Building Bridges, Supporting Livelihoods

Asia Dairy Network

Asian Milk for Health and Prosperity

The feeding of by-products on small holder dairy farms in Asia and other tropical regions

Final report of E-Conference held in November-December 2013

Summarised by

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Agriculture and Consumer Protection Department
Animal Production and Health

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
for a world without hunger

Photographs on front cover (provided by Dr Moran from Australia):
Left: Densified feed blocks based on molasses and protein meals (Indonesia)
Right: Corn stover from the lowlands is sold to dairy farmers in the highlands of East Java

ACKNOWLEDGMENTS

This volume is based on the contributions received during the four week E-Conference on the feeding of by-products on small holder dairy farms in Asia and other tropical regions. The conference was held under the auspices of Asia Dairy Network supported by the Animal Prouction and Health Commission for Asia and the Pacific (APHCA). Dr Vinod Ahuja (FAO Regional Office for Asia and the Pacific, Bangkok) and Dr Harinder Makkar (FAO, Rome) provided necessary program and technical support. Prof Krishna prepared a discussion paper which provided much useful basic information. Their support and contribution is gratefully acknowledged.

A total of 530 participants from at least 33 countries registered for the e-conference. All the tropical regions of the world were represented with 15 countries from South and East Asia, 4 from Africa, 2 from Central and South America, and 2 from the Middle East. In addition, there were 10 countries from Europe, America and Australasia represented, many of which have active development programmes in the tropical dairy industries. There was also a wide range of professionals involvement in tropical dairy farming, such as practicing veterinarians with farm manager duties to university teachers and scientists through to consultants (who were often retired government advisers and administrators) and dairy advisers from many government and non-government organisations (NGO). Their inputs led to considerable discussion and many useful practical conclusions about the feeding of by-products and other aspects of herd management on tropical dairy farms. I take this opportunity to profusely thank all the participants and contributors for theit active participation and generous contributions.

The initial establishment of the communication systems and advising the potential participants throughout the world was organized by technical specialists in FAO in Rome who are also thanked for their expertise.

John Moran

EXECUTIVE SUMMARY

The major constraints to tropical dairy production are the lack of good quality feeds and the limited ability of farmers to source, formulate and supply the feed nutrients for their dairy herd to achieve target milk yields that are realistic of their dairy herd's potential.

During a 4 week period in November/December 2013, an E-Conference was conducted under the auspices of the Asia Dairy Network of the Animal Production and Health Commission for Asia and the Pacific (APHCA) in collaboration with the FAO Animal Production and Health Division. The E-Conference was entitled "Role of agro-industrial and forestry by-products in the feeding of dairy animals in Asia and other tropical regions" and was moderated by Dr John Moran, the coordinator of the Asia Dairy Network. It provided an opportunity for researchers and development workers in government and non-government agencies and private sectors, with an interest in dairy farm development, to share their knowledge and experiences in feeding management (sourcing, storage, processing and feeding) of agro-industrial and forestry by-products to dairy cattle and buffaloes.

The E-conference process

The programme was split into 4 weekly segments to focus on different aspects of by-product feeding management. These were energy-rich by-products, protein-rich by-products, fibrous by-products and the handling and storage of by-products. In addition, the program covered many topics related to dairy cow nutritional and herd management and factors affecting adoption of improved feeding and herd management practices (such as cow breeding and calf rearing) in addition to the key topics of by-product sourcing, storage and feeding to dairy stock.

A total of 530 participants from at least 33 countries registered for the e-conference. All the tropical regions of the world were represented with 15 countries from South and East Asia, 4 from Africa, 2 from Central and South America, and 2 from the Middle East. In addition, there were 10 countries from Europe, America and Australasia represented, many of which have active development programmes in the tropical dairy industries. There was also a wide range of professionals involvement in tropical dairy farming, such as practicing veterinarians with farm manager duties to university teachers and scientists through to consultants (who were often retired government advisers and administrators) and dairy advisers from many government and non-government organisations (NGO). A total of 288 contributions were received during the 4 week E-Conference. During the final week, each participant was sent an evaluation form seeking details of their assessment of the E-Conference process, with a total of 39 completed forms received. Over 78% of these respondees considered the conference subject matter to be very relevant to their needs.

