that the less stability of yeast phytase may be responsible for the poorer efficacy of yeast phytase. Some researchers have isolated and characterized phytases from microbes other than *Aspergillus niger sp.* And yeast. These phytases may be applied as supplements for animal feeds. Before feeding trials, alternative phytases are preferably investigated with regard to stability in the stomach, which can be simulated by incubation in an acidic solution containing pepsin.

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Public Health Risks: Drug and Antibiotic Residues

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Food safety is a term broadly applied to food quality that may adversely affect human health. These include zoonotic diseases and acute and chronic effects of ingesting natural and human-made xenobiotics.

There are two major areas of concern over the presence of residues of antibiotics in animal-derived foodstuffs with regard to human health. The first is allergic reactions. Some antibiotics, such as penicillins can evoke allergic reactions even though small amounts of them are ingested or exposed by parenteral routes. The second is development of antibiotic resistance in gut bacteria of human. Recently multi-resistant pneumococcal, glycopeptide-resistant enterococci and gram negative bacteria with extended-spectrum β-lactamases have spread all over the world, and are now a serious therapeutic problem in human. Although it is evident that drugs are required in the efficient production of meat, milk and eggs, their indiscriminate use should never be substituted for hygienic management of farm. Drug should be used only when they are required.

In addition to veterinary drugs, environmental contaminants that were contaminated in feed, water and air can make residues in animal products. Mycotoxins, heavy metals, pesticides, herbicides and other chemicals derived from industries can be harmful both to animal and human health. Most of organic contaminants, such as dioxin, PCBs and DDT, and metals are persistent in environment and biological organisms and can be accumulated in fat and hard tissues. Some of them are suspected to have endocrine disrupting, carcinogenic, teratogenic, immunodepressive and nervous effects.

The governmental agencies concerned make efforts to prevent residue problems; approval of drugs including withdrawal times of each preparation of drugs, establishment of tolerances, guidelines regarding drug use and sanitation enforcement of livestock products. National residue program is conducted to audit the status of the chemical residues in foods. Recently HACCP has been introduced to promote food safety from farm to table by reducing hazardous biological, chemical and physical factors. Animal Production Food Safety Program, Quality Assurance Programs, Food Animal Residue Avoidance Databank are para- or non-governmental activities ensuring food safety.

This topic will cover classification and usage or sources of chemical residues, their adverse effects, and chemical residue status of some countries. Issues are expanded to residue detection methodologies, toxicological and pharmacokinetic backgrounds of MRL and withdrawal time establishments, and the importance of non-governmental activities with regard to reducing chemical residues in food.

Introduction

Great attention from a public health aspect has centered on the safety of tissue residues as a result of increased use of veterinary drugs and the expanding general increase of chemicals in the food supply. There are large demands for the intensified production of animal proteins for human consumption, along with concerns for potential worldwide food shortages. It is likely, therefore, that use of drugs in diagnosis, prevention, control and treatment of animal diseases become increasingly important. Use of drugs in animal production has expanded to the degree that approximately up to 80% of all animals produced for food purposes receive medication for part or for most of their lives. In the future, it is anticipated that nearly all animals produced in the world for food will have received a chemotherapeutic or prophylactic agent of some types.

Animal drugs and chemicals used for chemotherapeutic and prophylactic purposes are also used as feed additives to promote growth, improve feed efficiency and breeding performance, and enhance feed acceptability. More than 300 feed additives, antimicrobials, anticoccidials and hormone-type agents are used in animal production in the world. Although it is evident that drugs are required in the efficient production of meat, milk and eggs, their indiscriminate use should never be substituted for hygienic management of farm. Drug should be used only when they are required. Veterinary drugs may be used either relatively short period of 1～7 days in treatment of acute infectious diseases or for long periods, which may cover most of lifetime of the animal. Most long-term uses are directed toward the promotion of growth, increased weight gain, and feed efficacy or for prophylactic use against one or more diseases. All drugs used in food-producing animals are approved by the government authorities concerned on the basis that there will be zero residue present in the food, or does not exceed a tolerance level (Reviere ＆ Spoo, 1995).

Chemical residues may be also resulted from pesticides, herbicides, biotoxins and heavy metals contaminated in feed. Finally unintentional administration of drug or feed additives, and accidental and unintentional exposure to chemicals in the environment can also result in tissue residues.

Heavy responsibility is placed on the veterinarian and livestock producer to observe the period for withdrawal of a drug prior to slaughter and market to assure that illegal concentrations of drug residues in meat, milk and eggs do not occur. This is essential from a public health standpoint since levels of residues in excess of those legally permitted in edible tissues may produce injurious effects when consumed over a long time span. With greater use of drugs and chemicals required in production of food crops and animals, the possibilities of humans being continuously exposed to drug and chemical residues for a lifetime is unequivocally evident. The responsibility for residue control cannot lie solely on a governmental agency: rather the responsibility should be shared by producers, veterinarians, marketing associations, scientists and other related parties. The importance of chemical residues in the edible tissues of food-producing animals has been thoroughly reviewed elsewhere (Sundlof 1989; Riviere 1991; 1992; Van Dresser and Wilcke 1989; Mercer 1990; Kindred and Hubbert 1993; Bevill 1989).

There are some major areas of concern over the presence of residues of antibiotics in animal-derived foodstuffs with regard to human health. The first is allergic reactions. Some antibiotics, such as penicillins can evoke allergic reactions even though small amounts of them are ingested or exposed by parenteral routes. The second is development of antibiotic resistance in gut bacteria of human. Recently multi-resistant pneumococcal, glycopeptide-resistant enterococci and gram negative bacteria with extended-spectrum β-lactamases have spread all over the world, and are now a serious therapeutic problem in human. The third is aplastic anemia. Chloramphenicol can induce aplastic anemia in certain sensitive human. The fourth is carcinogenic effects in laboratory animals. Some sulfa drugs and nitrofurans are suspected as potent carcinogens in laboratory animals. Although it is evident that drugs are required in the efficient production of meat, milk and eggs, their indiscriminate use should never be substituted for hygienic management of farm. Drug should be used only when they are required.

In addition to veterinary drugs, environmental contaminants that were contaminated in feed, water and air can make residues in animal products. Mycotoxins, heavy metals, pesticides, herbicides and other chemicals derived from industries can be harmful both to animal and human health. Most of organic contaminants, such as dioxin, PCBs and DDT, and metals are persistent in environment and biological organisms and can be accumulated in fat and hard tissues. Some of them are suspected to have endocrine disrupting, carcinogenic, teratogenic, immunodepressive and nervous effects.

Definition and terminology

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Drug or chemical residue: The chemical residue is either a parent compound or its metabolites that may accumulate, deposit or otherwise to be stored within the cells, tissues, organs or edible products (e.g. milk, eggs) of animals following its use to control or treat animal diseases and its use as feed additives or unintentional exposure of chemicals in the environment. Residual quantities of a chemical are expressed in parts by weight such as ㎎/㎏ or ㎎/ℓ (ppm), ㎍/kg (ppb) or ng/kg (ppt).

Feed additives: Feed additives are defined as drugs, chemicals, or biological substances added directly to animal feeds in some quantities, usually in concentrations of a few ppm for the purpose of modifying some aspects of performance or production.

Unintentional residues: Unintentional residue is one that occurs in feed or food as a result of circumstances not intended to protect feed or food against the attack of infectious or parasitic diseases. Residues of mycotoxins, chlorinated hydrocarbon pesticides, PCB, HCB, PBB, dioxin etc. is included. Their residues are sometimes described as action levels.

Target animal: Use of target animal refers to the determination of safety and efficacy of a drug directly within the species for which therapeutic claims made by the drug manufacturer. Safety and tissue residue data for drugs to be approved in food-producing animals must have been obtained from so-called target species of animals.

Acceptable daily intake: The acceptable dairy intake (ADI) is the daily dose of a chemical residue that during the entire lifetime of a person appears to be without appreciable risk (deleterious or injurious effects) to health on the basis of all the toxicological facts known at the time. For a drug or chemical residue, the ADI is established to provide a guide for maximum quantity that can be taken daily in food without appreciable risk to the consumer. The calculation of the ADI is derived from feeding trials in laboratory animals.

No observable effect or maximum no adverse effect: For most biological responses, it is assumed that a threshold and a no effect level (NOEL) exist. NOEL is a concentration of a chemical that produces no harmful effect on laboratory animals. No effect denotes any change or effect upon physiologic activity, organ or body weight as well as in rate of growth, and cellular structure or enzymatic activity of cells. Before tolerance level of a chemical is established, it is necessary to obtain the NOEL.

Tolerance level: A tolerance level (or maximum residue levels, MRLs) is the maximum allowable level or concentration of a chemical in feed or food at a specified time of slaughter or harvesting, processing, storage and marketing up to the time of consumption by animal or human.

Action level: Tolerance of unintentional residue caused by environmental contaminants. Sometimes it is described as action level. Indirect additives, accidental, incidental or background of natural xenobiotics from circumstances are encompassed within this term.

Carcinogenic effect: Carcinogenic effect refers to an effect produced by a chemical having cancer-producing activity in the presence or absence of initiator or promotor.

Teratogenic effect: The teratogen applies to chemical agents that produce a toxic effect on embryo or fetus during a critical phase of gestation.

Veterinary drugs and other chemicals contaminated in feed and their side effects

Varieties of antimicrobial drugs including antibiotics are used to control the bacterial infections and parasite infestations. All drugs have side effects when they are exposed to human and animals with higher dose or prolonged time than recommended. These types of toxicity are elucidated by small amounts of residual drugs in foods. Subtherapeutic use of antimicrobial drugs induces resistance of microorganisms that cause difficulties in treatment of animal diseases, and consequently incurs abuse and tissue residue of drugs. The amounts of antimicrobial drugs added in animal feeds as feed additives to promote livestock production are less than minimum inhibition concentration (MIC). Thus it is too small to control microorganisms.

