Dairy production with local feed resources in Asian countries

Workshop of 17th AAAP Animal Science Congress

23 August, 2016

Kyushu Sangyo University

Fukuoka, Japan

Organized by the Research Center for Animal Science

Hiroshima University

Dairy production with local feed resources in Asian countries

Workshop of 17th AAAP Animal Science Congress

Date: 23 August, 2016 (9:00-11:00)
Venue: Kyushu Sangyo University

Organized by The Research Center for Animal Science, Hiroshima Univ.
Contact: Taketo Obitsu (Hiroshima Univ., tobitsu@hiroshima-u.ac.jp)

Demands of fresh milk and dairy products are increasing in most of Asian countries. However, domestic milk production by dairy cows does not satisfy their own demand of milk due to economic and political restriction and limited resources in each country. To improve the domestic self-sufficiency of milk products, efficient and safety production system is necessary to be established in each countries. However, the amount and quality of feed resources available in own country are limited even in tropical area where is rich in plant resources, due to seasonal variation, global climate change and relatively higher nutrient requirements of dairy cows. This situation results in increasing demand for imported feeds which, in part, causes increasing production cost and elevation of global feed prices. Global climate change and trend of consumers also affect dairy production system. Thus, current dairy industries in Asian countries need to respond these serious problems. In this context, this workshop focuses on nutrition and feeding in dairy cows in Asian countries, especially for efficient utilization of local feed resources. The outcome of this workshop will contribute to develop the dairy farming system based on local feed resources through sharing advanced findings obtained in several Asian counties.
Speakers of this workshop are working in the area of ruminant nutrition with future perspectives. Through this workshop, all participants will share common and diverse subjects and make plans for building a research network connecting Asian countries.

Speakers and Titles:

Utilization of local feed resources for dairy buffalo, cattle and yak in Nepal

Hajime Kumagai

Graduate School of Agriculture, Kyoto University, Kyoto, Japan

Dairy Cattle in Indonesia: Challenges and Opportunities

Andriyani Astuti, Adiarto, Ali Agus

Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia

Utilization of Agro-industrial by-product as protein sources for dairy cows

Phongthorn Kongmun

Department of Animal Science, Faculty of Agriculture, Kasetsart University, Bangkok, Thailand

Evaluation and utilization of rice as alternative feeds for dairy cows

Taketo Obitsu

The Research Center for Animal Science

Graduate School of Biosphere Science, Hiroshima University, Higashihiroshima, Japan

Efficient use of roughage resource for sustainable development of China's dairy industry

Chong Wang[1,2], Jianxin Liu[1], Huiling Mao[1,2], Diming Wang[1]

[1]*College of Animal Sciences, Zhejiang University, Hangzhou, China*

[2]*College of Animal Science and Technology, Zhejiang A&F University, Hangzhou-Lin'an, China*

Utilization of local feed resources for dairy buffalo, cattle and yak in Nepal

Hajime Kumagai
Graduate School of Agriculture, Kyoto University, Kyoto, Japan
Corresponding Email: hkuma@kais.kyoto-u.ac.jp

1. Introduction

In Nepal, the agricultural sector contributed 39.9% of the gross domestic product (GDP) and livestock production was one of the main sub-sectors in the country accounting for 26.8% of the agricultural GDP. The country raised 7.3 million cattle and 5.2 million buffalo in 2013, and total yield of milk was 1.8 million ton: 27.8% was from cattle and 67.1% was from buffalo (FAO, 2016).

The country is divided into three environmental zones: Tarai, hill and mountain. Tarai is a low-altitude, lower than 500 m above sea level, and southern plain region of Nepal and the main granary of the country. Hill is a medium altitude region, from 500 to 2,500 m above sea level. Mountain is a high altitude region, higher than 2,500 m above sea level, and yak and the crossbreds are raised for dairy production, besides cattle. There are three periods based on environments of pasture and fodder influenced by Asia monsoon: the pasture-sufficient period characterized by increased pasture, the pasture-decreasing period characterized by decline of pasture due to rainless and cool climate and the fodder-shortage period characterized by scarcity of fodder with dry climate. Although dairy in each region contributes to the local milk production, information on productivity of the animals is limited and attempts to improve animal performance, i.e. nutritional status and milk production, are scarce.

In the present report, feeding trait and milk production of buffalo, cattle and yak dependent on local feed resources in each environmental zone were overviewed (Hayashi et al., 2006, Sakai et al., 2010). Further, the outcomes of experiments feeding dairy buffalo and cattle with preserved feeds, i.e. silage and hay, in the fodder-shortage period were discussed (Hayashi et al. 2007; Hayashi et al., 2009; Sakai et al., 2015)

2. Feeding traits, nutritional status and milk production of dairy buffalo and cattle in small-scale farms of Tarai region

Nutritional status of buffalo and cattle were studied in surveys of small farms in 3 Village Development Committees (VDCs) in Chitwan District. The data from surveys suggested that the difference of feeding management among the villages and seasons resulted in the variance of nutrient supply of crude protein (CP), neutral detergent fiber (NDF) and total digestible nutrient (TDN), and consequently affected the physical traits and milk production in the animals. Supply of CP, in particular, should receive further attention.

3. Experiments feeding preserved feeds on performance of milk production of dairy buffalo and cattle

1) Effects of maize silage (*Zea mays* L.) feeding on dry matter intake and milk production of dairy buffalo and cattle

To identify the effects of whole crop maize silage (MS) as a substitute for rice straw (RS) on feed intake and milk production of mid-late lactating buffalo and cattle in Tarai, Nepal, eight Murrah and eight Jersey-Hariana were fed the basal diet, RS (ad libitum) with concentrate (0.68% of bodyweight [BW] on a dry matter [DM] basis). A 4 × 4 Latin square design experiment was conducted in each animal species with graded levels of MS substitution for RS (0%, T1; 33%, T2; 67%, T3 and 100%, T4). The MS had higher digestibility and total TDN than RS ($P < 0.05$). The DM intake per BW of the both species was highest in T3 ($P < 0.05$). The substitution of MS for RS increased the CP intake and the TDN intake in the both species ($P < 0.05$). Although the buffalo showed the highest milk production in T4 ($P < 0.05$), the cattle showed no significant differences in their milk production among the treatments. The substitution of MS for RS improved the feed intake and milk production in the buffalo. On the other hand, the milk yield was not raised in the cattle, though the feed intake was increased by the substitution

2) Effects of field pea (*Pisum sativum*) hay feeding on dry matter intake and milk production of buffalo

To identify the effects of field pea hay (FPH) as a supplement of RS on feed intake and milk production of mid-late lactation buffaloes in Tarai, Nepal, nine multiparous Murrah were fed a concentrate at 0.6% of their BW on a concentrate DM basis daily while having ad libitum access to RS. The buffaloes were divided into three groups, and the experiment with three levels of FPH feeding was conducted at the following rate of BW: 0% (T1), 0.5% (T2) and 1.0% (T3) on an FPH DM basis. The DM intake (DMI) was higher in T2 and T3 than in T1. As the amount of FPH was raised, the BW change, CP intake (CPI) and TDN intake (TDNI) were increased ($P < 0.05$). Although the yield of milk and milk composition did not differ among the treatments, the 7% fat corrected milk yield (FCMY) tended to increase as FPH feeding amount was raised. Although there were no significant differences in FCMY/DMI and FCMY/TDNI among the treatments, FCMY/CPI decreased with FPH feeding. Supplementary FPH increased DMI, CPI and TDNI that might have raised BW, and tended to improve FCMY in mid-late lactating buffaloes as a result of an increase in TDNI.