Energy-rich by-products

A great diversity of energy-rich by-products were discussed ranging from bread and other human food wastes, to rice, cassava and maize by-products through to fruit wastes, oil seed cakes and vegetable oils. Mulberry fruit waste mixed with water can be used as an alternative to molasses, a common constituent of urea feed blocks. Urea molasses blocks are primarily used as feed supplements for high yielding milking cows with production responses often resulting from the molasses and minerals incorporated into the blocks, rather than the urea. There is an urgent need for these blocks to be based on well balanced and more cost-effective formulations.

Protein-rich by-products
A great diversity of protein-rich by-products, ranging from brewers and distillers grains, copra and palm kernel cakes, through to fish waste, high protein tree leaves and grasses and Azolla were discussed. Azolla has the potential to provide protein in flood prone areas but its very low dry matter content limits its potential to small holder farmers. Protein meals can be protected by formaldehyde or through heat treatment to reduce their protein degradability. However formaldehyde has health risk and environmental implications while heat treatment is too costly for farmers. Instead, naturally protected protein sources such as meals of oilseeds and feeds of animal origin should be used as bypass protein source if required.

Instead of costly chemical and physical treatments to render dietary protein undegradable, it will be more appropriate for low to medium milk producing cows to balance the rumen through less expensive locally available feeds for maximum microbial growth. For high producing cows (>15 L/cow/day), intestinal supplies of amino acids from microbial protein alone may not be adequate and will then require undegradable protein supplement to complement their intestinal protein supplies. The cows should be fed according to their target milk yield to avoid overfeeding of low producers and underfeeding of high producers. This will not only reduce the cost of feeding but it will also improve their productive and reproductive performances with reduced emission of greenhouse gases.

Fibrous by-products
Asia is the highest producer of crop by-products contributing to about 46% of the total world production. Hence Asian animal nutritionists have paid more attention for improving the nutrient value of crop residues including by-products than those in other geographic locations.

The technology of chemical treatment of cereal straws has been established from several decades. However its adoption has been very slow. Treating straw with urea just to improve its digestibility seems to be mostly a waste of time, when we can easily feed urea and sugar to the animal and thereby improve the digestion of straw within the digestive tract.

Chemical and biological treatment of low quality forages and by-products is very labour intensive and cumbersome while farmers prefer not to use anything they could consider a corrosive chemical. Good milk responses to such treatments infrequent because they depend largely on the other ingredients of the milking ration, which are all too often nutrient deficient.

There should be increased efforts to select cultivars of cereal grain that produce better quality straw without comprising on grain yield. Searching for grains and oilseeds with low anti-nutritional factors is another area that requires joint efforts by animal nutritionists and plant breeders.

Despite legislations imposed, such as by Punjab State Government in India, on the burning of straw stubbles and other crop residues, farmers consider burning as the easiest and the most economical method to dispose of their rice straw; in Punjab more than 80% is burnt. Rather than burning, rice straw can be utilized by mulching in the field, composting with animal excreta and used as organic manure, pulp and paper industry, power generation, fuel for furnaces and gasifiers, building material, mushroom cultivation or as livestock feed.

Straw feeding is not at all advisable for the medium or high yielding dairy cows. For these types of animals, green grass of good digestibility is a must. Therefore straw feeding to the low milk producing animals in small holders should be supplemented with green grass or tree forages, preferably legume forage and for the medium to high yielder cows substituted with green grass.

Handling and storing by-products

Fruit, fish waste, vegetables and root crops are increasingly integrated into tropical farming systems and provide a wide range of valuable wet by-products and residues which are often underutilized or wasted. The ensiling of such by-products is a simple conservation method and the most effective way to improve animal feed resources through the rational use of such potential feedstuffs to small holder farming. The major problems usually encountered are the seasonality of supply and their high moisture content. High moisture by-products often have high nutritive value. It is difficult and expensive to dry them so all too frequently such by-products often become contaminating wastes that quickly go sour, moldy and lose much of their soluble nutrients as effluent.

With dry by-products, damage from rain, fungal and reptiles can amount to 45% even in hay stacks on a raised platform to avoid rats and termites and ground heat. When storing moist straw, urea spraying, covering the stack with polythene, building sheds or stacking it on raised platform can reduce the magnitude of damage but farmers have been slow to adopt these methods.

Straw treatment has failed to create popularity at the farmers' level for the many reasons mentioned above. Therefore instead of treatment, alternative use of straw should be given preference, say for example, use in densified feed blocks or even supplementation with legume forages etc. However, ultimately we have to reduce gradually the inclusion of straw in the dairy ration and encourage the use of alternative better quality fodders.