Various antimicrobial drugs are registered and being used in the field to promote growth of animals and to control bacterial diseases including mastitis. The drugs used for animal production are listed by generic groups as follows:

Penicillins and cephalosporins are β-lactam antibiotics that act as bactericidal to cell wall synthesis; Organisms resistant to these drugs produce an enzyme β-lactamase. Penicillin Gs (benzathine Pc, procaine Pc) have narrow spectrum (G+) and are sensitive to penicillinase. Ampicillin, amoxicillin, carbanicillin, carbenicillin-indanyl, mezlicillin and ticarcillin have broad spectrum and are sensitive to penicillinase. Methcillin, oxacillin, cloxacillin, dicloxacillin and nafcillin have narrow spectrum but are resistant to penicillinase. Acute allergic reactions to penicillins are the most common untoward effect in people. Recently methicillin resistant organisms are widely spread in human hospital.

Cephalosporins are usually divided into classes based on the chronological development of the drugs: first (cephalothin, cephaloridine, cephapirin, cephalexin, cephaloglycin, cephazolin and cephadroxil), second (cefoxitin) and third generation (cefoperazone, cefotaxime, moxalactam and ceftiofur). They have wide antibacterial spectra depending on each generation and used to control animal diseases including mastitis. Hypersensitivity reactions to cephalosporins have been reported in people Patients who are allergic to penicillins may also allergic to cephalosporins. They may be destroyed by β-lactamase produced by resistant microorganisms.

Tetracyclines are bacteriostaic and have broad spectrum at therapeutic concentrations. Tetracycline, oxytetracycline, chlortetracycline, doxycycline, rolitercycline and minocycline are used for veterinary use as feed additives, injections and ointments. Immunedepression and phototoxicity may occur in animals and human. Superinfections related to tetracyclines have been reported in human hospitals.

Aminoglycosides are effective to G^- bacteria. Aminoglycosides are rarely absorbed from intestine and thus effective intestinal infections. However, drugs absorbed from intestine may be persistent in tissues and not readily eliminated. Streptomycin, neomycin, gentamicin, kanamycin, spectinomycin, tobramycin, amikacin, apramycin, netilmycin, paromycin, and dihydrostreptomycin are used as feed additives, injections and ointments.

Macrolides are bacteriostatic and maily effective to G^+ and some extent to G^- organisms. Resistance to macrolides may occur easily and thus cross-resistance with other antibiotics has been reported. Erythromycin, oleandomycin, josamycin, kitasamycin, troleandomycin, rosaramicin, tylosin and spiramycin are included in macrolide group and used as feed additives.

Lincosamides are used to treat G+ aerobes and anaerobes and are frequently referred as “penicillin substitutes, and so used in bacterial resistance and patient hypersensitivity to penicillin. Lincomycin and clindamycin are included lincosamides. Lincomycin is used as feed additives and injections especially for pigs.

Verginiamycin and bacitracin are polypeptides used for growth promoting. These drugs are restricted to use as feed additives in EU recently due to resistance. Chloramphenicols is the first synthetic antibiotics and has wide-spectrum of antibacterial activity. Use of this drug banned from 1990’s because it develops aplastic anemia in human. The properties of toxicity are very unique. In general, toxicity of a chemical increases with increasing dose of exposure, However it shows toxicity regardless of exposure dose in genetically susceptible human. Thiamphenicol and fluorothiamphenicol are developed to overcome this side effect.

Nitrofurans are bacteriostic and some of them have broad spectrum, and comprise several synthetic compounds such as nitrofurazone, nitrofurantoin, furazolidone, furaltadone, nifuraldezone and so on. Furazolidone and nitrofurantoin are banned from use in food producing animals due to their carcinogenicities.

Quinolones are congers of nalidixic acid, which is the first quinolone markted. Although fluoroquinolones are structurally and chemically similar, difference in antimicrobial spectrum does occure. They are usually effective to respiratory infections in animals and culturing fish by susceptible organisms. Recently fluoroquinolone resistant organisms are widely spread in human hospital. Flumequine, floxazone, oxolinic Acid, piromic acid, norfloxacin, danofloxacin, sarafloxacin, cenfloxacin, ciproxacin, orbifloxacin, ofloxacin, enrofloxacin, and pefloxacin are included in this group. Polymyxin B, colistin, novobiocin, tiamulin and carbadox are widely used as feed additives and some of them are used as ointments to treat mastitis.

Sulfonamides are synthetic old drugs to have unique antibacterial spectrum. There many sulfonamides including sulfathiazole, sulfadiazine, sulfamerazine, sulfadimethoxoine, sulfamonomethoxine, sulfaethoxypyridazine, sulfamethazine, sulfapyridine, mefenide, sulfabromomethazine, sulfachlorpyridazine, sulfisoxazole, sufacetamide, sulfaguanidine, succinylsulfathiazole, phthalylsulfathiazole, sulfquinoxaline, sulfamethoxazole, sulfaclozine, sulfamethoxypyridazine, sulfatolamide, and sulfadimethyldyrimidine. They are used as feed additives, oral powders, injections and ointments. Sulfonamides are frequently detected in meat and milk. Sulfamethazine and sulfamethazole can induce thyroid adenoma and hyperplasia in laboratory animals. To reduce bacterial resistance to sulfonamides to get synergistic effect, pyrimethamines such as trimethoprim and ormethoprim are used in combination.

Polyether antibiotics such as salinomycin, rasalocid, monensin, seduramycin and maduramycin are used as feed additives to promote growth and prevent coccidial infections. These drugs can also induced resistance. Other anticoccidial drugs such as amprolium, ainitolmide, nicarbazine, arprinocid and haloginone are also used as feed additives. Antihelminc drugs such as phenothiazine, piperazine, benzimidazoles (thia-, al-, me-, cam-, fen-, parbendazole, oxfendazole, thiopamate), imidazothiazoles (febantel, butamizole, levamisole), tetrahydropyrimidines ((pyrantel, morantel) and organophosphates (dichlorvos, haloxon, coumaphos), ivermectin, doramectin are used for control internal parasites.

Hormones are used to promote growth and lactation performance. Zeranol, trembolone acetate, PST, BST, estrogens and progesterones are permitted to use. PST, BST, estrogens and progesterones are chemically identical to the natural hormones. In some countries these kinds of hormones are not permitted. DES was used to promote growth of cattle. It is known as strong carcinogen and banned from use for food producing animals. Anabolic steroids such as non-testosterone and testosterone are no permitted to use for food producing animals.

Beta-agonists such as salbuterol, clenbuterol and cimaterol have lean enhancing effect. They are known to be very toxic to human. Some episodes of food poisoning related to β-agonists have been reported in European countries.

Some pesticides are used to control ectoparasites. Synthetic pyrethroids (alphamethrin, deltamethrin, tetramethrin, permethrin, cypermethrin, flumethrin and cyfluthrin), organophosphates (azamethiphos, coumaphos, phoxime, tetrachlorvinphos, dichlorvos and chlorpyrifos), and carbamates (propoxur) are registered for use in some countries. Other insecticides such as phospmet, methomyl, lufenuron, diflunon, cypromazine, pyriproxyfen, muscalure, muscamone, bewndicarb, piperonyl botoxide, allethrin, and synethrin are also used. Some organophosphate insecticides such as dichlorvos, haloxon and coumaphos are used for internal parasite control. Organochlorine insecticides (aldrin, dieldrin, gama-BHC, DDT, endrin, endosulfan, hepachlor) are destroyed very slowly in environment and can Organochlorine insecticides (aldrin, dieldrin, gama-BHC, DDT, endrin, endosulfan, hepachlor) are destroyed very slowly in environment and can accumulate highly in the fat tissue. Although some of them banned to use for crop protection 20 years ago. They are persistent in nature and detected in the body of wildlife and livestock animals. Of these, synthetic pyrethroids, methomyl, dieldrin, γ-BHC, DDT, endrin, endosulfan and hepachlor are suspected as endocrine disruptors by WWF. Thoxlyate nonylphenol, butyl adipate and dioctylphthalate are used as drug and pesticide vehicles. These chemicals are also suspected as endocrine disruptors

Veterinary uses of pesticides can cause tissue residue problems. In addition to veterinary use of pesticides, they are also used for crop protection broadly. Animal feeds can be contaminated by them and resulted in tissue residues. For example, endosulfan sprayed for control cotton insects by aircraft is contaminated the pasture and causes tissue residues of cattle in Australia every year. Australian government makes great efforts to prevent consumption of beef with violative level of endosulfan.

Heavy metals are widely distributed in environment. Most of them can be accumulated in the soft and hard tissues of wildlife, animals and human. Feedstuffs such as mineral supplements and fish meals contaminated with them are resulted in tissue residues in livestock products. Most of countries have no regulations of their contamination.

Mycotoxins are metabolic products of some fungi and produced under the adequate environmental conditions such as substrate availability, humidity and temperature. Most of them are very toxic to animals and human. Aflatoxin B_1 and M_1, a metabolite of aflatoxin B_1 in cattle’s body and present in milk, are known as strong carcinogens. Zearalenone has estrogenic effect specially in swine and suspected as endocrine disruptor. Ochratoxin A and tricothecene mycotoxins are known to have immundepressant effects.

Establishment of tolerance levels

Determination of NOEL and ADI: In chronic or lifetime toxicity studies involving mammalian species, rodent and nonrodent species should be used in determining NOEL. Toxicity tests are usually required including a 2-year chronic toxicity study in rat or mouse, a 6-month or longer study in nonrodent mammalian species such as dog, a three generation reproductive study with teratologic phase, and other special toxicity tests. The level of X chemical when fed in the diet to animals revealed the NOEL to be 100 ppm (100 mg/kg feed) in the rat, which was the most sensitive species tested. If the average consumption of the mature rat weighing 200 g is 15 g feed/day, a dietary intake of 100 ppm would result in a total consumption of 1.5 mg of X chemical/200 g body weight of rat or 7.5 mg/kg of body weight, which would be ADI for rat. A safety factor of 100 (x10 interspecies variation and x10 intraspecies variation) has been widely accepted in extrapolation from chronic animal toxicity data to humans in case of noncarcinogenic chemicals. Therefore, ADI value for human is derived by taking 1/100 of the NOEL of the X chemical. In this case, 1/100 of 7.5 mg equals to 0.075 mg/kg of body weight for the ADI level in human. A safety factor 1,000 or more is usually accepted for carcinogens and teratogens depending on toxicological test employed. Any residue of carcinogens in food is illegal in most of countries. Carcinogens such as nitorofurans and DES were banned to use for food-producing animals as feed additive and chloramphenicol, which can induce fatal effect on humans such as aplastic anemia and granulocytopenia regardless of exposure level and frequency, is approved to use only for nonfood-producing animals.