3) Evaluation of total mixed ration silage with brewers grains for dairy buffalo in Tarai, Nepal

To investigate the effects of total mixed ration (TMR) silage, which contained brewers grain and rice straw as a substitute for conventional concentrate on feed intake and milk production in middle-to-late lactation buffaloes, four multiparous Murrah buffaloes were assigned to a 3 × 3 Latin square design experiment. The TMR silage, which had higher NDF contents and digestibility than concentrate ($P < 0.05$) and similar CP and TDN contents with concentrate were used for the lactation experiment. The treatments were control (CTL) fed concentrate at 0.6% of body weight (BW), and T1 and T2 fed the TMR silage at 0.6 and 1.2% of BW on a dry matter (DM) basis, respectively, with rice straw ad libitum. Daily intakes of DM, CP and TDN, and BW change were higher in T2 than in CTL and T1 ($P < 0.05$). Although milk composition did not differ among the treatments, milk yield (MY) was higher in T2 ($P < 0.05$). There were no significant differences in MY/DM intake and MY/TDN intake among the treatments. The increase of BW and MY in middle-to-late lactation buffaloes might have been due to high TDN intake from supplementary TMR silage.

4. Feeding traits and milk production of dairy buffalo and cattle of small-scale farms in hill

region

Although fodder trees are fed as of supplement to the animals because of limited land to cultivate feed crops of small-scale farms in hill region, the nutritional values of fodder trees are poorly recognized. A survey was carried out in 10 and 8 small farms of VDCs in Gorkha and Gulmi Districts, respectively, three times a year to find out the characteristics of buffalo and cattle production and the feed resources in the regions. Milk production (L/day/head) were 3.9 for buffalo and 6.9 for cattle from improved crossbred of Jersey and Hoistein in Gorkha, and 4.1 for buffalo and 8.2 for cattle in Gulmi. Total DM supply for milking animals in August, November and March was 20.7, 16.3 and 12.1 kg/day/head in Gorkha and 21.6, 10.1 and 8.5 kg/day/head in Gulmi, respectively. Total CP supply for milking animals in August, November and March was 2.52, 1.57 and 0.83 kg/day/head in Gorkha and 2.06, 0.90 and 0.99 kg/day/head in Gulmi, respectively. In November, CP supply for animals was dependent on fodder trees in both the districts. The number of species of fodder trees in November was largest (16 and 25 in November, 6 and 10 in August and 13 and 17 in March for Gorkha and Gulmi, respectively). This study indicated that the ingredients of feeds and number of fodder trees species well varied among the seasons, which linked to the feed utilization for buffalo and cattle in order to realize their full potential.

5. Statuses of milk production, and health and mineral nutrition of yak in mountain region

Fifteen yak owners who lived in 3 VDCs in southern Mustang District were interviewed on their production performances of yak farming. Totally 762 yaks were owned by the 15 farmers in the villages. The yaks migrated summer pastures in highlands at 3,400-4,600m above sea level from May to October and winter pastures in lowlands at 2,500-3,400m above sea level from November to April. Mating is natural and occurred from July to October; and consequently calving is from April to July. Amount of milk produced from dams for human use was 1.0-1.5 L/day/head. Only commercial salt was given to the yaks as supplement once a week. Nine pasture species palatable for yaks were identified. Plasma samples of female yaks collected in April and September/October were offered to measure biochemical values and mineral concentrations. Seventy-four percent of yaks showed lower plasma total-cholesterol concentrations than the lower limit of reference range (100 ml/dL) and the values in spring (83.41 mg/dL) is lower (P<0.05) than those in autumn (95.05 mg/dL). All the yaks had lower plasma albumin concentrations than the lower limit of reference range (3.0 g/dL) and 66% of yaks showed lower plasma inorganic phosphorus concentrations than the critical level of phosphorus deficiency (4.5 mg/dL). Thirty-five percent of yaks showed lower plasma calcium contents than the lower limit of normal range (8 mg/dL) and the contents were lower in spring than in autumn (P<0.01). Seventy-five percent of yaks presented lower copper contents than the critical level (0.65 mg/L) and the concentrations were lower in spring than in autumn (P<0.01). Since the low plasma total-cholesterol level might have indicated shortage of DM and energy intake, attention should be paid to the nutritional statuses of energy, phosphorus, calcium and copper in winter and early spring when yaks are entirely based on available pasture grazing.

6. Conclusion

Low quality and low quantity of feeds supplied are the main constraints to improve animal production during dry season in each environmental zone of Nepal. Utilization of local feed resources i.e. fodder trees, silage, hay, etc. has the possibility to enhance milk production of dairy animals in Nepal economically whereas utilization of non-conventional feedstuffs could be another area for further research and to increase the feed resources..

References

Food and Agriculture Organization of the United Nations (FAO). 2016. FAO Statistical Database. Retreaved July 9, 2016, from http://faostat3.fao.org/home/E

Hayashi Y, Maharjan KL, Kumagai, H. 2006. Feeding traits, nutritional status and milk production of dairy cattle and buffalo in small-scale farms in Terai, Nepal. Asian-Australasion Journal of Animal Science. 19: 189-197.

Hayashi Y, Devkota NR. Kumagai, H. 2007. Effects of field pea (*Pisum sativum*) hay feeding on dry matter intake and milk production of Murrah buffaloes fed rice straw *ad libitum*. Animal Science Journal. 78: 151-158.

Hayashi Y, Thapa BB, Sharma MP, Sapkota M, Kumagai H. 2009. Effects of maize (*Zea mays* L.) silage feeding on dry matter intake and milk production of dairy buffalo and cattle in Tarai, Nepal. Animal Science Journal. 80: 418-427.

Sakai T, Araki C, Devkota NR, Oishi K, Hirooka H, Kumagai H. 2010. Characteristics of buffalo and cattle productions and the feed resources in mid-hill regions, Nepal. 14th AAAP Animal Science Congress Proceedings. Pintung, Taiwan, Republic of China.

Sakai T, Devkota NR, Oishi K, Hiroyuki H, Kumagai, H. 2015. Evaluation of total mixed ration silage with brewers grains for dairy buffalo in Tarai, Nepal. Animal Science Journal. 86: 884-890.