Challenges and possible solutions to technology transfer

Research or technology development should not only be technically sound but also economically beneficial to producers and adoptable by animal owners, most being small holders or resource poor. Most extension training programs to date cover the communication aspect but never follow up with assessing behavioral changes in farmers for adoption. This requires continuous and strong technical backup visits to farmers after training which unfortunately is frequently missing in many of our extension systems. Once trained, farmers are all too often left on their own and seldom revisited.

Aspects of management of tropical dairy systems

This section of the E-Conference led to considerable spontaneous discussions about practical aspects of feeding and managing tropical dairy cows. Much of it related to providing quality forages throughout the year, such as during the wet season in flood prone areas where the only forage available is rice straw stored from the previous dry season's crops. Associated with these nutrient imbalances and deficiencies was poor reproductive performance, commonly expressed as repeat breeding. Some development workers considered that "the answers to many of these concerns" were already available but the problem was a communication breakdown between researchers, advisers and farmers.

Other topics of discussion included the potential for hydroponics to produce cost effective quality rations for dairy small holder farmers, the problem of encouraging farmers to keep better herd records through to the appalling management systems of buffaloes and their calves in parts of Pakistan. Slaughter of week old heifer calves and using oxytocin and growth hormone to stimulate milk production and let down seems incomprehendable in modern day tropical dairy production, but it is occurring.

Making silage in old water tanks, where the forage is placed and compacted by a group of farmers for several hours (Photos provided by Dr Inglesias from Cuba)

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INTRODUCTION

The major constraints to tropical dairy production are the lack of good quality feeds and the limited ability of farmers to source, formulate and supply the feed nutrients for their dairy herd to achieve target milk yields that are realistic of their dairy herd's potential. Their dairy herds are made up of adult milking cows (both lactating and non-lactating), young stock (both milk fed and weaned heifers) and male stock destined for breeding or sale for slaughter.

The feed base for the herd comprises forages specifically grown for the dairy animals; high energy and/or high protein concentrate supplements including agro-industrial and forestry by-products, other agro-industrial by-products such as crop residues, mineral and vitamin additives. There is a wide range of available co-products/by-products and this E-Conference aimed to discuss their nutritional value, feeding, sourcing, storage and processing. When selecting the most appropriate by-products, farmers should be able to compare them in terms of costs per unit of feed nutrient when delivered to the feed trough. This takes into account the costs of purchasing, transport, storage and preparation of feed for feeding the animals. Many by-products are not readily available year-round so need to be purchased when at their cheapest then stored until required. A number of these by-products have anti-nutritional and toxic factors which impose a challenge in feeding them. These then require simple, robust and economically viable processing techniques to make them a good feed. Throughout the world, farmers, feed merchants and farm service providers have a wide range of experiences in these aspects of incorporating by-products into dairy feeding systems.

To learn from these experiences, the Asia Dairy Network of the Animal Production and Health Commission for Asia and the Pacific (APHCA) in collaboration with the FAO Animal Production and Health Division conducted an E-Conference entitled "*Role of agro-industrial and forestry by-products in the feeding of dairy animals in Asia and other tropical regions*" during November and December 2013. This was a stock-taking exercise describing the current status and analysing the reasons why by-products are and are not incorporated into dairy feeding systems, how to convert unconventional by-products to conventional ones and draw conclusions for the future. The focus was on developing countries and covered both cattle and buffaloes but not sheep, goats and camels. It is also noted that co-products and by-products have the same meaning for the purpose of this E-Conference.

The E-Conference was moderated and provided an opportunity for researchers and development workers with an interest in dairy farm development in the government, NGO and private sectors to share their knowledge and experiences in feeding management (sourcing, storage, processing and feeding) of agro-industrial by-products to dairy cattle and buffaloes.

The entire 288 contributions have been documented in chronological order in a report " Daily contributions to the E-conference on the Role of agro-industrial and forestry by-products in the feeding of dairy animals in Asia and other tropical regions, 11 Nov to 10 Dec 2013" freely available on the Dairy Asia website (www.dairyasia.org).