Determination of maximum residue level: Tolerance level of a chemical in food is computed on the basis of the toxicological NOEL and food factor values as follows:

$$\text{Tolerance} = \frac{\text{ADI for human x average consumer's body weight (60 kg)}}{\text{Food factor x 0.5 kg food}}$$

Food (or consumption) factor is introduced to account for the variable quantities of edible products of the various food species that are consumed. US-FDA assumes that muscle and eggs comprise 0.5 kg of the total of the 1.5 kg of solid food ingested daily. Milk may comprise the total diet (1.5 kg). Food factors recommended by FDA are listed below (Table 1, CVM Guidelines). The real food consumption is different from country to country, so the international harmonization is difficult. JECFA of WHO, uses the daily intake values as follow; muscle 300 g, liver 100 g, kidney 50 g, fat 50 g, eggs 100 g and milk 1.5 *l*.

The unit of ADI for human is mg of a chemical/kg of body weight, therefore, that of tolerance is mg of a chemical/kg of food (ppm). The ADI of noncarcinogenic drug X was 0.075 and the tolerance of X in meat calculated by the equation would be 9 ppm.

Table 1. Food factors recommended by US-FDA

Tissues	Cattle	Swine	Sheep	Poultry
Milk	3	-	-	-
Muscle	1	1	1	1
Liver	1/2	1/3	1/5	1/3
Kidney	1/3	1/4	1/5	-
Fat	1/4	1/4	1/5	-
Fat/skin	-	-	-	1/2
Eggs	-	-	-	1

$$\text{Tolerance} = \frac{0.075\ (\text{mg/kg BW}) \times 60\ \text{kg (BW)}}{1 \times 0.5\ \text{kg of food}} = 9\ \text{ppm}$$

MRLs in Korea: KFDA is charged with the responsibility of establishing the tolerances of chemicals toxicologically concerned. The tolerances for chemicals in animal products are established using food factor obtained from domestic statistics. However, some countries accept the tolerance established by Codex for international harmonization. The established tolerance of drugs and chemicals in tissues are listed in Code of Food Standards of Korea (see Table 2). The government concerned has established tolerance levels for veterinary drugs including antibiotics, synthetic antimicrobials, anticoccidials, anthelmintics, growth promoting hormones, mycotoxins and agricultural chemicals such as organochlorinate, carbamate, and organophosphate pesticides and herbicides.

Concerns over food residues are economic as well as public health related. Both the government and producer associations have taken active roles in minimizing chemical residues in livestock products. Of the antibiotics employed as feed additives or for chemotherapy, penicillins, aminoglycosides and to a lesser extent some macrolide antibiotics appear to produce hypersensitivity or allergenicity in some sensitive people. Similarly, as mentioned above, chloramphenicol has been reported to induce blood dyscrasias that may lead to death; hence its use in food-producing animals has been banned by the government. The government has also banned the use of nitrofurans in food-producing animals as feed additives because recent researches have shown them to be carcinogenic.

Tolerance and action levels of chemicals in feedstuffs: Chemicals contaminated in the feedstuffs can affect animal health. Some heavy metals and chlorinated

Table 2. Maximum Residue Levels of Chemicals in Tissues

2-1. Antibiotics (Unit: mg/kg)

Chemicals	Beef	Pork	Chicken	Turkey	Duck	Sheep	Goat	Deer
Gentamicin	0.1	0.1	-	0.1	-	-	-	-
Neomycin	0.25	0.25	0.25	0.25	0.25	0.25	0.25	-
Novobiocin	1.0	-	1.0	1.0	1.0	-	-	-
Monensin	0.05	-	0.05	-	-	-	0.05	-
Bcitracin	0.5	0.5	0.5	0.5	-	-	-	-
Viginiamycin	-	0.1	0.1	-	-	-	-	-
Salinomycin	N.D	N.D	-	-	-	-	-	-
Streptomycin	-	N.D	N.D	-	-	-	-	-
Spiramycin	0.025	0.025	0.025	-	-	-	-	-
Chemicals	Beef	Pork	Chicken	Turkey	Duck	Sheep	Goat	Deer
Amoxicillin	0.01	-	-	-	-	-	-	-
Ampicillin	0.01	0.01	-	-	-	-	-	-
Erythromycin	N.D	0.1	0.125	0.125	-	-	-	-
Oxytetracycline	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Oleandomycin	-	0.15	0.15	0.15	-	-	-	-
Chloramphenicol	N.D	N.D	N.D	-	-	-	-	-
Chlortetracycline	0.1	0.1	1.0	1.0	1.0	0.1	0.1	0.1
Tetracycline	0.25	0.25	0.25	0.25	-	0.25	-	-
Tylosin	0.2	0.2	0.2	0.2	-	-	-	-
Penicillin	0.05	0.05	N.D	0.01	-	N.D	-	-
Hygromycin B	-	N.D	N.D	-	-	-	-	-

N.D; not detect

Chemicals	Beef	Pork	Chicken	Turkey	Duck	Sheep	Goat	Deer
Nicarbazin	-	-	4.0	-	-	-	-	-
Nitrobin, anazon	0.1	0.1	0.1	-	-	-	-	-
Decoquinate	2.0	-	2.0	-	-	-	2.0	-
Sulfadimethoxine	0.1	0.1	0.1	0.1	0.1	-	-	-
Sulfamerazine	0.1	0.1	0.1	-	-	-	-	-
Sulfamethazine	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sulfamonomethoxine	0.1	0.1	0.1	-	-	-	-	-
Sulfaquinoxaline	0.1	0.1	0.1	-	-	-	-	-
Albendazol	0.1	0.1	-	-	-	0.1	0.1	-
Amprolium	0.5		0.5	0.5	-	-	-	-
Ethopabate	-		0.5	-	-	-	-	-
Olaquindox	0.05	0.05	-	-	-	-	-	-
Oxolinic acid	0.05	0.05	-	-	-	-	-	-
Ormethoprim	-		0.1	0.1	0.1	-	-	-
Isometamidium	0.1	-	-	-	-	-	-	-
Zoalene	-		3.0	3.0	-	-	-	-
Thiabendazole	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Thiamphenicol	0.5	0.5	0.5	-	-	-	-	-
Cabadox	-	N.D	-	-	-	-	-	-
Clopidol	0.2	0.2	5.0	5.0	-	0.2	0.2	-
Furazolidone	-	N.D	-	-	-	-	-	-
Flubendazole	-	0.01	0.2	0.2	0.2	-	-	-

Chemicals	Target animals	Organs	MRLs
Penicillin G	Cattle, Pig	Kidney	0.05
		Liver	0.05
		Kidney	0.6
		Oxytetracycline	Cattle, Pig, Chicken Sheep, Turkey

Synthetic antimicrobials

(Unit: mg/kg)

Chemicals	Target animals	Organs	MRLs
Albendazole	Cattle, Sheep	Fat	0.1
		Kidney	5.0
		Liver	5.0
Carbadox	Pig	Liver	0.03
Flubendazole	Pig	Liver	0.01
	Chicken, Turkey, Duck	Liver	0.5
Isometamidium	Cattle	Fat	0.1
		Kidney	1.0
		Liver	0.5
Sulfamethazine	Cattle, Pig, Chicken, Duck, Turkey, Sheep, Goat, Deer, Rabbit, Horse	Fat	0.1
		Kidney	0.1
		Liver	0.1
Thiabendazole	Cattle, Pig, Goat, Sheep	Fat	0.1
		Kidney	0.1
		Liver	0.1

Hormone

(Unit; mg/kg)

Chemicals	Beef	Pork
Diethylstilbesterol, DES	N.D	N.D
Zeranol	0.002	-

Chemicals	Target animals	Organs	MRLs
Zeranol	Cattle	Liver	0.01

- Maximun Residue Levels of Antimicrobial Drugs in Milk

① Antibiotics
Penicillin G : 0.004 ppm
Oxytetracycline : 0.1ppm

② Synthetic antimicrobials
Sulfadimethoxine : 0.01 ppm
Sulfadiazine : 0.01 ppm
Sulfathizole : 0.01 ppm
Sulfamethazine : 0.01 ppm
Sulfachlorpyridazine : 0.01 ppm
Sulfaquinoxaline : 0.01 ppm

hydrocarbons can be accumulated and cause residues in the animal tissues, and aflatoxin B_1 has been known to decrease the performance of young livestocks and poultry and reported as one of strong carcinogens. Consequently, public health problems can be caused by the chemical residues in edible tissues. The government concerned, established tolerance or action levels of chemicals in feedstuffs including heavy metals, aflatoxins and pesticides.

Toxic metals and chlorinated hydrocarbons are cumulative and stored in definite tissue locations; metals in bone, hair, liver and kidney, and chlorinated hydrocarbons in fat tissue. These chemicals can be recycled from soil, water, plants, animals and to humans. BSE (bovine spongeform encephalophapathy) causes a progressive, degenerative disease of the central nervous system. Epidemiological studies in the United Kingdom showed that BSE was caused by the contamination of meat and bone meal with a scrapie-like agent, prion protein, derived from infected sheep and goat. Recently, avian influenza was sporadically prevalent to humans in Hong Kong. Hence the recycled animal wastes should be used under strictly controlled conditions from a public health standpoint of humans and animals.

Methodologies of tissue residue determination: Constantly improving of analytical methods make it possible to detect minute quantities of drug and chemical residues in animal tissues ranging from ppm to ppt. Tolerance is regulative and so the standard operation procedures for residue tests are recommended. As mentioned above, KFDA is responsible for establishing tolerances of drugs and chemicals for all foods as well as official test methods to determine the residue levels. Code of Food Standards of Korea has also regulated the sampling and test methods. The methods have been adopted and modified from AOAC, FSIS of USDA, Directives of European Community, Ministry of Human Health of Japan and other foreign countries or communities. Briefly, antibiotics and sulfonamides are screened and confirmed the generic groups by bioassay methods. Multi-residue determination methods using high performance liquid chromatography (HPLC) are employed to confirm and quantitate each species of a generic group of antibiotics and sulfonamides after purification by complex solvent extraction and clean-up procedures. HPLC methods are also applied to determine tissue residues of synthetic antimicrobials such as nicarbazin, ethopabate, olaquindox, carbadox, ormethoprim, oxolinic acid, albendazole and thiabendazole. For thiamphenicol, clopidol, furazolidone, zoalene and majority of pesticides, gas chromatographic methods are employed. Hormones of zeranol and DES are confirmed by GC/MS. Other techniques of spectrofluorometry for amprolium and decoquinate, and thin-layer chromatography for nitrovin are used in assessing residues of the drugs.