Dairy cattle in Indonesia: challenges and opportunities

Andriyani Astuti, Adiarto, Ali Agus
Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia
Corresponding email: andriyaniastuti@ugm.ac.id

1. Introduction

Milk is a highly strategic economic commodity along with the increasing awareness of the importance of milk consumption and improves the living standards for the people of Indonesia. In 2002-2007 the demand for milk consumption in Indonesia grew very rapidly showing an increase of 14.01%. On the other hand, the growth of milk production increased by only 2% during the same period (Direktorat Budidaya Ternak Ruminansia, 2010). Subsequently, this has led to e increasing amount of milk imports and reduced the level of milk self-sufficiency. Therefore, it is necessary for the government to develop policies that include the enactment of milk as a strategic food commodity and apply a variety of technological innovations to improve the productivity of dairy farm business in Indonesia.

The breed which serves as the foundation stock of dairy cows in Indonesia is the Friesian Holstein cows (FH) originating from the sub-tropical areas with a total population of about 600,000 heads and the average milk production of 10-12 liters per day. Friesian Holstein cows are considered as descendants from Bos Taurus are likely to have more difficulties in adapting to local environment and are more susceptible to heat stress, a condition that must be avoided in the lactating dairy cows. Therefore, the studies on selection of dairy breeds which have high adaptability to tropical climates should be a top priority in Indonesia.

In Indonesia, the four main categories of farmers in the dairy cattle industry in the last 20 years are: (a) cooperatives of dairy farmers, (b) individual dairy farmers, and (c) large and (d) medium scale dairy cattle companies (Yusdja and Rusastra, 2001). Until now, individual dairy farmers are the backbone of the dairy industry in Indonesia, with a total number of approximately 100,000 farmers and most are members of the dairy cooperatives. Most dairy farmers in Indonesia still practice the traditional farming system keeping a few cows (2-3 head/farmer) with land ownership of 0.2-0.3 ha. The limited number of cows and the land is also an obstacle in the efforts to increase the population and productivity of dairy cows (Farid and Sukesi, 2011). The average price of fresh milk at farm-gate amounts to Rp 4, 200, - per liter. Aside from the low productivity, the low scale of dairy business results in the low income of dairy farmers. Currently, the low milk price and the weak bargaining power have made it difficult for the farmers to develop and expand their business. It is hoped that in future, the high milk price and strong bargaining position of farmers will motivate them to develop the dairy cattle farming, and thus increasing the country’s milk production and consumption.

2. Challenges

The low economic viability of dairying in Indonesia is due to the following factors: unsuitable dairy breeds, hot tropical environment, supply and quality of feeds, unskilled human resources/farmer, poor health management and problems in reproduction. Smith and Rietmuller (1995) earlier stated that the development of dairy farming was hampered by problems such as lack of forage and low quality of the concentrate, poor feeding treatment to the dairy cows and low health condition, low quality breeds, absence of recording, etc.

The increasing importation of pregnant dairy cows has caused problems for farmers because Holstein Friesian dairy cows are less adaptive to our hot and humid environment. The limited availability of forage and concentrates is an obstacle in the feeding management of dairy cows. The low ownership of forage land is also one of the obstacles faced by farmers. In dry season, the forage commonly given is sourced from agricultural waste products, the feeding quality of which is not in accordance with the purpose of milk production The introduction high qualities forage and adaptive in tropical areas need to be developed. The improvements of concentrates (quantity and quality) at the farmer level still needs to be considered and at the same time serves as a challenge for researchers and academics.

Improvement of human resources/farmers is imperative in order to improve productivity and economic value of milk, through increased understanding and application of good farming practices. Another factor that was proposed by Alia *et al*. (2014) was farming skills and knowledge development of dairy farmers and mapping of the dairy farming areas through a cluster that is the geographic concentration of livestock, industries, and related institutions.

Moran (2008) stated that the measurement of dairy cattle reproduction performance necessary to assess was: 100 day in calf rate, 200 day not in-calf rate, submission rate and conception rate. The target indicator for farm people in Asia were: 100 day in calf rate: 55-60%, not 200 day in-calf rate: 13-15% submission rate: 65-70%, voluntary waiting period: 50-60 day, conception rate to first insemination 45-50%, and the insemination per conception in an AI program: from 1.8 to 2.0. Improved reproductive performance can only be done by the improved cattle management and maintenance of good feed.

3. Opportunities

Farm business conditions already implemented for more than 40 years in Indonesia has a lot of opportunities for development.

Those opportunities among others include the cooperatives which have been established. Farmers and dairy cooperatives have the same concern for a mutually beneficial position. The dairy farmer’s product is in the form of perishable commodities that needs a cooperatively well-managed post-harvest handling. So far, the cooperatives have helped farmers in milk collection, transport, storage (cooling) and marketing (Siregar, 2003). However, the cooperatives have not been able to contribute optimally to the farmers because they have not yet applied the efficient and economic management system. Improved efficiency and management of dairy cooperatives is absolutely necessary so as to further contribute to the welfare of farmers.

Various policies and facilities provided by the government to the farmers have served as an opportunity to enhance the productivity of dairy cattle in Indonesia. The government has formulated policies and programs pertaining to the increase of breeding stock and milking cow population. Some programs which have been implemented by the government include the establishment of a dairy breeding center, artificial insemination and embryo transfer center, dairy training center, animal health services, research centers, and credit programs. In recent years, the government has also been promoting the milk school program and drinking fresh milk in the effort to familiarize the consumption of fresh milk early on.

Dairy cows need high nutrients, thus fulfilling the cows requirement by providing high-quality forage and concentrates is absolutely necessary in order to make the dairy farm business profitable (Moran, 2008). Improvement in feed and management is one of the opportunities in the development of the dairy farm. Several researches have been conducted in an effort to increase the consumption of nutrient for dairy cows, among others studies by Adiarto (2006) discussing the supplementation of milk inducer (25% protein, TDN 70%) amounting at 15% of the concentrate in Friesian Holstein crossbreds (PFH) with Elephant Grass basal feed, increasing the milk production at peak production (27.6 vs 22.5 liters/day), with the average production of 115 days lactation (22.4 vs 16.6 liters/day).

Provision of High Quality Feed Supplement (HQFS) (19% protein, TDN 76%) is able to reduce the decline in milk production, without changing the contents of fat, protein, lactose, Solid Non Fat, and mineral phosphorus but increasing Total Solid and calcium as well as the consumption and protein digestibility of dairy cows at early lactation (Astuti *et al*., 2009; 2011). Feeding HQFS and herbal-protein mix can affect the milk production and quality as well as reduce the number of worm's egg in dairy cattle feces (Agus *et al*., 2010). Agus *et al*. (2001) also explained that the supplementation of cooked corn to feed formulations at the lactating dairy cows can also increase the production and composition of milk. The government has also introduced the subsidy scheme for concentrates to farmers through cooperation with the cooperatives as concentrate supplier to help farmers purchase concentrates at a lower price and of better quality.

4. Blueprint of the Indonesian Dairy 2013-2025

Indonesian government has already developed a blueprint for the local dairy industry from 2013-2025 with the first step, to focus on the increase in population and improving the productivity and milk quality. The increase in the production and the quality of fresh milk will guarantee the availability of raw materials for the dairy processing industry, hence will further reduce the dependence on imported milk and milk products. Increased milk production and quality will improve the income and welfare of farmers thereby increasing purchasing power as an indicator of the growing prosperity of farmers.