THE E-CONFERENCE PROCESS

The E-Conference was moderated by Dr. John Moran, Coordinator, Asia Dairy Network. Participation in the E-conference required membership of Asia Dairy Network. Each registered participant received an electronic copy of the review "An inventory of agro-industrial and forestry by-products and an overview of their nutritional traits" prepared by Prof. N. Krishna (Former Dean and Professor & Head, Department of Animal Nutrition, College of Veterinary Science, ANGR Agricultural University, Hyderabad, India). In addition, the participants were encouraged to consult following publications which could be downloaded from www.dairyasia.org

- Utilization of fruit and vegetable wastes as livestock feed and as substrates for generation of other value added products
- Smallholder dairy development in Asia and the Pacific

The E-Conference ran over 4 weeks, from 11 Nov to 10 Dec 2013, and was split into four 7-day periods during which time participants were asked to restrict their comments to specific aspects of by-product feeding.

- Week 1 (11 to 17 Nov), Energy-rich by-products fed to dairy animals
- Week 2 (18 to 24 Nov), Protein-rich by-products fed to dairy animals
- Week 3 (25 Nov to 1 Dec), Fibrous by-products fed to dairy animals
- Week 4 (2 to 8 Dec), Handling and storing by-products for feeding to dairy animals plus any other topic relevant to the E-Conference

The expected outputs included:

- Documentation of the current status of feeding management practices in dairy cattle and buffalo production systems in developing countries
- Documentation of the current and potential status of the use of the by-products in the feeding of such dairy systems
- Mapping of the by-products, their nutritive values, and milk responses to their feeding.
- Guidelines to assist developing countries make informed decisions about the adoption of appropriate by-products and technologies.
- A plan of action to enhance the feed resource base by enlarging number of agro-industrial and forestry by-products that can be used as feed, reducing their wastage, and increasing efficiency of their use

Participants were encouraged to:

- Identify agro-industrial by-products that are currently being used in dairy production systems
- Identify agro-industrial by-products with the potential for use in dairy production systems
- For each by-product, identify current methods for their sourcing, storing, processing and feeding, highlighting any constraints limiting their impact in dairy herd management and farm performance
- Provide insight into ways to overcome such constraints
- Discuss what lessons have been learnt when overcoming such constraints
- Describe first hand experiences in by-product feeding management that may be relevant to the audience of the E-Conference

A checklist before submitting a message

Before submitting a message, participants were requested to ensure that:

- The message only considered the issues discussed in a particular week of the E-Conference.
- The message, including contribution to by-product technology/practice was no longer than 600 words
- It followed the basic rules and guidelines for participation in the E-Conferences
- Each participant included his/her name and country of residence in any message sent for the discussion
- Participants should not send unfounded, defamatory, obscene, violent, abusive, commercial or promotional messages or materials, or links to such materials
- Each participant was legally responsible, and solely responsible, for any materials, or links to any materials sent
- Participants were courteous at all times and exercised tolerance and respect toward other participants whose views may differ from their own
- The subject header of the message described the content

The participants were provided with the 4 week program of proposed discussion (presented above) to give them some guidance as to when to submit their messages. However in many cases this was not followed closely, meaning that there were often quite a few "conversations" going on simultaneously. In addition, the messages often did not follow the main theme, that is the role of by-product feeding in tropical dairy systems. In other words, the program covered many topics related to dairy cow nutritional and herd management and factors affecting adoption of improved feeding and herd management practices (such as cow breeding and calf rearing) in addition to the key topics of by-product sourcing, storage and feeding to dairy stock.

The Moderator made several attempts to ask the participants to try and limit their messages specifically to by-product utilisation, but because this topic covers such a wide range of technical disciplines, some of the conversations meandered to the many aspects of herd management influenced by feeding practices.

This was not necessarily a bad thing because it highlighted the importance of nutrient intakes on dairy herd performance and farm profitability. The many complimentary comments about the E-Conference that were included both in the messages and the formal evaluation process over the last few days of the E-Conference. This clearly indicated that the participants were happy with the way the conference evolved over the four week period.

Participants and their countries

There were 530 participants who came from at least 33 countries, as identified by the addresses from contributors or the country codes when incorporated into the email addresses of the participants. However this was only possible for 212 participants so the countries of origins were unknown for 318 participants. Of these, over 50% of the identifiable participants (50.7%) came from Indonesia, with nearly 10% (9.5%) from Thailand and India. There was obviously an effective promotion of the E-Conference by Indonesian government and agribusiness. Representatives from several other countries were identified from the Questionnaire and other general emails to the Moderator.