National residue program and the results: Department of Veterinary Service, Ministry of Agriculture and Forestry of Korea is responsible for approval of animal drugs, sampling and testing of tissue residue, and enforcement. As part of its responsibility, the Department has conducted National Residue Program (NRP) to collect samples for residue tests at slaughtering establishments under its inspection authority and from import shipments at the port of entry since 1986. In 1997, a total of 45,000 samples comprising 10,000 beefs, 23,000 porks and 11,000 poultry meats were analyzed for 5 antibiotics (penicillins and tetracyclines), 6 sulfonamides and 6 chlorinated hydrocarbon pesticides. Violative residues of tetracyclines, sulfonamides and aminoglycosides were detected in beef, pork and poultry meat as an average violation rate of 6%. Chlortetracycline was the most frequently detected one of the antibiotics in imported and domestic pork. Previous NRP results from 1989 to 1896 showed sulfonamides (sulfamethazine) had been considered to be associated with the most violative one in pork. Sulfamethazine is known to be retained in tissue longer time (long biological half-life for elimination) compared with other sulfonamides and to be recycled from excretes of feces and urine of pig. Nowadays sulfamethazine has been replacing by sulfathiazole, sulfamerazine and others that are relatively less tissue-retaining and shorter withdrawal time.

Van Dresser and Wilcke (1989) reported that streptomycin, penicillin, oxytetracycline and sulfonamides were the most common drugs found in tissues and milk in USA, with sulfamethazine being the most commonly found sulfonamides in pork tissues. Long-acting formulations of penicillins and oxytetracycline were more likely to be associated with residue problems than feed additives and oral dosage forms. In 1994, FSIS monitoring of drug residues in 38,894 samples from livestock and poultries, it was revealed that 23 sulfoamides, 19 antibiotics, 10 chlorinated hydrocarbons and organophosphates, 7 ivermectin, 6 levamisole, 5 arsenic and 1 moratel tartrate were found (Cross, 1994). Similar results of FSIS monitoring in 1991 were reported (Craigmill, 1996). Violative residues in livestock products are usually resulted from failure to observe the correct withdrawal time for a drug after it has been used to treat or prevent diseases.

Australian Govermmental agency reported the results of his National Residue Survey conducted from Feb. to Jun. 2000. NRS was conducted to sample size of 3,549 cattle, 1,166 pigs and 153 poultry. The chemicals monitored were hormones (stilbens, zeranol/zearalenone, androgens, nonsteroidal antiimflammatory drugs and β-agonists), pesticides (organochlorines, organophosphates, pyrethroids and bezoyl ureas), antimicrobials (sulfonamides, antibiotics), antihelminics, and heavy metals.

As the results of the NRS, flumethin, Cu an Zn were detected with violative level of Australian standard in 1 fat, 3 liver and 1 liver samples of cattle, respectively. In pigs, chlorfenvinfos in 1 fat, sulfamethazine in 2 kidney, cloxacillin in 1 kidney, Cu in 1 liver, and Hg in 2 liver samples were detected with violative level. However, none of violative residues were detected in poultry tissues. Zeranol and zearalenone are frequently detected in cattle samples with less than Australian standard. Trenbolone, organochlorines and pyrethroids are also detected in trace. In pigs penicillins and neomycin were detected in trace in lots of animal samples. Heavy metals were the most frequently contaminated in cattle, pig and poultry.

Even though the tolerance is established by scientific toxicological principle with a safety factor, it is important to realize that the endpoint for determining withdrawal times and tolerance, is a legal and not a biological concept and therefore is controlled by regulatory and not medical practices.

M. Establishment of withdrawal times

Establishment of withdrawal times: The withdrawal period and milk discard time are the time required for the residue of toxicological concern to reach safe concentration in edible target tissues or milk as defined by the tolerance. It also refers to the interval between the time of the last administration of a drug and the animal treated may be slaughtered for food or milk may be safely consumed. This interval is required to minimize or prevent violative levels of residues in edible tissues for human consumption. Withdrawal times vary with each drug preparation and target animals. Depending upon the drug products, dosage form and route of administration even with the same active ingredients, it may vary from a day to several days or weeks. Drug manufacturers are required to submit tissue residue and depletion rate data on all new animal drug applications, including a method to detect the residues. The pharmacokinetic experiment is ordinarily conducted with a metabolism study of a drug side by side. In general, a drug is administered to at least 20 healthy animals, 5 animals in a group are slaughtered with each of evenly distributed four sequential time intervals, and the parent drug and metabolites are analyzed in tissues (CVM Guideline). The residue data obtained from target animal tissues or fluids are plotted as a function of time (t) after the last treatment of the drug. The decline of residue concentration of the drug is expressed graphically by the depletion curve. Many depletion curves follow the first-order decay principle and the resulted graph is usually curvilinear form. Since the curve is an exponential function plotted against time t, the plot on semilogarithmic scale provides a straight biphasic line. The time, which contains the drug below the established tolerance, is the withdrawal time (Fig.1). The authority concerned generally requires depletion data for urine, blood, bile and edible tissues such as liver, kidney, heart and fat as well as skeletal muscle. Withdrawal times of drugs for use in food-producing animals are only valid for the specified species, dose, route and frequency of administration.

The depletion curve is necessary in establishment of biological half-life (t1/2) of a drug. The depletion curve indicates when one-half the drug disappears from the animal in t units of time. The remaining half also requires the same length of time for one-half of it disappears. Depending on the drug preparation, several t1/2 times (withdrawal time) may be required before the tissue residues decline to or below the acceptable tolerance level. When the drug depletion is plotted on a semi-logarithmic scale, the slopes of three lines may be obtained, which represent distribution (α), short-term elimination (β) and long-term elimination (γ) from the body (Fig.2). The end phases are monitored over a short period of time after dosing and used to predict therapeutic drug concentrations (in case of serum concentration profile). When the concentrations are monitored for longer periods of time, the phase of elimination appears for certain drugs depending on the physicochemical properties. This terminal phase

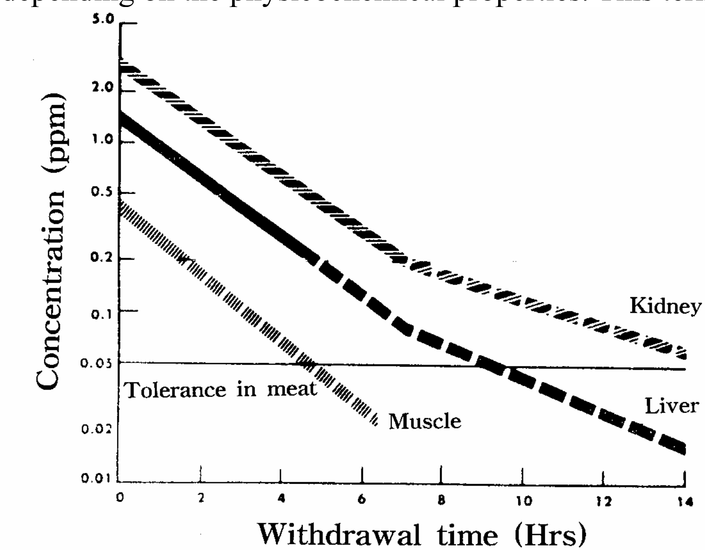

Fig.1. Fictional depletion curves of a drug from animal tissues.

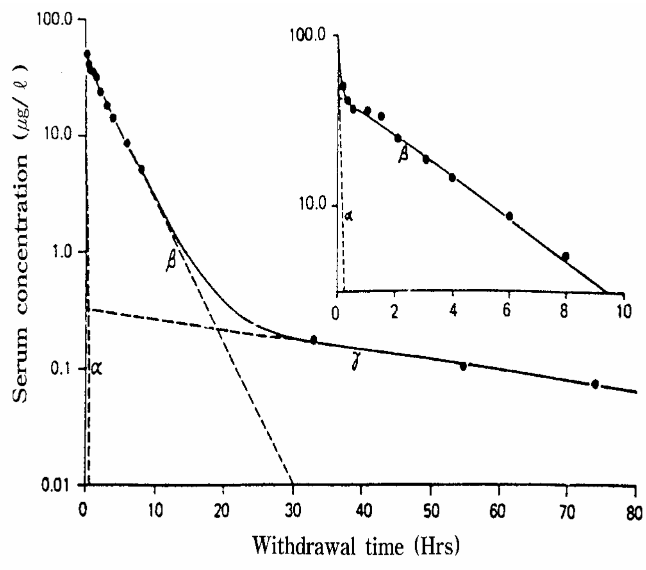

Fig.2. Semilogarismic graph depicting a serum concentration-time profile.

reflects drug disposition in the so-called deep compartments and may be used for determining t1/2 and withdrawal time in food-producing animals. The t1/2 is calculated using the equation:

Withdrawal time = 1.44 In (C0/tolerance)(t1/2).

This equation would work if C_0 was the concentration of drug in the target tissue at the end of administration, as this amount is dependent upon the -phase of depletion profile (Reviere & Spoo,1995; Leemput, 1994). More detailed information on tissue depletion pharmacokinetics is published elsewhere (Riviere et al. 1991; Craigmill et al. 1994).

Withdrawal times of feed additives and veterinary drugs: Various veterinary drugs are used for swine production in Korea to treat and control animal diseases, promote growth rate and improve feed efficiency as feed additives. Thirty-eight drugs including antibiotics, anticoccidials and anthemintics have been approved as feed additives for pig, 16 drugs for cattle and 38 drugs for poultry. The drugs are not permitted to be added in feed for adult cattle, milking dairy cattle, late finisher of fattening swine and laying hen in Korea.