The stages of implementation of Indonesian dairy development are as follows: a) Preparation and Stabilization (2013-2014), which is a coordinated planning and synchronization of policies in support of national dairy; b) Advanced National Milk (2015-2020), which is the changes toward the increase in the consumption of fresh milk in the country, the increase in population of dairy cattle, formation of dairy cattle breeding cluster, increase the fresh milk production, growth of the dairy industry, an increase in the ability of farmers in livestock management and post-harvest processing, and increased farmer incomes; c) Self Sufficient National Dairy (2021-2025), namely the realization of food security in the Indonesian milk that led to an intelligent, independent, sovereign, and prosperous Indonesian society (Kementerian Koordinator Bidang Perekonomian, 2014) .

5. Conclusion

The opportunities in the development of dairy cattle production in Indonesia are enormous, which include the improvement of feed supply and quality, farmer's management skills and efficiency, the government support and incentives, and the increasing demand for milk due to the increased social awareness of milk consumption and people prosperity. These open opportunities that cannot be separated from the existing challenges, such as low breeder population and productivity of dairy cows, reproductive efficiency, and quality of human resources/farmers. The efforts to address these challenges in line with the existing opportunities can be created through a well-managed cooperation among the governments, farmers, cooperatives, and the dairy industries.

References

Adiarto. 2006. Efek substitusi konsentrat suplemen energi dan protein terhadap kinerja produksi dan reproduksi sapi perah PFH awal laktasi. Agrosains (ISSN 1411-6170). Berkala Penelitian Pascasarjana Ilmu-Ilmu Pertanian, Universitas Gadjah Mada. Vol.19 pp. 381 – 394.

Agus, A., A. Astuti and A. Munawar. 2001. The effect of cooked corn supplementation as sources of energy in the diet of lactating cows on milk yield and composition. Buletin Mediagama. Vol III (2) Mei 2001. pp. 27-36.

Agus, A., A. Astuti, and S. Bintara. 2010. Effect of supplementation of herbal-protein mix concentrate on dairy milk quality and production. Proceedings of International Conference on Food Safety and Food Security, UGM, Yogyakarta.

Alia, D., Y. Prasetyawan, CH. Wardhani, and ER. Paramita. 2014. Peningkatan nilai bisnis susu sapi dalam kerangka penguatan ssstem inovasi daerah di Kabupaten Malang. Simposium Nasional RAPI XIII. Fakultas Teknik. UMS. Solo.

Astuti, A., A. Agus, and SPS. Budhi. 2009. The effect of high quality feed supplement addition on consumption and digestibility of early lactating dairy cows. Buletin Peternakan. Vol 34 June 2009.

Astuti, A., A. Agus, and SPS. Budhi. 2011. The effect of high quality feed supplement addition on production performance of early lactating dairy cows. Proceedings of International Conference on Sustainable Animal Agriculture for Developing Countries, SAADC.Thailand.

Direktorat Budidaya Ternak Ruminansia. 2010. Road Map Revitalisasi Persusuan Nasional. Direktorat Budidaya Ternak Ruminansia Tahun 2010-2014. Kementrian Pertanian. Jakarta.

Farid, M. and H. Sukesy. 2011. Pengembangan susu segar dalam negeri untuk pemenuhan kebutuhan susu nasional. Buletin ilmiah litbang perdagangan. Vol. 5. No. 2.

Kementrian Koordinator Bidang Perekonomian. 2014. Cetak Biru Persusuan Indonesia 2013-2025. Kementrian Koordinator Bidang Perekonomian RI. Jakarta.

Moran, J. 2008. Key performance indicators for indonesia's small holder farmers. Wartazoa Vol. 18. No. 2.

Siregar, SB. 2003. Peluang dan tantangan peningkatan produksi susu nasional. Wartazoa Vol. 13. No. 2.

Yusdja, Y. and IW. Rusastra. 2001. Industri agribisnis sapi perah nasional menantang masa depan. Forum Penelitian Agro Ekonomi.Vol. 19. No. 1:33-42.

Utilization of Agro-industrial by-product as protein sources for dairy cows

Phongthorn Kongmun
Department of Animal Science, Faculty of Agriculture, Kasetsart University, Bangkok, Thailand
Corresponding email: fagrptk@ku.ac.th

1. Introduction

Utilization of agro-industrial by-product for dairy cows in urgently required, to raise the competitiveness of Thailand's dairy cow production. Cattle producers frequently look for low-cost feed alternatives, especially when traditional feeds are expensive. Many of these alternative feeds are by-products and waste products from the processing of various foods from agro-industrial. These alternative feeds can fit into a feeding program as the primary roughage, as a supplement to a regular ration or as a replacement for part of the ration or roughage. Most Agro-industrial by-products have high moisture content and need to be dried and processed before being used by farmers. The high moisture content causes difficulties in storage, transportation and handling, which constrains the regular use of these materials as animal feed. Thus, to improve the utilization of agro-industrial by-product such as monosodium glutamate by-product (MSGB) as protein source for dairy cows concentrate diet was investigated

2. Monosodium glutamate by-product (MSGB)

Monosodium glutamate is used in the food industry as a flavor enhancer. The by-products from a MSG factory are rich in amino acids and nitrogen (N). Monosodium glutamate by-product (MSGB) was studied in various animals. For example, the addition of MSG in swine diet was studied to see effects on carcass quality. In cattle, effects on feed intake, growth rate, and carcass quality were studied. Keaokliang et al. (2012) supplemented MSGB in heifer diets. Those studies reported that MSGB could be used as protein in non-ruminant and non-protein nitrogen in ruminant animals.

Padunglerk et al. (2016) reported that MSGB contained 894 g/kg of OM, 106 g/kg of crude ash, 460 g/kg of CP and 5 g/kg of EE on a DM basis. For mineral composition of MSGB based on a DM basis, sulfur was the most common mineral (73.5 g/kg) followed by sodium chloride (22.6 g/kg) and potassium (6.64 g/kg). In terms of heavy metal, lead, arsenic, cadmium and mercury were not detected. The level of total amino acid was 91.8 g/kg on a DM basis as shown in table 1. Glutamic acid was the most common amino acid (47.9 g/kg on a DM basis) contained in MSGB.

Monosodium glutamate by-product was studied to use in cow diet on performance of lactating dairy cows. However, it was found that MSGB replacement for soybean meal at 20-60% in the feed for dairy cows presented on negative effects on their performances. In addition, it could decrease feed cost 2.9-17.3% and increase milk production profit up to 33.3% in the MSGB replacement for soybean meal at 60% (Padunglerk et al., 2016).

Due to the MSGB can use in ruminant diet and rich in crude protein. we investigated the effect of combination of MSGB with cassava pulp to use as protein source in concentrate diet. The combination contains 26-30% crude protein and substitution soybean meal with MSGB+cassava pulp up to 40% of DM in the diets of goats had no effect on the feed intake and ruminal fermentation patterns when compared to control treatment (unpublished data). Moreover, we also studied to improve rice straw quality by treated with MSGB for ruminant roughage. It was found that MSGB can improve qualities of rice straw in terms of increase crude protein up to 42.2% and increase *in sacco* dry matter digestibility when compare with 4% urea treated rice straw (unpublished data).