All the tropical regions of the world were represented with 15 countries from South and East Asia, 4 from Africa, 2 from Central and South America, and 2 from the Middle East. In addition, there were 10 developed countries from Europe, America and Australasia represented, many of which have active development programmes in the tropical dairy industries. Details of each country grouping were:

South and East Asia (15); India, Indonesia, Bangladesh, Pakistan, Thailand, Philippines, Sri Lanka, Vietnam, Nepal, Laos, Myanmar, Malaysia, Japan, South Korea, China
Africa (4); Nigeria, Mauritius, Ethiopia, Sudan
Central and South America (2); Cuba, Brazil
Middle East (2), Iraq, Yemen
Australiana (2); Australia, New Zealand
Europe (6); United Kingdom, Italy, France, Netherlands, Portugal, Switzerland
North America (2); United States, Canada

There was also a wide range of professionals involvement in tropical dairy farming, such as practicing veterinarians with farm manager duties to university teachers and scientists through to consultants (who were often retired government advisers and administrators) and dairy advisers from many government and non-government organisations (NGO).

Contributions
A total of 288 contributions were received during the 4 week E-Conference. The weekly contributions from participants varied from 58 to 90 with up to 28 submitted on one single day. There were 22 countries from where the contributors came. The Indian participants contributed 43% of them, the Bangladesh 22% with the remaining 36% originating from the other 20 countries.

Although it was worrying to see how many of the participants expressed concern over the lack of adoption of improved management practices (this will be discussed in more detail later in this report) but it was also encouraging to find some novel practical innovations that drew further discussion. One such example was the feeding of raw eggs to milking cows in early lactation which provided stimulation to their subsequent reproductive performance. There were some good practical suggestions such as using old water tanks as “ring silos”, and incorporating combinations of wet and dry by-products in blended silage mixtures through to using mulberry fruit slurry to replace molasses in urea liquid mixtures or feed blocks. Several participants asked specific questions which received virtually instantaneous answers from nearby neighbours, such as within Bangladesh, a discussion on an example herd management recording card.

It was also very pleasing to note that many "behind the scene" dairy professionals, particularly those not with English as their mother tongue, contributed to the discussion. One of the major benefits of this E-Conference has been the receipt of feedback from the "real hands on people" namely those that lived in their working boots and durable work clothes on a day to day basis following on from their more formal, technical training in their early post-secondary school days.

This rather open and relaxed programme provided some participants with the confidence to express their opinions, often not in their mother tongue, in a world-wide forum on many general aspects of their work such as looking towards “keeping the take home messages simple” for the small holder farmers who largely depend on tradition and their next door neighbour for “new ideas” in their day to day management farming practices. There were many contributions expressing this concern.

The information profile

We could generalise by saying, the research scientists are the *information generators*, the tertiary teachers are the *information disseminators* while the practicing farm managers, veterinarians and other service providers (including those in the technology transfer profession) while support staff for the farmers are the *information assessors*. Only since the advent of e-information are we starting to hear more about whether this information achieves its major objectives, that is to improve the productivity, profitability and sustainability of all of those we work for and the only ones who "put their money where their mouth is", the ultimate *information users*, namely the dairy farmer, whether he milks 2, 10 or 100 cows. E-Conferences are then the new "best way" to assess on a large scale, how effective we all are in our profession or more simply, how good we are at our jobs.

The fact was that for four weeks we were able to communicate directly with over 500 of the world’s tropical dairy nutrition specialists, farm managers and extension workers. Rarely is there such a combined brain power on which to draw to ask and receive often instantaneous answers to virtually any question related to dairy cow feeding and herd management.

Evaluating the E-Conference

During the last week of the E-Conference, all 520+ participants were sent a questionnaire seeking details of their assessment of the E-Conference process. The questions were:

1. From what country do you come?
2. How would you describe your profession in the dairy industry?
3. Did you actively contribute to the E-Conference with a question or comment?
   Yes, No
4. How did you find the subject matter of the E-Conference?
   Very relevant, Relevant, Not so relevant
5. Internet accessibility
   Easy Internet access, Sometimes/slow/difficult, no Internet access
6. Do you have any future topics for E-Conference, on some aspect of dairy farming?
7. Do you have any additional comments/suggestions for improvement of the E-Conference process?
8. *This is an optional question to answer.* Would you tell us to your name, location address and email address?