Antibiotic resistance: Antibiotic resistance has become a definite complicating factor in treatment of human and animal diseases. It is generally accepted that subtherapeutic level of antibiotic use in feed of food-producing animals has less than an optimum antimicrobial effect and that induction of antimicrobial resistance including transference of R factor can occur. The resistant organisms shed by animals may transfer R factors to the enteric organisms of human and could conceivably complicate the treatment of human diseases. Recently, it has been suggested that the vancomycin-resistance gene clusters in *Enterococcus faecium* strains from human and animals were identical and that the vancomycin-resistance gene clusters present in human *Enterococcus faecium* strains originate from poultry isolates previously exposed to avoparcin (Bakes et al.1993, 1994; Williamson et al. 1989). Avoparcin and vancomycin are glycopeptide antibiotics and the organisms resistant to avoparcin may be resistant to vancomycin as well. However, there is little evidence currently to show that resistance gene originating in animal bacteria are being transferred to human pathogens and are resulting in untreatable infections. However, virginiamycin, tylosin, spiramycin and avoparcin are banned recently to use as feed additives in EU countries.

The Food Animal Residue Avoidance Databank (FARAD): The FARAD is a program designed to minimize the incidence of residues of veterinary drug in food-producing animals and is sponsored by the USDA's Extension Service and FSIS. The purpose of the program is to assemble information on veterinary drugs and chemicals that have potential to give rise to residues in food. The following information are provided alphabetically by generic name and indexed by trade name of drugs; product name, sponsor, active ingredients, classification, formulation, product type, approval species, withdrawal time, indications, directions and further information. The information are stored on computer and regularly updated, so that it is no more than 2 months out-of-date. Their activities are expanded to gain a perspective on the withdrawal time of a drug by using the pharmacokinetic parameters (bioavailability, the volume of distribution, clearance, biological half-life and so on) known already. Additional information is available from two regional access centers based at the North Carolina State University and University of California/Davis.

Rapid screening test methods: Variety of rapid screening tests have been developed and applied for determining drug contamination of animal products on farm and at slaughterhouse. The principles employed in the tests are bioassays using susceptible microorganisms to antibiotics, microbial receptor assays using antibiotic-binding molecules in microorganisms, enzyme-linked immunosorbent assays (ELISA) using antibodies against antibiotics and thin-layer chromatography (TLC). The Live Animal Swab Test (LAST) is a modified application of the Swab Test On Premises (STOP). In LAST, a streptomycin assay agar is uniformly swabbed with a suspension of *Bacillus subtilis* spores. As the spores vegetate, a uniform lawn of bacterial colonies grows on the surface of the agar. A cotton swab saturated with urine sample is positioned on the agar and incubated at least 18 hours. If antibiotic residues are present in the sample, inhibition zone around the swab is formed. The Calf Antibiotic Sulfa Test (CAST) is designed to detect both antibiotics and sulfonamides and the principle is the same as LAST besides using Mueller-Hinton agar plate and *Bacillus megaterium* rather than streptomycin assay agar plate and *Bacillus subtilis*. Sulfa On Site (SOS) test is a TLC technique using urine as a sample and designed for detecting sulfonamide residues. Charm Tests is based on the reaction between drug functional groups and the receptor sites on microbial cells. Radiolabelled target drug is added and compete with incurred drug residue present in the sample to bind at the receptor sites. The greater the amount of drug residue in the sample, the lower the counts of the radioactivity. These assays were first developed to test antimicrobials in milk. Recently the assays have been modified to use for screening tissue residues. A variety of ELISAs and other test methods have been developed to test antimicrobials in milk. The methods available are Agri-Screen, CITE, Delvotest, EZ-Screen, LacTek, Parallux, Penzymes, Signal, SingleStep, Spot Test and so on. It is difficult to adequately summarize because rapid advances in analytical screening methodologies have led to the rapid development of new tests. Extralabel usages of drugs in food-producing animals may increase the potential for the illegal residues in edible tissues. The rapid screening tests on farm may reduce the residue problems.

Conclusion

Various drugs are registered and being used for animal production. Most of them are known to be safe. However, antimicrobial drugs can develop bacterial resistance in farm. The possibilities of drug residue in tissues are increasing. The resistant organisms can share their R-plasmids with such organisms that have not been exposed to the drug and make the organism resistant to the drug. Some of drugs have their own severe toxicities. Some pesticides are used to control parasites. Of them organophosphates and carbamates are highly toxic, and pyrethroids are suspected as endocrine disruptors. In some countries, it is true that people are very sensitive to the use of hormones in animal production. Pesticides used for crop protection can be contaminated in animal tissues through feeds. Organochlorine pesticides banned from use 30 years ago are frequently detected in the fat tissue due to their persistence in nature and high bioaccumulation. Environmental contaminants such as heavy metals, dioxins, dibenzofurans and PCBs may be contaminated in animal tissues and recycled soil, plants, animals and human body.

All chemicals are poisonous and hazardous. However, the risks can be reduced through sound use of chemicals by farmers and veterinarians and proper management of chemicals by Government authorities. It is generally accepted that the risk portion of pathogens contaminated in food is 96% and the remainder is chemicals and physical factor. Human beings are continuously exposed to various chemicals simultaneously. We know the toxicities of each chemical precisely. But we don’t know the effects when the chemicals exposed simultaneously. Fortunately, status of chemical residues in animal products is relatively clean. We should thrive to reduce the chemical residue to ensure the safety for human. For this, thorough enforcements of drug registration, labeling, sound use of drugs, observing withdrawal times, development of rapid screening methods and live animal tests, extension of HACCP from farm to table including quality assurance programs are consistently required.

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PUBLIC HEALTH RISKS: ANTIBIOTIC RESISTANCE

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Introduction

Antibiotic resistance in human pathogens has been identified as one of the most serious problems facing human medicine. Much of the resistance stems from overuse and misuse of antibiotics in hospitals and community practice but in the case of some human enteric pathogens there is evidence for transfer of resistant bacteria and resistance genes via the food chain from animals to humans.

Antibiotic resistance in animals

Exposure of populations of bacteria to antibiotics selects for bacteria resistant to the antibiotics used. This was recognised early in medical therapeutics with the emergence of penicillin resistant *Staphylococcus aureus* within a very short time of introduction of penicillin as a therapeutic agent. Similarly, *E coli* resistant to tetracyclines were isolated from pigs and poultry within a few years of the commencement of feeding the mycelial waste from tetracycline production as a growth promotant to those species. As new classes of antibiotics were developed and introduced into veterinary medicine and animal husbandry, so strains of bacteria resistant to those antibiotics emerged. Resistance to tetracyclines, sulphonamides and streptomycin is now widespread in *E coli* and salmonella and resistance to multiple classes of antibiotic is common. However, in the case of some antibiotics (ampicillin and olaquindox, for example) resistance has emerged more slowly. Its also clear that there are differences between different strains of salmonella in the extent to which resistance emerges – for example *Salmonella* Typhimurium seems to readily display antibiotic resistance, other serotypes such as *S* Dublin remain sensitive when exposed to the same treatment regime. Antibiotic resistant bacteria are isolated more frequently from intensively farmed animals as antibiotic use for therapeutic and prophylactic purposes as well as for growth promotion are used more commonly in intensive animal production.

While there is data from many countries on resistance patterns of *E coli* and salmonella, there is very little information on other enteric bacteria such as enteric campylobacters and enterococci. The latter are not pathogens in animals and so are rarely looked for in veterinary laboratories. It is only in recent years with concerns about transfer of resistance via the food chain has led to investigation of resistance in these bacteria. In the case of campylobacters resistance to erythromycin (presumably reflecting use of tylosin or clindamycin), tetracycline and ciprofloxacin/enrofloxacin are reported. The situation with enterococci is more complex as these organisms are intrinsically resistant to many antibiotics and also very readily acquire resistance to new antibiotics to which they are exposed. In the mid-1990s resistance to the growth promotant antibiotic avoparcin (a glycopeptide) was reported in Denmark in isolates from pigs treated with avoparcin and subsequent studies have shown that glycopeptide resistance only occurs in treated animal populations. In addition, resistance has also been reported to other antibiotic growth promotant antibiotics such as avilamycin and virginiamycin.

While the focus of this paper is the impact on human health of antibiotic resistance in humans, from an economic perspective it is important to recognise that antibiotic resistance in animal pathogens reduces the efficiency of animal production and that resistance in enteric commensals provides a reservoir of resistance genes that could transfer to pathogens.

Transfer of antibiotic resistant bacteria and resistance genes from animals to people

Salmonella, campylobacter and E *coli* are recognised food-borne pathogens and meat (and sometimes dairy) products are acknowledged as the primary source for most salmonella and campylobacter infections. Thus it is easy to see that when the infecting strain is resistant to one or more antibiotics, then the patient will be infected with that antibiotic resistant strain. Numbers of epidemiological studies have demonstrated the spread of various antibiotic resistant strains of *S* Typhimurium from animals to people. Currently *S* Typhimurium DT104 is of major concern in the UK and USA. It has also been shown that resistance to apramycin, an aminoglycoside antibiotic not used in human medicine was detected in human isolates of salmonella within a year or two of its release as a treatment in animals. In the case of *E coli,* elegant studies by Witte and co-workers in the then East Germany traced the spread of resistance of nourseothricin (a growth promotant antibiotic used only in animals in eastern Europe) from pigs, to pig farmers and their families and to residents of local villages and towns. Horizontal gene transfer is well described in salmonella and *E coli* and this provides a ready mechanism for transfer of resistance genes between strains of salmonella or *E coli* and between salmonella and *E coli* and other enteric genera of bacteria.

Campylobacters resistant to ciprofloxacin (a fluoroquinolone) were isolated from human infections in Europe soon after enrofloxacin started to be used in the chicken industry. A study in the USA which included detailed molecular typing has found very similar resistance patterns in campylobacter isolates from chickens and in human isolates.