Table 1. Amino acid profile and concentration in MSGB on dry matter basis

Amino acids	**g/kg of MSGB**	**Amino acids**	**g/kg of MSGB**
Aspartic acid	11.8	Tyrosine	1.4
Threonine	2.1	Phenylalanine	1.9
Serine	1.9	Lysine	2.5
Glutamic acid	47.9	Histidine	1.4
Glycine	2.2	Arginine	2.2
Alanine	8.7	Methionine	0.5
Valine	0.9	Proline	0.5
Isoleucine	2.1	Crytine	0.5
Leucine	3.3	Total	91.8

Source: Padunglerk et al. (2016)

3. Future challenges

In further studies, MSGB is necessary to study on nitrogen utilization in ruminant, especially in rumen fermentation and the effect of glutamic acid contained in MSGB on ruminal microorganism population. Moreover, MSGB treated rice straw need to study for ruminant as roughage or total mixed ration (TMR) as a new high quality roughage.

References

Padunglerk, A., S. Prasanpanich, and P. Kongmun. 2016. Use of monosodium glutamate by-product in cow diet on performance of lactating dairy cows. Animal Science Journal. DOI10.1111/asj.12572.

Keaokliang O., S. Siwichai , P. Kongmun and S. Prasanpanich. 2012. Effects of monosodium glutamate (DSCL) by-product mix molasses replaced concentrates feed in Holstein Friesian crossbred heifers. The Proceeding of 50th Kasetsart University Annual Conference 1, 92-99.

Evaluation and utilization of rice as alternative feeds for dairy cows

Taketo Obitsu
Graduate School of Biosphere Science, Hiroshima University, Higashihiroshima, Japan
Corresponding Email: tobitsu@hiroshima-u.ac.jp

1. Introduction

Japanese dairy industries are characterized into two distinct regions: Hokkaido (the large northern island) and Tofuken regions (those other than Hokkaido). The Hokkaido region contributes about one-half of the total domestic milk production. Most of the milk produced in Hokkaido is used for processing of dairy products such as cheese and butter. In contrast, Tofuken region contributes to provide fresh milk for local consumers. This means that both regions have significant roles in suppling dairy foods for our healthy life. However, the number of dairy farmers and milk production, especially in the Tofuken region, is declining, because of higher production cost. Global fluctuation in cereal and forage prices raises feeding cost for livestock farmers depending on imported feeds. In fact, Japan's feed self-sufficiency ratio is calculated as 27% on total digestible nutrient basis (MAFF, 2015). To improve the low self-sufficiency of feed and to reduce production cost, Japanese government promotes increasing the production and utilization of domestic feeds. One of the strategies to improve feed self-sufficiency and to reduce feed cost is the utilization of rice as livestock feeds.

Rice crop byproducts such as straw and rice bran have been traditionally used as ruminant feeds. Recently, various types of feed rice have been developed to be used for whole-crop silage and grain sources. The information of the nutritive values of these feeds for ruminant production have been accumulated in the past few years.

2. Rice grain

Both unhulled rice grain and brown rice grain are used for dairy and beef production, although the crushing treatment is necessary for unhulled rice to improve digestibility. The preparation techniques of soft grain silage of unhulled rice have also been developed. For brown rice, the processing such as crashing, stem flaking and pelleting are also applied. The starch content of brawn rice is similar to that of corn grain. Unhulled rice has low starch and high fiber contents compared with brown rice. Ruminal starch degradability of rice grain is higher than in corn but lower than in barley and wheat (Enishi et al., 2000; Miyaji et al., 2010). For dairy cows, steam flaked brown rice can be used in mixed diets at the level of 30% of dry matter without adverse effects on milk production (Miyaji et al., 2012).

3. Whole-crop rice silage

Whole mature rice plants can be used as whole-crop silage. Harvested whole plants are chopped, baled and wrapped, then preserved as round bale silages. Nutritional values of rice silages prepared by the conventional cultivar are lower than those of grass or corn silages, because they have high lignin content and cause fecal loss of ingested paddy. To address these problems, new types of cultivars which have low-panicle and high leaf and stem proportion have been developed. This type has high sugar content in the stem and leaf. Paddy excretion is low due to the low proportion of panicle. The short panicle type shows higher fiber digestibility and less fecal paddy excretion, which contributes to higher energy content of the short panicle type silage.

4. Combination of silages and grains

The proportions and rates of ruminal degradation of dietary carbohydrates vary with different kinds of grains and crops. Thus, we tested the effects of combination of rice grain or corn grain and whole-crop rice silage or whole-crop corn silage on carbohydrate digestion and microbial protein synthesis in the rumen of steers (Li et al., 2014). As a result, we found that ruminal non-fiber carbohydrate digestibility for the diets containing rice grain or whole-crop rice silage was higher compared with that containing corn grain or whole-crop corn silage. However, ruminal total carbohydrate digestibility and the efficiency of ruminal microbial protein synthesis were not affected by the dietary combination, even though ruminal fiber digestibility and dry matter intake were slightly lower for the rice diets. These results indicate that the higher starch degradation of rice grain may affect ruminal fiber digestion.

Both grains and silages of corn and rice have relatively low protein content. Thus, optimum supply of protein and amino acids for these diets needs to be considered. To confirm a limiting amino acid in intestinal digestible amino acids, we tried to infuse methionine into the duodenum and to measure amino acid metabolism in the gastrointestinal tract and liver of steers. However, no difference in amino acid flux released by visceral tissues was observed between the corn and rice grain diets with or without methionine. Even in a more practical study, supplementation of methionine did not affect milk production and mammary arterial-venous differences of amino acids in lactating cows fed the rice grain or rice silage based diets.

Table 1. Comparison of milk production in dairy cows fed whole crop silage of corn or rice

	Corn silage	Rice silage
Composion of diets (%DM)		
Corn silage	35.7	10.2
Rice silage	-	20.9
Concentrates	43.7	45.2
Others	20.6	23.7
Dry matter intake (kg/day)	26.0	24.0
Milk yeild (kg/day)	38.0	39.0
Milk compostion		
Fat (%)	4.0	4.1
Protein (%)	3.4	3.3
Lactose (%)	4.6	4.6
Ethanol (μmol/L)	9.1	69.7

5. Alcohol in whole-crop rice silage

Whole-crop rice silage contains relatively higher amount of ethanol (about 5% of dry matter) compared with grass silage and whole-crop corn silage. Dietary alcohol is absorbed in the gastrointestinal tract and probably affects energy and amino acid metabolism in ruminants. Milk from cows fed whole crop rice silage contains a low concentration of ethanol (Table 1). We investigated the effects of ethanol on energy and amino acid metabolism under various nutritional conditions using sheep infused with ethanol into the rumen, as model studies. Ruminal ethanol infusion for sheep with restricted feed intake reduced glucose concentration but increased triglyceride and lactate concentration in the plasma. The reduction of plasma methionine concentration was also observed with ruminal ethanol infusion.

