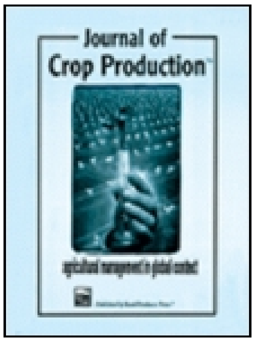

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Use of Effective Microorganisms to Suppress Malodors of Poultry Manure

Weijiong Li
Yongzhen Ni

SUMMARY. A serious problem and major constraint to the development of more efficient and sustainable animal and poultry production system in China is the generation of malodors from manure in rearing facilities and from handling, storage and use of these wastes after removal, particularly in the urban and suburban sectors. Because of their high malodor potential, these wastes are not effectively recycled on agricultural land. A cooperative research study was conducted with the International Nature Farming Research Center (INFRC), Atami, Japan to evaluate the use of a microbial inoculant, Effective Microorganisms or EM, to suppress malodors of poultry manure. Feeding trials consisted of adding EM either to drinking water and feed, or to both water and feed, and comparing the results with non-EM controls. EM markedly reduced the malodor level of the poultry manure, associated mainly with a dramatic decrease in the ammonia (NH_3) levels (i.e., 42 to 70% lower than the controls). The amino acid content of the feed increased 28% after it was inoculated and fermented with EM. EM also improved the growth and disease resistance of the birds and net returns in the marketplace. These results indicate that EM use in poultry operations has great potential for suppressing malodors of manure, improving sustainable production, and protecting the environment, all on a cost-effective basis. *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-342-9678. E-mail address: getinfo@haworthpressinc.com <Website: http://www.HaworthPress.com>]*

KEYWORDS. Animal waste, effective microorganisms, EM, malodor, microbial inoculant, poultry manure, waste management

Weijiong Li and Yongzhen Ni are Professors, College of Resource and Environment, China Agricultural University, Beijing 100094, China.

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INTRODUCTION

It is estimated that at the present time there are about 2.3 billion chickens being reared intensively in China. This number of birds produces an annual output of 84 million tons of fresh manure or 21 million tons on a dry weight basis. This output combined with the manure of cattle, swine, ducks, geese and other animals amounts to an annual production of several billion tons, much of which contributes to severe problems of environmental pollution, and human and animal health. Improper handling and storage of poultry manure from rearing facilities has generated malodors, attracted flies, and adversely impaired air quality, especially in the urban and suburban sectors. Impacted citizens continue to submit complaints and grievances about the problem, particularly in the spring and fall months when malodors are most intense. In response, the poultry industry has explored alternative methods and techniques for processing and utilizing the manure to alleviate malodors including methane production through anaerobic digestion, high temperature drying, and heat spraying methodology. Unfortunately, these technologies are energy-consuming ventures that require long-term large capital investments. Thus, the problem of malodors of manure from rearing facilities remains unsolved and continues to intensify.

In seeking alternatives and solutions to the problem of malodors we became aware of a new technology called "Effective Microorganisms" or EM, a microbial inoculant that has been developed by professor Teruo Higa, University of the Ryukyus, Okinawa, Japan. EM is a mixed culture of naturally-occurring beneficial microorganisms (i.e., predomiumthy lactic acid bacteria, photosynthetic bacteria, yeast, actinomycetes, and certain fungi). EM has reportedly improved soil quality; the growth, yield and quality of crops; and suppressed the generation of malodors from swine and poultry manure (Higa, 1993; Li et al., 1998). In view of this, we established a cooperative research project with the International Nature Farming Research Center (INFRC) to determine whether EM technology could help to resolve the malodor problem. In doing so, we applied the principle of micro-ecological engineering combined with biological technology (Ma and Li, 1987). This paper presents the results of this project.

MATERIALS AND METHODS

Preparation and Presentation of Test Materials

Treatment of poultry feed with EM. Poultry feed was inoculated with EM and subject to anaerobic fermentation to increase the population and activity of EM microorganisms. Fermentation also increases the availability of feed nutrients and their utilization after ingestion to enhance animal growth and weight gain (Li and Ni, 1995a, b). The period and temperature of fermentation are considerably influenced by ambient conditions and seasons. For example, in warm summer months complete anaerobic fermentation may require only 3 to 5 days, while in cold winter months it may take twice as long, possibly 7 to 8 days. Anaerobic condition also suppresses the growth of molds or other contaminating organisms. Feed that is successfully fermented will have a pleasant "sweet and sour" odor and large populations of EM-inoculated microorganisms, often reaching levels of 1×10^8 organisms per gram of material. Nevertheless, the extract quantitative index of EM fermentation of various feeds is in need of further research and refinement.