Early evidence of transfer of avoparcin/vancomycin resistance from animal enterococci to human isolates came from observational studies in Denmark and other parts of Europe. However, there is now compelling scientific evidence based on molecular analysis of the distribution of the *van*A resistance determinant Tn1546 in animal and human isolates for the transfer of *van*A vancomycin resistance from animals to people. *van*B vancomycin resistance had not been documented in animal isolates and presumably originated through overuse of vancomycin in hospitals. Resistance to quinupristin/dalfopristin, a recently developed human antibiotic in the same family (streptogramin) as virginiamycin in enterococci has been attributed to the use of virginiamycin as a growth promotant. Similarly, resistance to everninomycin, another new human product which has just been withdrawn from advanced clinical trials was linked to the use of avilamycin as a growth promotant.

Conclusions

Antibiotic resistant bacteria and antibiotic resistance genes can transfer via the food chain from animals to people. However, it is important to assess each organism and each antibiotic individually using a risk assessment approach as it is not possible to generalise.

Development and application of Chinese herbal medicines as feed supplements

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Infectious diseases of chicken and other live stocks are major threats to animal industry. Administration of preventive medicines as feeding supplements has been proven to be the most effective method to treat livestock in a large scale. Most of the feeding supplements available to date are antibiotics and chemically synthesized compounds. However, the toxicity and side effects of these drugs usually cause concerns, and the poor clearance of certain compounds and the resistance to antibiotics are major problems as well. Thus, many countries have begun to invest in developing new drugs from natural products such as herbal medicines. The development concepts of the new drugs include extraction of active ingredients from natural products, study of the pharmacological activity of the ingredients and developing new commercial products based on the results from the first two steps.

1. animal-use herbal medicine in China

The latest nation-wide survey reveals that about 11,200 kinds of Chinese medicinal herbs are being used in China[1], and among of them about 500 kinds were supplied as feeding supplements[2]. It is common practice to add ground dry herbal plants directly to feed meals, and the procedure lacks quality control. Since 1980s, many clinical observations of single herb and compound prescription have been carried out in the country. Only previous clinical experiences on using herbal medicine on live stocks have been summarized, however, few improvements have been made.

The study on activity ingredient is a weak point in research and development of the herbal medicine feeding supplements in China. Based on Chinese Veterinary Pharmacopoeia(1990 edn.), 81 pharmaceutical preparations of compound prescription herbal medicines are recorded, and among them 97.5% are powder preparation. No ingredient concentration analysis is included. Compared to human-use herbal medicines, there is lack of phytochemical, pharmacological and pharmacokinetic research of herbal medicines used for live stocks. Because of aged manufacture condition and lack of quality control, the effects of herbal supplements are inconsistent, which results in the amount of used is unnecessarily large. Thus, it is important to clarify the active components of herbal medicines and improve the production procedures. High standard of quality control should be established to ensure high efficacy. Utilization of advanced technology will allow the modernization of herbal medicine production.

We have studied the anti-bacterial, anti-viral and growth enhancing effects of herbal medicine extracts during the "9/5 national research project". We have improved extraction techniques and analyzed active ingredients of herbal extracts. The results from these initial studies will help to further understand the mechanism of herbal medicine effects, and provide technical bases for large-scale production.

2. Research

2.1 ingredients of Natural extraction

12 medicinal plants collected from north of China, and selected herbal plants were ground into powder and extracted with ethanol or water. Certain concentrations of extract solution were prepared, and the active compounds also have been identified. several active compounds and their Concentration of Herbal extract were showed on Table 1.

Table 1 several active compounds of Herbal extract

Herbal extract	Active compound	Concentration %
MP-012	lipid	4.73
MP-061	flavonoid	38.35
MP-081	flavonoid	7.03
MP-091	saponin	15.74

2.2 Antibacterial effects

In vitro anti-bacterial experiments were performed using test tube method. 2 strain *Escherichia coli* (C84010 Avian, and C83645 swine),*Salmonellae gallinarum*(strain C79-13) and *Salmonellae typhimurium* (strain C77-31) were provided by National institute for control of veterinary bioproducts and pharmaceuticals. Twelve different herbal extracts were tested for their anti-bacterial activity. Among them, MP-012 and MP-061 exhibited the highest anti-bacterial activity in MIC experiments. The results are summarized in Table 2.

Table 2. The MIC of 2 herbal extracts for the tested of bacteria (mg/ml)

	C84010	C83645	C79-13	C77-31
MP-012	2.00	1.00	1.00	1.00
MP-061	1.56	1.56	0.78	0.78

2.3 Antiviral effects

Avian influenza virus (AIV) H9N2 and avian infectious bronchitis virus (IBV M41) were provided by Chinese Agriculture University Experimental Animal Institute Virus lab. Transmissible gastraenteritis of pig virus (TGEV) was provided by Chinese Academy of Agriculture Herbin Veterinarian Research Institute. Antiviral experiments were performed using chicken embryo inoculation or cell infection. For *in vivo* antiviral experiments, 5-day old chickens were inoculated with AIV or IBV, and 0.2% of herbal extracts were added to the feed meals before and after the viral inoculation.

The results of chicken embryo inoculation experiments are summarized in Table 2. Four herbal extracts showed inhibitory effects towards AIV and IBV. The results from the anti-cell infection experiments demonstrated that the lowest antiviral concentrations (or the highest titer) of extract MP-061 and MP-031 required were 1:6400 and 1:25600, respectively. The results from *in vivo* anti-AIV experiments showed that adding 0.2% extracts to feeding meals effectively prevented AIV infection. In addition, adding the extract supplements significantly reduced AIV infection related syndromes and shortened duration time of infection.

Table 2. Antiviral effects of different herbal extracts against AIV and IBV using SFP chicken embryo(%)

herbal extracts	Concentration(mg/ml)	Inhibition AIV%	Inhibition IBV%
MP-012	20	100	80
MP-061	30	100	40
MP-081	20	100	0
MP-091	20	100	100

2.4 Effects of herbal extracts on growth of meat chickens

For the feeding experiments, one-day old chicks were fed with herbal extract containing meals, and the body weight was measured at week 3 and 7. Three antibacterial and antiviral herbal extracts had no side effect on the growth of AA meat chickens while used as feeding supplements. The experimental results are shown in Table 4.

Table 4. Effects of herbal extracts on the body weight of meat chickens

herbal extracts	% of supplements	average body weight at week 3(g)	average body weight at week 7(g)
CK	0	623.23 [a]	2233.4 [a]
MP-012	0.1	644.44 [a]	2241.5 [a]
MP-061	0.1	665.14 [b]	2319.2 [a]
MP-081	0.1	616.61 [a]	2150.0 [a]

3. Discussion

3.1 Unlike therapeutic drugs, herbal extracts are to be used as long term feeding supplements. Thus, in addition to the necessary studies of the preparation and dosage of the extracts, it is essential to consider the potential effect of the supplements on the immune function of the livestock.

3.2 Although herbal supplements are relatively widely used in China, production techniques are old. To improve the quality control of the production, it is necessary to elucidate the active ingredients of certain herbal extracts (single or combined) whose therapeutic effects have been proven. Previous experience with Chinese herbal medicines used for human will help to achieve this goal.

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Regulatory Analytical Methods for Veterinary Drug Residues

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Drug residue analyses related to public health, international trade or environmental problems and as powerful tools for regulation purpose have to be performed fast, reliable and within a limited budget. This requires not only good professional behavior of all involved officials but also an integrated analytical approach, quality assurance and quality control. This paper illustrated the characteristics of drug residue analyses, corresponding measures, described how to choose and evaluate the analytical method and how to perform it properly in routine work.

Veterinary drug residue analyses play important parts both in understanding drug metabolic mechanism and toxicological studies, as well as serve a valuable function to support inspection , residue monitoring system and national regulatory programs. Therefore, the analytical methods are directly related to the public health, international trade and accuracy and effectiveness of law executed. Ideally, these methods have to be fast, reliable, economic and had better be standardized for the whole country or even on a worldwide base. In fact, that is often very difficult to achieve due to not only the characteristics of the drug residue analysis but also the broad variety of environmental conditions that may exist between different laboratories and countries. It might be more appropriate to adopt an integrated strategic approach, choose a proper method for a particular purpose and to develop national or international performance criteria for analytical method that must be achieved in its quality assurance and quality control.

1 The characteristics of the drug residues analyses and integrated strategic approach

Compared with general physical and chemical analyses, drug residue analyses are more complicated and difficult. (1) There are too many kinds of animal drugs that might be misused, abused or even illegal used may cause residues in the edible tissues of slaughtered animal that could be hazardous to consumers, (2) There are too many animals need to be monitored and tested and different areas and countries have different husbandry and drug use practices. (3) Different drugs have different metabolic mechanism in animal bodies; the analytes are distributed in different tissues, therefore different matrices in analysis. (4) The drug compound used to food-producing animals is not necessarily the substance present in the edible products from the target animals; the parent drug, metabolites and degradation products are not equally toxic and have different distributions and depletive time. (5) The contents of drug residues are very low, normally in ppb level or even lower.

For these characteristics, a good integrated strategic approach must be developed for regulatory drug residue detecting and measuring. That includes (1) classifying or grouping veterinary drugs according to their chemical structures or biological functions and put in an order of priority based on their significance in human health and their potential to create problems in international trade. Following are the identified a number of groups of compounds and certain specific examples which appeared to be of more immediate concern:

- Antibiotics
- Sulfonamides
- Nitrofurans
- Benzimidazoles
- β-Agonists
- Anabolics
- Anthelmintics
- Sedatives and tranquillizers

(2) Setting up multi- step programs for drug residue analysis to achieve optimized professional feasibility, cost effectiveness and flexibility.
In the multi-step programs at least two steps are included - screening and confirming, sometimes quantitative determination is in between. That is based on the fact that the large majority of samples tested in residue monitoring programs do not contain drug resides of public health concern, only a small fraction of samples cannot fulfill the regulatory requirements and should undergo further analysis by validated quantitative methods.