6. Future challenges

We need further studies to clarify the metabolic effect of alcohol produced in the rice silage and will provide the practical way for the efficient use of such alternative feed resources. In addition, we are also planning a more practical study in collaboration with local farmer organizations.

References

Enishi O, Terada F, Ishikawa T. 2000. Chemical composition and ruminal disappearance characteristics of grains for cattle feed. Grassland Science. 46: 305−308. (in Japanese with English abstract)

Li Z, Sugino T, Obitsu T, Taniguchi K. 2014. Effects of dietary combination of corn and rice as whole crop silage and grain sources on carbohydrate digestion and nitrogen use in steers. Animal Science Journal. 85: 127-134.

MAFF, Food Balance Sheet. 2015.

Miyaji M, Nonaka K, Matsuyama H, Hosoda K, Kobayashi R. 2010. Effects of cultivar and processing method of rice grain on ruminal disappearance characteristic. Japanese Journal of Grassland Science. 56: 13−19. (in Japanese with English abstract)

Miyaji M, Matsuyama H, Hosoda K, Nonaka K. 2012. Effect of replacing corn with brown rice grain in a total mixed ration silage on milk production, ruminal fermentation and nitrogen balance in lactating dairy cows. Animal Science Journal. 83:585-593.

Efficient use of roughage resource for sustainable development of China's dairy industry

Chong Wang[1,2], Jianxin Liu[1*], Huiling Mao[1,2], Diming Wang[1]
[1]*College of Animal Sciences, Zhejiang University, Hangzhou 310058, China*
[2]*College of Animal Science and Technology, Zhejiang A&F University, Hangzhou-Lin'an 311300, China*
Corresponding Email: wangcong992@163.com, liujx@zju.edu.cn

1. Introduction

One of main constraints for China's dairy industry is the shortage of the forage source. High-quality forages such as alfalfa hay for dairy cows is especially in short supply in China. In 2012, 460×10^6 kg of alfalfa hay had been imported from foreign countries, whereas only 100×10^6 kg was produced domestically. In the same time, it is estimated that more than 700 million tonnes crop straws are produced annually in China, and most of them are not reasonably utilized. Thus, how to use these forage resources efficiently is important for sustainable development of China's dairy industry.

2. Forage resources in China

Crop residues are the most abundant and widespread non-conventional feed resources. It is estimated that more than 700 million tonnes of crop residues are produced in China. Straw and stovers are the main crop residues, accounting for 84.8 %.

However, low content of nutrients and poor digestibility of most crop residues limit their efficient use in the diets for high-yielding animals. Currently, only about 31.9 % of the crop residues are used as feedstuff in China. Besides, 33.4 % of crop residues are used for fuel and fertilizer, 2.6% for paper industry and other 29.4 % are abandon or burn (Figure 1). There are enormous potential to improve the feeding value and increase the use of crop residues in animal feeding.

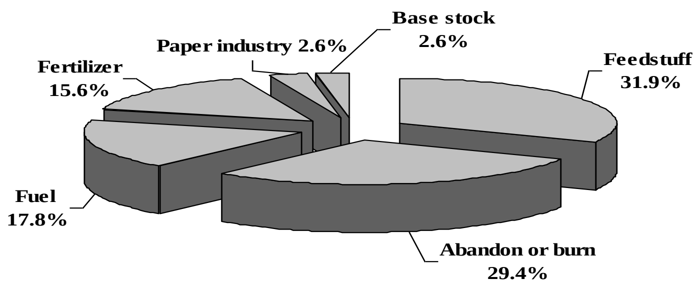

Figure 1. The utilization of the crop residues
（Source: Science and technology education department of Ministry of Agriculture）

3. Upgrading of forage sources for dairy cattle

Utilization mode of crop residues

The ammoniated straw increased more quickly than ensiled (11.4 vs. 20.7 %), but from the data of 2000 to 2006 it indicated that ensiling was more accepted than ammonia treatment (Figure 2).

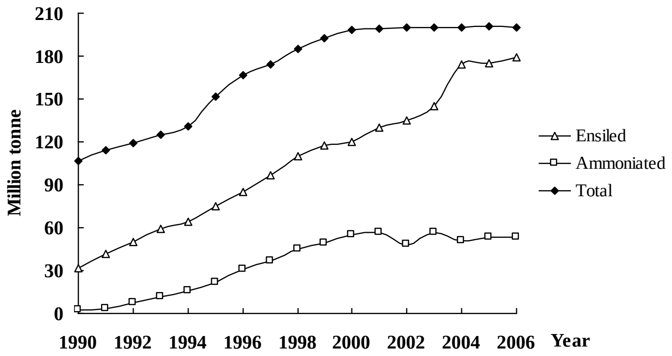

Figure 2. Quantity of crop residues used for animal feed in China during 1990-2006 (Department of Livestock Production, 2007)

Technology of ensiling and ammonia treatment

Use of silage additives

During the recent years, use of silage additives has been encouraged in China to ensure silage quality through promoting lactic acid fermentation, inhibiting undesirable microbes or improving its nutritional value. Commonly-used silage additives include bacterial cultures (Xu and Yu, 2004; Zhang et al., 2004), acids (Guo et al., 2000a; Zhang et al., 2002b; Shen et al., 2004), inhibitors of aerobic damage (Xi et al., 2002; Yang et al., 2004), and nutrients (Guo et al., 2000b). Cereal straws and stover are high in lignocellulose. A mixture of inoculum or enzymes containing cellulase and xylanase is often used (Zhang et al., 1997; Xing et al., 2004; Lv et al., 2005).

Ammonium bicarbonate as source of ammonia for pre-treatment

With regard to ammonia treatment, ammonium bicarbonate, with its abundant source and lower price, has been widely accepted, especially in southern provinces (Zhou et al., 1991; Liu et al., 1991, 1995; Xu et al., 1994). Treatment with ammonium bicarbonate at 5-15 %, N content was doubled, NDF content was decreased by 8 %, and rumen dry matter digestibility was increased by 14 %. Heifers consumed more dry matter from the treated rice straw even than from wild hay. Besides, ammonium bicarbonate was superior to urea in preventing mould in South China (Liu et al., 1990), for ammonia is released faster from ammonium bicarbonate than from urea, especially in warm seasons with high humidity.

4. Improvement of forage utilization in dairy cattle

Yeast culture to improve milk performance and rumen fermentation of forages

Yeast culture (YC) has been shown to improve lactation performance in a cost effective manner (Desnoyers et al., 2012). The YC contains residual yeast cells, fermentation metabolites and growth media.

The effects of YC addition have been evaluated on in vitro fermentation and microbial communities of low-quality forages (Mao et al., 2013). Total VFA reached peak at 1 g/L YC for rice straw and corn silage with or without grain, and increased linearly for corn stover (Table 1).