Treatment of drinking water with EM. Presenting EM to poultry at all stages of growth and maturity is relatively simple, since liquid EM culture is easily miscible with water, and dilutions can be selected to provide the desired intake depending on age/size of the bird, the drinking water device, and the water metering system. Even so, some poultry farmers prefer not to add EM through the drinking water because of these and other variables that can influence the rate of EM intake per bird.

Experimental design and analysis. Table 1 shows the main treatment designations for the study including the group species and number of birds to determine the effect of EM applied to drinking water or feed, or both water and feed on malodor levels of poultry manure. A non-EM control treatment was established for each of the three main treatments with the same number of birds, same kind and amount of common feed and drinking water (no EM added), and all other conditions the same.

All treatments were applied to separate rooms or compartments and tests were conducted for 30 days. Air samples were collected throughout and ammonia concentration determined by the Kjeldahl Method. Amino acid composition and concentration of the feed were determined before and after inoculation and anaerobic fermentation with EM. An economic analysis was conducted to determine the effect of EM on rate of weight gain, market weight, feed conversion efficiency and the meat:feed ratio.

TABLE 1. Main treatment designations, including group species and number of birds, to determine the effect of EM applied to drinking water or feed, or both water and feed on malodor levels of poultry manure

Treatment	Group/species	Number	EM Applied
1	Ruman table poultry	400	EM drinking water + common feed
2	Dike laying poultry	500	EM feed + common water
3	AA laying poultry	50	EM feed + EM drinking water

RESULTS

The main constituents of animal and poultry wastes that induce malodors are ammonia, hydrogen sulfide, mercaptan and methylmercaptan. Because ammonia usually occurs in higher concentrations in the gaseous environments of animal and poultry rearing facilities, and because it is known to have adverse effects on human and animal health, the ammonia concentration in these facilities is often used as an environmental index. In the present study, the effects of adding EM to drinking water (Treatment 1), to feed (Treatment 2), and to both drinking water and feed (Treatment 3) on the ammonia concentrations from poultry manure and percentage reduction due to EM compared with non-EM controls are reported in Table 2. The greatest reduction in ammonia concentration was 69.7% and occurred when EM was added to both drinking water and feed. The second and third best reductions in ammonia concentration were 54.25% and 41.12% and occurred with treatment 2 (EM added to feed) and treatment 1 (EM added in drinking water), respectively.

The test was conducted for 30 days after which ammonia (NH_3) concentrations were monitored continuously for the number of days indicated.

The dramatic reduction in ammonia concentration, especially where EM was inoculated into feed and fermented, suggests that ammonia was utilized in some biosynthetic pathway. An analysis of the composition and concentration of amino acid before and after inoculation and fermentation with EM showed that the concentration of amino acids in EM-fermented feed had increased 28% (Table 3). This suggests that EM microorganisms accelerate nutrient transformations and availability, enhancing the rate of uptake and utilization by the animal which, in turn raises the nutrient value of the feed and increases the rate of gain and production of animal products. At the same time, EM microorganisms likely suppress the growth and activity of putrefactive microorganisms in the intestine that produce malodorous nitrogen compounds, thereby reducing the concentration of ammonia in their manure.

The action of EM increases the utilization and transfer rate of nitrogenous

TABLE 2. Effect of EM treatments on ammonia concentrations from poultry manure and percentage reduction due to EM compared with non-EM controls

Treatment (No.)	Sampling time (Days)	NH_3 (ppm)		NH_3 reduction by EM (%)
		Controls (No EM)	Main treatment EM	
1	3	8.95	5.18	42.12
2	6	16.13	7.38	54.25
3	3	87.6	26.5	69.7

compounds from the feed to the growth and production phase of animal and poultry. For example, egg production by some laying hen facilities has increased by 13% from use of EM, which has also increased the length of the laying period. Table 4 shows an economic analysis of the effect of EM (in feed) on broiler production. EM increased the rate of weight gain, increased meat production, increased the feed utilization efficiency and increased the meat:feed ratio compared with the non-EM control group. These results show that EM technology can suppress malodors of poultry manure without a great