2 The methods used in multi-step programs

Methods for screening purpose (screening methods) are used to detect the presence of an analyte or class of analytes at the level of interest. These methods have to be suitable for large-scale repetitive routine application, have to be relatively fast, simple and inexpensive. Normally, they do not require complicated instrumentation, more skilled staff and many of them are commercially available, so they can be used easier and even non-laboratory environment. Although screening methods can be based on any aspect of analytical technology, most of the screening tests are based on biological techniques or immunoassay .The most popular methods used are four plate test (and similar techniques such as USDA Stop Test or Swob test) and ELISA (or EIA) test kits. The former based on antimicrobial activity is sensitive for most the antimicrobials, especially for the β-lactam antibiotics, aminoglycosides, macrolides, tetracyclines, novobiocin, polypeptide antibiotics and bacitracin. ELISA test kits are the most widely used commercially available assay kits. It can be used for detection of Antibiotics, anabolics, β-agonists and hormones, especially chloramphenicol, sulfonamides and nitrofurans. The last three, as we all known,are not so sensitive to four plate test. Screening methods should create minimum false negative results.

Methods for confirmatory purpose (confirmatory methods) are used to provide definitive or complementary information enabling the analyte to be identified unequivocally at the level of interest. The definitive information is often given by mass spectrometry (MS) in regulatory analysis since MS can give specific information on the chemical structure of the compounds. Coupled with techniques such as gas chromatography (GC) or liquid chromatography (LC), these have become very powerful confirmatory tools for both qualitative and quantitative assessment. In EU reference methods for drug residues about half of them are GC-MS, mainly for the determinations of anabolics, β -agonists as well as for some antibacterials .As for LC-MS, having advantage for the drugs with high molecular weights or thermo-unstable drugs, it is more and more used in the detecting and measuring of chloramphenicol, furazolidone, tetrecyclines, sulfonamides, sedatives and tranquillizers. Confirmatory methods are usually the most expensive analytical procedures in terms of equipment, time and human resource cost. The confirming methods are aimed at preventing false positive results as well as having an acceptable low probability of false negatives.

Methods used for determination purpose (determination methods) are used to detect the presence of the analytes as well as to provide quantitative information. They seem to be between the screening methods and confirmatory methods in technique level, sample throughput and analytical cost. Many of
them are involved chromatography, especially GC, LC and TLC. Tetracyclines, benzimidazoles, carbadox and furazolidone are often determined by TLC and HPLC.
Since GC and LC are more popular in China and most of the countries in the world, use determination methods can not only make full use of these available facilities in regulatory detecting and measuring, make the work more efficient, but also can reduce the operating load of GC-MS or LC-MS.
The wide variety of drugs and their residues requires several different procedures to monitor all the possibilities. It is ideally to analyze one sample for all possible residues but by using one procedure. The complete separation of residues by chromatography coupled with a sensitive end-point detection system gives people unlimited imagination and some progress is made. The multi-residue techniques of a modular nature are developed. More than thirty of the most probable residues, which could occur in animal products, can be determined using just three multi-residue methods. The multi-residue methods are more meaningful for screening purpose. Here are some examples:

Antimicrobials by four plate test
Benzimidazoles by HPLC
Antibiotics by IA or GC-MS
Beta-agonistes by GC-MS or IA
Sulphonamides by TLC or IA
Sedative and Tranquillizer by HPLC

In multi-step program people can use the methods step by step or directly choose a proper method for a particular purpose.

3 General performance criteria for residue analytical method

As for any method of analysis, whenever drug residue analytical method is developed, chosen and performed, a set of attributes that demonstrate its quality must be achieved. They are the performance criteria including mainly the sensitivity, specificity, precision and accuracy.

Sensitivity is one of the most critical and limited factors for all drug residue analysis. Sensitivity of a method may be described by different technical terms. Normally, people pay more attention to limit of detection. It is the lowest analyte content of detection with reasonable statistical certainty. For drug residue analysis, the method (either screen or quantitative method) must be sensitive enough to measure the permitted maximum residue limit (MRL), ideally half the MRL. Except in a few cases the MRL or tolerance of prohibited drug is fixed at zero and therefore the most sensitive screening method available must be used. As for confirmative or quantitative method, the limit of detection must be sufficiently low that the residue levels, which would be expected after illegal use, will be detected with at least 95% probability.

Specificity is predominantly a function of the measuring principle used, but can vary according to class of the compound or matrix. This criterion is equally critical to all the screening, quantitative and confirmatory methods. A method is not sufficiently specific, than a confirmatory procedure will be needed. If a single technique lacks sufficient specificity, suitable combinations of several techniques, such as clean-up, chromatographic separations and detection, can achieve the desired specificity. Certain instrumental techniques such as IR or MS can provide definite information about specificity. TLC, formation of typical derivatives and re-chromatography under different conditions, may verify specificity. Blank sample determination and co-chromatography of the fortified sample can also give some valuable information for specificity of a method.

Accuracy: As well known accuracy is the measure of closeness of agreement between the true value and the mean result. Since nobody knows the true value, it is generally expressed as the percent recovery of added analyte, although realizing, in the case of residue analysis, that analyte added to the sample may not behave in the same manner as the same analyte biologically incurred. Recovery is a function of content of the analyte. The guideline ranges of recoveries are as follow: when the concentration of analyte is 0.1ppm or greater, an average recovery of 80 to 110% should be obtained. When the concentration of analyte is less than 0.1ppm, average recoveries of 60 to 110% will be accepted. Higher recovery (great than 100%)may indicate a lack of specificity.

Precision: Precision is expressed as a relative standard deviation (or coefficient of variation, CV) since it is relatively constant over a considerable concentration range. There is numerous sources affect precision, but the major components are those from within a laboratory (repeatability) and those from different laboratories (reproducibility).
The typical inter-laboratory CV normally acceptable can be calculated according to the Horwitz equation, CV (%)=$2^{1-0.5\log C}$ where C is the content as a power of 10.For analyses carried out under repeatability conditions, the intra-laboratory CV would typically be one-half to two-thirds of above value. As a general rule, the intra-lab CV should not exceed 10% where the analyte content or concentration is greater than or equal to 0.1ppm. Where the concentration of the analyte less than 0.1ppm, within lab's CV should not exceed 20%.

Both Accuracy and precision are important quantitative characteristics for method performance. They are not critical to screening methods, since quantification may not be necessary for it. False positives are acceptable for screening methods but false negatives at the level of interest should be minimal.

All methods should fulfill other important performance characteristics, such as practicability, applicability, and cost effectiveness. The methods should utilize commercially available reagent, instruments and supplies; be capable of being performed by reasonable experienced analysts; be capable of being completed within reasonable time periods consistent with regulatory objectives, usually no more than 48 hours; be capable of being performed safely; be capable of being suitable for all varieties of the samples may be met; be capable of completing the whole program under the limited budget.

4 Special points important for quality assurance and quality control of drug residue analysis

A. In drug residue analyses, all the methods have three key elements - extraction, clean up and determination. There are some important steps should be emphasized:

(a) Hydrolysis: Many analyets form conjugates in animal fluids and tissues, e.g. sulphates or glucuronides. The conjugates must be hydrolyzed to liberate the free analytes. The best way of hydrolysis is using proper enzyme under mild condition. Acids or alkalis used in hydrolysis may cause degradation of the analytes.

(b) Initial extraction: This is based on solvent/solvent partition and solid phase extraction. The main factors including solvent polarity, pH and the solubility of the analyze(s) must be chosen properly.

(c) Chromatographic clean up: The purpose is to get highly purified analytes fraction. We can use the traditional chromatographic column as well as SPE or IAE cartridges. The latter two techniques developed very fast in recent years. We must choose suitable packing materials and operating parameters.

(d) Determination: Normally use GC or LC chromatography coupled with spectrometry: MS, UV, and IR, IA. We should choose Proper instrument and experimental conditions.

B. In the experimental practice, the conditions such as temperature, pH, and stability of reagents, composition of sample that could be subject to fluctuation therefore could affect the analytical result and different interpretation scale of the analytical result may make things more complicated. So to achieve a reliable analytical results, especially for confirmatory method , except good professional behavior and good lab practice, many details in a procedure and interpretation must be defined and standardized. For example: Whether or not (if it is needed when and where) the reference material or control samples should be used through the entire procedure simultaneously with each batch of the samples analyzed. What are the quantitative criteria of the acceptable separation for GC, LC and TLC? How many diagnostic ions should be used in the determination by GC-MS or LC-MS. and so on.

5 closing remark

Safety of veterinary drug residues in foods of animal origin is a systematic project involving many scientific and managerial areas. Residue analysis being only a small part of it should act in close coordination with others, especially with the experts and officials in animal production and feed manufactory to establish criteria for safety of individual veterinary drug residues as appropriate, know the likelihood of residues, take into account their public health significance, provide adequate analytical methodology and rear good animal husbandry and drug use practices.

Safety of veterinary drug residues is also a worldwide problem. We need strengthening cooperation with other countries to develop new methods, organize collaborative studies, exchange ideal and information, even exchange reference materials or deuterated standards.

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Feed antibiotics and Feed Safety

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In recent two decades, there are brilliant achievements in feed industry in China. The feed industry in China has come to a all-round industrial system, which is composed of the raw feed materials, the feed machinery, the feed processing and so on. The output of feed is going up steadily. The amount of compound feed of last year is about 60 million metric tons. China was the second largest feed producer in the world, following USA. In China, there are 400 millions pig, 4000 millions poultry and 90 millions cattle, so the feed industry must be developed significantly in the future. Along with the vigorous development of feed industry and the increase in social concept of food and environment safety, most people are becoming deeply aware of that the feed safety is important for keeping food and environment healthy. Safety feed means safety food. The feed antibiotics are now one of the most important factors that affect the feed safety.

Feed Antibiotics in china

Sub-therapeutic concentrations of antibiotics have been added to livestock and poultry rations to improve animal performance for nearly five decades. Generally, there are three feed antibiotic stages: First, during 1955-1980, the feed antibiotics, such as tetracyclines, bacitracin zinc, penicillin, shared the antibiotics used for human medicine. Secondly, during 1980-1990, while China government banned the use of the human medicine antibiotic growth promoters, and the use of tetracyclines and bacitracin zinc for human medicine were banned. Thirdly, during 1990-now, new and special kinds of feed antibiotics have been developed and used in feed production, such as flavomycin, apramycin, maduramicin salinomycin, mean time tetracyclines and bacitracin zinc are also used.