Microbial protein increased linearly with increasing level of YC for rice straw, while it reached peak values at 1 or 2 g/L YC for corn silage with or without grain, respectively. Fungi population was increased with 1 g/L YC for all forages except corn silage without grain. Population of *Ruminococcus flavefaciens* increased at 1 or 2 g/L YC for rice straw and two types of corn silages. Addition of YC can support ruminal fermentation of low quality forages with its stimulating effect on the number of functional rumen microbes, especially fungi populations.

Table 1. Effect of yeast culture on fermentation parameters and rumen microbials on low quality forage substrates.

Items	YC (g/L)				SEM	Effect[1]	
	0	1	2	3		L	Q
Rice straw							
Total VFAs (mmol/L)	14.9[ab]	19.6[a]	17.5[a]	10.1[b]	1.53	*	**
Ammonia N (mg/L)	80	89	83	105	7.2	ns	ns
Microbial protein (mg/ml)	3.09[b]	3.67[b]	4.03[b]	6.51[a]	0.672	**	ns
Corn stover							
Total VFAs (mmol/L)	18.7[b]	24.0[b]	26.9[ab]	37.8[a]	3.49	**	ns
Ammonia N (mg/L)	137[c]	202[a]	169[b]	153[bc]	8.9	ns	**
Microbial protein (mg/ml)	4.59	4.36	5.90	5.93	0.574	ns	ns
Corn silage without grain							
Total VFAs (mmol/L)	21.1[b]	27.8[a]	26.6[a]	16.7[c]	1.02	*	**
Ammonia N (mg/L)	142	127	158	137	7.8	ns	ns
Microbial protein (mg/ml)	6.76[a]	8.60[a]	8.68[a]	3.50[b]	0.568	**	**
Corn silage with grain							
Total VFAs (mmol/L)	23.7[b]	31.3[a]	25.9[b]	28.9[ab]	1.59	*	**
Ammonia N (mg/L)	201[a]	134[b]	147[b]	208[a]	11.1	ns	**
Microbial protein (mg/ml)	4.40[b]	5.80[a]	3.80[bc]	2.90[c]	0.257	**	**

[a-c]Means within a row with different superscripts differ ($P < 0.05$).

[1]L = linear; Q = quadratic.

* $P < 0.05$; ** $P < 0.01$; ns = not significant.

Supplementation with available energy source

Energy source available for the rumen microbial growth may be insufficient when corn stover is used as main forage, leading to a lower milk protein yield (Zhu et al., 2012). Starch as a major energy source in most feedstuff for dairy cows, accounting for 50 to 100% of non-structure carbohydrate (NRC, 2001), and an increased milk yield and nitrogen (N)-utilization efficiency may be expected with increasing non-structure carbohydrate intake, particularly corn starch, in lactating cows (Rius et al., 2010).

Zhu et al. (2013) found that supplementation of starch to the corn stover (CS) diet had a little lower milk efficiency than cows fed alfalfa hay (milk yield/DMI = 1.35 vs. 1.39), but the difference was not significant. It is inferred that the supplementation of readily fermentable carbohydrates, such as starch to a corn stover diet achieve a similar lactation performance as cows fed alfalfa.

Supplementation with amino acids

The Lys and Met are considered to be the most limiting AA for milk protein synthesis in dairy cows (NRC, 2001), and improving the balance of these AA is an effective approach to enhance milk protein production and improve milk protein synthesis efficiency (Cho et al., 2007; Wang et al., 2010).

Sun et al. (2013) investigated the effect of dietary addition of 2- hydroxyl-4-(methylthio) butanoic acid (HMB), a common source of supplemental Met, on milk production and rumen fermentation in dairy cows. There is a tendency to increase the contents of milk protein (3.12 vs. 3.07%) and fat (3.59 vs. 3.50%) and the yield of milk protein (0.94 vs. 0.88 kg/d) and 3.5% fat-corrected milk yield (30.47 vs. 28.58 kg/d) by addition of HMB. Addition of HMB significantly increased concentrations of rumen microbial protein and total volatile fatty acids. Populations of rumen fungi, *F. succinogenes* and *R. flavefaciens* relative total bacterial 16S rDNA increased with addition of HBM. Activity of carboxymethl cellulase was significantly higher by adding HMB.

With further supplementing rumen-protected AA (RPAA) on lactation performance of lactating dairy cows fed corn stover and starch (CSS) in comparison with alfalfa hay (AH), there were no significant effect on the 4% fat-corrected milk and milk efficiency (Zhu et al., 2013). The contents of milk protein, fat, and lactose were not different among the treatments. Ruminal ammonia N concentration for AH diet was lowers than for CSSAA. CSSAA diet resulted in a lower urea N concentration in the milk and blood than CSS, with a medium value for AH. There was no difference between CSSAA and AH on N conversion. It is suggested that RPAA supplementation would further improve the lactation performance and N utilization.

Other feed additives

Feed intake by dairy cattle does not increase as rapidly as the increase of milk production in the early lactation stage. Gamma-aminobutyric acid (GABA) has been shown to increase DMI in lactating sows. Addition of rumen-protected GABA increased DMI and NEL intake linearly, and milk yield quadratically in early lactation dairy cows. Anti-oxidative status was improved by GABA supplementation. The optimal addition level of rumen-protected GABA was at 0.8 g/d for milk production (Wang et al., 2013).

Maximized milk production and decreased environmental pollution have always been a challenge for dairy scientists. N-carbamoyl glutamate (NCG) is a synthetic product of sodium glutamate and considered as arginine raiser. The NCG has variable advantages over arginine. In our previous study (Chacher et al., 2012), the proportion of arginine and NCG degradation in rumen fluid for 24 h was 100.0% and 17.8%, respectively. Rapid degradation of ARG in rumen is a nutritionally wasteful process. Thus, ARG should be spared from rumen degradation, while

NCG could be fed to ruminant without need for coating. Furthermore, NCG is much cheaper than ARG. Supplementation of NCG to high yielding cows altered the plasma ammonia N, nitric oxide and improved the amino acid AA profile that is narrowly related to the AA supplies for milk synthesis, thereby improved the lactation performance and N utilization efficiency in high-yielding dairy cows. The optimal addition level of NCG was 20 g/d/cow (Chacher et al., 2013).

5. Concluding remarks

Grain-saving strategy for the animal agriculture and the crop residues-based animal production system promote the sustainable development of China's dairy industry. Ammoniated, ensiled crop residues and supplementations have great potentials for improving crop residues use by ruminants.

References

Chacher, B., D. M. Wang, H. Y. Liu, and J. X. Liu, 2012. Degradation of arginine and N-carbamoyl glutamate and their effect on rumen fermentation in vitro. Italian J. Anim. Sci. 11e68: 374-377

Chacher, B, W. Zhu J.A. Ye, D.M. Wang, J.X. Liu. 2013. Effect of dietary N-carbamoyl glutamate on milk production and nitrogen utilization in high yielding dairy cows (Abstract # 56069). Accepted for presentation at JAM 2013 (ADSA-ASAS) Indianapolis, USA.

Cho, J., T. R. Overton, C. G. Schwab, and L. W. Tauer. 2007. Determining the amount of rumen-protected methionine supplement that corresponds to the optimal levels of methionine in metabolizable protein for maximizing milk protein production and profit on dairy farms. J. Dairy Sci. 90:4908–4916.