TABLE 3. The analyzed results of the amino acids concentration in the EM fermented foodstuff of poultry

Amino Acid	A. After treatment (%)	B. Before treatment (%)	A/B
Aspartic	2.94	2.48	1.19
Threonine	1.25	1.05	1.19
Serine	1.88	1.63	1.15
Glutamate	6.17	3.60	1.71
Glycine	1.74	1.39	1.25
Alanine	1.71	1.37	1.25
Cystine	0.45	0.42	1.07
Valine	1.17	1.01	1.16
Methionine	0.63	0.48	1.31
Isoleucine	0.97	0.78	1.24
Leucine	2.16	1.81	1.19
Tyrosine	0.93	0.85	1.09
Phenylalanine	1.38	1.16	1.19
Lysine	1.02	0.84	1.21
Histidine	0.72	0.57	1.26
Arginine	1.89	1.68	1.13
Proline	3.96	3.16	1.25
Tryptophan	–	–	–

TABLE 4. Economic analysis of EM for feeding table poultry (Yuan)

Treatment	Chicken cost	Feed cost	EM cost	Revenue from chicken sale	Net gain	Relative gain	Meat:feed ratio
EM	100	207.74	10.0	427.00	109.26	125.18	2.06
CK	100	227.73	0.0	415.01	87.28	100.00	1.82

All values in the table are in terms of Chinese Yuan. Exchange rate is 1 US$ = 8.3 Chinese Yuan.

investment of money and equipment, and likely would improve the management and efficiency of poultry farms.

DISCUSSION

In recent years, our applied efforts in the poultry rearing industry have indicated that EM fed to birds can effectively suppress malodors of the manure, improve the growth of animals and enhance their disease resistance, and thereby improve the local environment surrounding the rearing facility. EM applied in feed and drinking water improves the feed conversion rate and other production parameters as well as social and economic benefits (Cai and Huo, 1993). Thus, EM provides a multiple function of micro-ecological applications that are related to its predominant microbial types and numbers, i.e., lactic acid bacteria, photosynthetic bacteria, yeast, actinomycetes and certain fungi.

The ability of EM to suppress malodors of animal manure, either through direct or indirect mechanisms or modes-of-action require further study and evaluation. According to our research and observations, the following mechanisms maybe involved: (1) EM is a mixed culture of many species of naturally-occurring, beneficial microorganisms (Li and Ni, 1995a, b) some of which can transform NH_4^+-N to NO_3-N, thereby decreasing the potential for N-volatilization and increasing the potential for nitrogen fixation (through photosynthetic bacteria); (2) EM contains beneficial microorganisms which come to reside in the animals intestines as feed and drinking water are utilized. The EM microorganisms suppress the growth and activity of the indigenous putrefactive types that cause malodors in the manure and transform proteins and amino acids into NH_3-N and NH_4^+-N; (3) Thus, the EM in the intestines reduce the ammonia levels in the manure and blood (Lu, 1992; Kang, 1988). These three combined actions of EM may transfer protein in the feed into effective and available nutrients, thereby increasing the feed utilization rate and suppressing malodor production by indigenous intestinal microorganisms, alleviating the problem of malodors from manure both at the rearing farm and the surrounding urban/suburban environment. This suggested action of EM is similar to the ‘‘anti-oxidation theory’’ proposed by Dr. Teruo Higa, the innovator of EM technology (Higa, 1993).

Feeding EM allows animals to utilize beneficial microorganisms that enhance their health and well-being and restore their micro-ecological balance. This helps the farmer to avoid the malpractice of using commercial antibiotics, which can disrupt the micro-ecological balance and reduce the animal’s natural recuperative capacity. Thus, EM allows the animal to produce high quality products for the marketplace, which increases the farmer’s profitability and net returns. All of this means that the farmer can better conserve energy and resources; recycle animal wastes and manure to improve soil productivity and avoid malodors throughout (i.e., from rearing facilities to the external environment); protect the natural environment; and reduce the usage of chemical fertilizers, pesticide and antibiotics.

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