In China, there are about 3000 metric tons feed antibiotics used as growth promoter per year. The review of the effect of some of the key feed antibiotics on publications on the growth and feed efficiency of pig and broiler are shown in *table 1.* On an average, gain and feed/gain of pigs during the growing phase (1-60 day old) were improved by 20% and 6% respectively, gain and feed/gain of broilers during 0-21 day old were improved by 8% and 5% respectively.

Table 1 Effects of key antibiotics on the gain and feed efficiency of pig and broiler in China

Antibiotics	Pig			Broiler		
	Mg/Kg	Gain %	Efficiency %	Mg/Kg	Gain %	Efficiency %
Chlortetracycline	75	27	9.8	35	7.6	6.9
Bacitracin Zinc	40	15	5.6	20	12	5.0
Flavomycin	20	21	7.6	5	4.1	5
Virginiamycin	20	10	5	10	5.4	4.3

How and why do feed antibiotics work

The mechanisms of the growth promoting antibiotics are still not fully understood in detail, but a number of reports have enlightened this area. Tong Jianming et al. (1998) reported that long term sub-therapeutic chlortetracycline (CTC) has a significant growth enhancement effect on broilers. CTC inhibited *E.coli* in rectum or jejunum before 33 or 19 days of age significantly, and then the inhibiting effect disappeared. *Lactobacillus* both in rectum and jejunum were inhibited significantly by CTC before 12 days of age, and then the inhibiting effect disappeared. *Bifidobacterium* both in rectum and jejunum were not inhibited by CTC at anytime of age. Zhang Rijun et al. (1998) reported that CTC inhibited the immunity of broiler significantly. Tong Jianming (1999) studied the mode of action of CTC growth promoter in broilers. The results shown that CTC can inhibited the *E.coli* both in rectum and jejunum and the immunity of broilers, mean time, it improved the growth rate of broilers. Yao Langqun (2000) studied the effect of apramycin on the performance of swine. He reported that apramycin could increase the growth rate and alleviate the cold stress to piglet.

Animal growth is dependent on the quality, quantity, and timing of nutrients delivered to the cells. The metabolic activity of the cells is regulated through the integration of biosignals that are elaborated in the milieu of endocrine hormones and immune cytokines. When environmental, disease, or genetic stresses impact on the regulation of nutrient intake and use, endocrine regulation, or immune function, the metabolism of specific cells is affected and the result is a shift away from growth to support a greater need to regain homeostatic equilibrium (S. Thomke, 1998). Based on the former studies, therefore, the following modes of action of feed antibiotics have been suggested :

- Regulating the gut flora with reduction in population of *Escherichia coli*;
- Alleviating challenges to the immune system and endocrine system;
- Increasing feed intake.

Toxicological and Microbiological risks

The toxicological risks associated with the use of feed antibiotics in animal industry are generally very low, owing to their extensive safety evaluation, and that large safety margins exist between the no-toxic-effect-level in animals and the permissible levels for human (Kroes, F. H., 1986). Broquist and Kohler (1953) found no detectable amounts of chlortetracycline in the liver and muscle of chicks receiving chlortetracycline, 200mg./kg. of diet. Barely detectable amounts were present in the blood serum. In the further studies, Kohler (1955) found that chlortetracycline in poultry meat was readily destroyed by cooking. Theoretically, the biggest residual hazards should be food allergies in consumers. However, the specialized literature in human medicine fails to indicate a role of antibiotics in food allergies, although these have been generally rising in the recent years. In fact, the major concern is the illegal and unscientific use of non-licensed growth promoters.

Ever since the early 1950s, there is a growing uneasiness among consumers about the use of growth promoters in farm animals. Most of the debate is now focussed on the possibility of antibiotic-resistant pathogens being transferred to humans and causing therapeutic failure in the treatment of emergency situations. It is true that antibiotic-resistance has reached epidemic proportions in human patients, particularly in large hospital settings. On the other hand, antibiotic resistance is also on the risk in animal patients. However, the crucial evidence linking agricultural use of antibiotics as growth promoter to human health risks was again missing.

Trends and Perspectives

The rate of daily weight gain and feed conversion efficiency in food animals depend on a variety of factors, including genetics, diet, husbandry, and the health of the animal. Health is probably the most important because almost all disease inevitably results in a degree of metabolic inefficiency. Disease affects the animal's performance by depressing the rate of growth, either through low-grade of toxicity or impaired physiologic or metabolic activities. How much the performance is depressed by subclinical or chronic disease is variable. Therefore, how efficiently the animal disease is controlled is very important research work in the future.

The basic research front on new antimicrobial materials is moving fast. The most promising development is the discovery of "endogenous antibiotics" of the group of the magainins, crecopins and defensins (Jacob and Zasloff,1994). They were originally found in fork skin and later in intestinal epithelium of swine and bovine tongue (Schonwetter et al., 1995). Now it is assumed that they are ubiquitous in higher organisms and that they play an important role in the first line of antimicrobial defense also in human. On the other hand, Chinese herbial medicine is another important source from which to develop antibiotic replacements as feed supplements.

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Fat Blends for Carcass Quality

Reduction in Animal Waste Through Effective Nutritional Means

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Abstracts

1. Amino acid digestibility of high quality rendered protein meals (e.g. MBM) are only slightly lower than that of SBM.
2. Phosphorus availability of MBM is very high (-90% relative to MSP).
3. Fats offer a distinct advantage in supplying NE for growing lean-type hogs.
4. High nutrient density diets is recommended for high lean market hogs for improved ADG, F/G, waster output, margin over feed cost and carcass quality.
5. Rendered products should be part of environmental conservation centered animal production system.

HACCP for Control of Microbial Contamination

2000 APEC China Seminar

Lynn McMullen, PhD
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Foodborne Disease In Canada

- 1998 >2 million cases
- Estimated cost $1.2 billion/year
- Meat and poultry products traditionally account for >24% of cases

Todd, 2000

Bacterial Pathogens of Greatest Concern to the Meat Industry

- *Camplyobacter* spp.
- *Escherichia coli* O157:H7
- *Listeria monocytogenes*
- *Salmonella* spp.

SETTLEMENT CLOSES CHAPTER IN '93 HAMBURGER DEATHS

Feb. 26/98

CHICAGO -- A $58.5 million payment to Foodmaker Inc. by nine beef suppliers this week clears up nearly all claims stemming from four deaths and many illnesses in 1993 from *E.coli* O157:H7 tainted hamburgers.

Challenges for the Meat Industry

- New Pathogens
- Changes in susceptibility of host populations
- New food vehicles
- Chronic sequalae

Food Safety: who is responsible?

- Animal Producer
- Packer
- Further processor
- Retailer
- Consumer

Hazard Analysis Critical Control Point

- systematic approach
- prevent food safety problems

  before they occur

Why HACCP?

- Documentation of a safe process
- Enhanced safety
- Purchase specification
- National and International trade standard

Goal

prevent, eliminate or reduce hazards to acceptable level

Before HACCP

- Need to have Good Manufacturing Practices as prerequisite to HACCP

Good Manufacturing Practices

- Premises
- Receiving and storage
- Equipment
- Personnel
- Sanitation
- Health and safety recalls
- Record keeping

Develop a HACCP Program

- HACCP team
  - multidisciplinary
  - knowledge of hazards
  - knowledge of process
  - management commitment

Develop a HACCP Program

- HACCP team
- Describe the product
- Identify the intended use
- Process flow
- Product flow

Principles of HACCP

1. Identify hazards
2. Identify critical control points
3. Establish critical limits
4. Establish monitoring procedures
5. Establish corrective action
6. Establish a verification program
7. Establish a record keeping system

1. Identify Food Safety Hazards

- Biological
- Chemical
- Physical

Biological Hazards

- Contamination
  - parasites, bacteria
    - contamination of product during processing
- Growth of bacterial pathogens

2. Identify critical control points

- a point, step or procedure where control can be applied

a hazard can be prevented, eliminated or reduced to an acceptable level

Hazard	Critical Control Point
• Contamination	eviseration
• Growth of bacterial pathogens	cooling after slaughter

On-Farm HACCP - CCP's

- water and feed quality
- environmental conditions
- application of therapeutic agents

3. Establish critical limits

- a point, step or procedure where control can be applied
- a hazard can be prevented, eliminated or reduced to an acceptable level

CCP	Critical Limits
• Eviseration	no breakage
• cooling after slaughter	maximum # of carcasses in cooler
	cool to < X° C in Y h

4. Establish monitoring procedures

- Planned sequence of observations or measurements
- provides an accurate record of CCP
- ensures CCP maintains product safety
- should be “real-time”

CCP	Monitoring
• Eviseration	supervisor monitors working techniques
• cooling after slaughter	employee records carcass temperatures check for overcrowding

5. Establish corrective action

- Action to be taken when critical limit at CCP fails compliance

CCP	Corrective Action
• Eviseration	identify and detain carcass trim contamination
• cooling after slaughter	if temperature too high stop production until corrected if too many carcasses remove excess

6. Establish a verification program

- Methods, procedures and tests to determine if HACCP system is operating properly

CCP	Verification
• Eviseration	unannounced inspection microbial testing
• cooling after slaughter	unannounced inspection evaluation of record microbial testing

7. Establish a record keeping system

- Documentation for each CCP

  - provides a product processing profile
  - allows trace back of process

CCP	Records
• Eviseration	slaughter records record of corrective action
• cooling after slaughter	refrigeration records record of corrective action

HACCP

Write what you do.

Do what you write.

Prove it!

Benefits of HACCP

- Systematic approach
- Proactive
- Continuous control of problems
- Real-time monitoring for problems
- Cost effective

HACCP - Does it work?

HEADLINE

U.S. SALMONELLA RATE FALLS

March 10, 1999

1998 45% decline in the rate of salmonella contamination on chicken

Decrease a result of HACCP

Before and After HACCP at FoodMaker Inc.

	Specification maximum	Before HACCP	After HACCP
TPC	≤500,000/g	100,000 to 500,000	≤25,000
Coliforms	≤500/g	100 to 300	≤30
E. coli	≤100/g	30 to 100	≤5
E. coli 0157:H7	negative	negative*	negative
Salmonella spp.	negative	1% positive	negative

Who should have a HACCP plan?

- Anyone producing food for human consumption
  - Canadian Pork Quality Assurance Program
  - Alberta Egg Producers - Start Clean, Stay Clean