Desnoyers M., M., S. Giger-Reverdin, G. Bertin, C. Duvaux-Ponter, and D. Sauvant. 2012. Meta-analysis of the influence of Saccharomyces cerevisiae supplementation on ruminal parameters and milk production of ruminants. J. Dairy Sci. 92:1620–1632

Guo, J. S., G. Y. Zhao, Y. F. Yang, and X. H. Kong, 2000b. Effect of sugar supplementation on the quality of barley silage and NDF and ADF degradation in the rumen of cattle. Chinese J. Anim. Sci. 36: 18-20.

Guo, J. S., G. Y. Zhao, Y. L. Feng, and X. H. Kong, 2000a. Effects of formic acid on the quality of barley silage and the *in sacco* digestibility of ADF. Chinese J. Anim. Sci. 36: 21-22.

Li. X.L., and L.Q. Wan. 2005. Research progress on Medicago sativa silage technology. Acta. Prataculturae Sinica 14(2): 9-15.

Liu, J. X., N. Y. Xu, Y. M. Wu, X. M. Dai and Y. G. Han, 1991. Ammonia bicarbonate as a source of ammonia for upgrading the feed value of rice straw. China Feed (Suppl.): 87-92.

Liu, J. X., X. M. Dai, A. G. Chen, N. Y. Xu, Y. M. Wu and Y. G. Han, 1990. Study on improving the feed value of cereal straws by treatment with ammonia. Treatment effect on fresh wheat straw. Zhejiang J. Anim. Sci. Vet. Med., 15: 1-3.

Liu, J. X., Y. M. Wu and N. Y. Xu, 1995. Effects of ammonia bicarbonate treatment on kinetics of fibre digestion, nutrient digestibility and nitrogen utilisation of rice straw by sheep. Anim. Feed Sci. Technol., 52: 131-139

Lv, J. M., W. L. Hu, and J. X. Liu, 2005. Addition of cell wall degrading enzyme and wheat bran on fermentation characteristics and in vitro gas production of ensiled rice straw. J. Anim. Feed

Sci. 14: 365-372
Mao, H. L., H. L Mao, J. K. Wang, J. X. Liu, and I. Yoon, 2013. Effects of *Saccharomyces cerevisiae* fermentation product on *in vitro* fermentation and microbial communities of low-quality forages and mixed diets. J. Anim. Sci. (accepted)

NRC. 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed. Natl. Acad. Sci., Washington, DC.

Rius, A. G., J. A. D. R. N. Appuhamy, J. Cyriac, D. Kirovski, O. Becvar, J. Escobar, M. L. McGilliard, B. J. Bequette, R. M. Akers, and M. D. Hanigan. 2010. Regulation of protein synthesis in mammary glands of lactating dairy cows by starch and amino acids. J. Dairy Sci. 93:3114–3127.

Shen, Y. X., Z. G. Yang, X. B. Liu, 2004. Effects of wilt and organic acid addition on silage quality of Italian ryegrass. Jiangsu J. Agric. Sci. 20: 95-99.

Wang, C., H.Y. Liu, Y.M. Wang, Z.Q. Yang, J.X. Liu, Y.M. Wu, T. Yan and H.W. Ye. 2010. Effects of dietary supplementation of methionine and lysine on milk production and nitrogen utilization in dairy cows. J. Dairy Sci. 93, 3661-3670.

Wang, D. M., C. Wang, H. Y. Liu, and J. X. Liu, 2013. Effect of rumen-protected GABA on feed intake and milk performance of early lactating dairy cows. J. Dairy Sci. (in press)
http://dx.doi.org/10.3168/jds.2012-6285

Wang, J. Q. 2011. Five key indicators leading the direction of China dairy industry. China Anim. Husb. Vet. Med. 38 (2): 5-9.

Xi, X. J., L. J. Han, S. I. HARA, and A. Masahiro, 2002. Effects of hydrochloric acid and caproic acid on quality of corn stover silage. J. China Agric. Univ. 7: 54-60.

Xing, L., L. J. Han, Y. M. Cai, and M. Amari, 2004. Effects of lactobacillus and cellulase addition on the fermentation quality of corn stover silage. Grassland Sci. 50: 434-435.

Xu, N. Y., J. X. Liu and Y. M. Wu, 1994. Studies on ammonia bicarbonate treatment of rice straw: effects of ammonia level, moisture content, treatment time and temperature on straw composition and degradation in rumen of sheep. Chn. J. Anim. Nutr. 6: 10-15.

Xu, Q. F. and Z. Yu, 2004. The effects of inoculated lactobacillus on alfalfa silage fermentation quality. J. Shanxi Agric. Sci. 32: 81-85.

Yang, F. Y., H. Zhou, J. G. Han, and Y. W. Zhang, 2004. The effect of formaldehyde additives on sweetclover silage quality. Grassland China 26: 39-43, 56.

Zhang, J. G., K. Sumio, F. Ryohei, and Y. K. Fu, 1997. Effects of lactic acid bacteria and cellulase additives at different temperatures on the fermentation quality of corn and guineagrass silages. Acta Prataculturae Sinica. 6: 66-75.

Zhang, T., Z. J. Cui, L. J. Gao, W. Q. Kang, X. F. Wang, and Y. G. Hu, 2004. The effect of fermented green juice and silage inoculant bacteria MMD3 on the fermentation of Alfalfa silage. J. China Agric. Univ. 9: 32-37.

Zhang, W. J., J. Q. Wang, Y. S. Gong, X. H. Yan, and J. R. Sang, 2002b. Effects of formic acid on quality of whole corn silage. China Dairy 5: 27-29.

Zhou, Y. J., P. Y. Guo, Z. H. He, N. L. Tan, and L. J. Han, 1991. New ammoniation technology of straw by quick thermo-decomposing ammonium hydrogen carbonate. J. Beijing Agric. Engineer. Univ. 11: 72-79.

Zhu, W., Y. Fu, B. Wang, C. Wang, J.A. Ye, Y.M. Wu and J.X. Liu. 2013. Effects of dietary forage sources on rumen microbial protein synthesis and milk performance in early-lactating dairy cows. J. Dairy Sci. 96, 1727-1734.

Zhu, W., C.H. Tang, X.P. Sun, J.X. Liu, Y.M. Wu, Y.M. Yuan, X.K. Zhang. 2013. Effects of starch and rumen-protected amino acid supplementation on rumen microbial protein synthesis and milk performance in lactating dairy cows fed corn stover (Abstract # 56638). Accepted for presentation at JAM 2013 (ADSA-ASAS), Indianapolis, USA.

Sun, H, Y.M. Wang, K.J. Zhu, Y.B. Zhou, B.C. Zheng, C. Wang, Y.M. Wu, J.X. Liu. 2013. Effects of addition of *Aspergillus oryzae* culture and 2-hydroxyl-4-methylthio butanoic acid on milk production and rumen fermentation in lactation dairy cows (Abstract # 56106). Accepted for presentation at JAM 2013 (ADSA-ASAS), Indianapolis, USA.