Answers to the evaluations is based on 39 returned questionnaires

1. ***Country***; India (10), Bangladesh (8), UK(3), Pakistan (2), Indonesia (2), Australia (2), Netherlands, Yemen, Sri Lanka, Cuba, Iraq, Thailand, Sudan, Philippines, USA
2. ***Profession***; Research scientist (15), Uni lecturer/professor (7), Consultant (8), Development worker (6), Extension worker (4), Teacher (2), Milk processor (1)
3. ***Active contributor***; Yes (27), No (12)
4. ***Subject matter***; Very relevant (29), Relevant (9)
5. ***Internet access***; Easy access (33), Sometimes difficult (5)
6. ***Suggested future topics***; see below
7. ***Additional comments***;

The conference was very well organised
This E-Conference was a good model to follow
Maybe there were too many topics discussed at this E-Conference
Regularly remind people of topics to be covered each week
We want pdf or Word document of the entire list of daily contributions
Make sure all requests for sourcing information are met
Use alternative media to emails.
Consider an E-Conference participation certificate
The E-Conference should run longer than 4 weeks
Representatives from more countries should be specifically invited
More scientists should be involved
More editing and less verbiage
More economic assessments of technologies being proposed
Develop a "Country Champion" network to help promote and coordinate future E-Conferences within each country

The diversity of suggested future topics were:
Specific nutrition topics

- Metabolic disorders and clinical nutrition of dairy stock
- Strategic feeding of livestock to reduce methane production
- Precision feeding of dairy stock
- New innovations (and interventions) in dairy nutrition
- Mineral nutrition of dairy stock
- Silage production
- Use of "top" feed (flowers, leaves, seeds) for dairy feeding
- Dairy/feed engineering

Herd management

- Reproductive management (6 requests)
- Young stock management (5 requests)
- Rearing dairy stock at the poor producer's doorstep
- Genetic upgrading of indigenous dairy cows
- Genetics and selection for dairy production
- Parasite infections
- Cattle health card for developing countries and other relevant topics for small scale farmers
- Quality milk production

General dairy farming

- Dairy farming in the hot humid tropics
- Small holder dairy production and marketing
- Steps to progress from a small scale to a large scale farmer
- Good Farming Practices for milk production
- Dairy farming and processing for resource-poor farmers
- Sharing business development models in dairy farming
- Causes of climatic change
- Rural milk processing

Miscellaneous topics

- Objectives, Processes of Planning and Implementation of Livestock Research and Extension' in developing countries
- Small ruminant production in developing countries

Baby corn from specialized sweet corn (maize) plants harvested early, while the ears are very small and immature (Photos provided by Habib from Pakistan)

SYNTHESIS OF THE E-CONFERENCE

In the following sections, continual references are made to contributors of messages to the E-Conference. In addition to the name, and sometimes location, the message number (#) of their contribution is included in the text. Appendix 1 provides the contact email address of the key contributors.

1. Energy-rich by-products

These include mostly by-products obtained after subjecting the major cereal grains to milling industry. Grain is separated and used for human consumption mostly and a part is also used for feeding animals as medium source of energy. They also include a diversity of by-products with energy levels sufficiently high as to allow for the replacement of formulated concentrates, a common source of energy and protein for dairy stock.

These by-products obtained from processing of grains, pulses and fruits serve as the major energy sources for feeding cattle and buffaloes in Asia and other developing countries. They are rich in B-complex group of vitamins besides energy with moderate protein content. They also provide bulk in the concentrate mixture and keep the feed particles dispersed during digestion in the gastro-intestinal tract.

They are important since they serve as energy and/or protein sources in many of the developing countries. They play an important role in reducing the cost of compound feeds (formulated concentrates) due to their higher inclusion rates as they are available in considerable amounts. These resources are region specific with seasonal availability. Some of these resources are bulky and hence need suitable processing prior to their optimum use.

The high requirements of milking cows for energy and protein have resulted in considerable global competition for ration ingredients with humans and other monogastric livestock. The high costs of cereal grains and other high energy, high protein feeds has created growing interest in sourcing agro-industrial and forestry by-products for feeding dairy stock. The small holder nature of the majority of tropical dairy farmers means that they frequently neither have the resources or the purchasing power to access nor store large quantities of animal feed stuffs. Consequently they are very dependent on the current vagrancies of the market place, such as costs and availability, to provide their stock with sufficient amounts of quality feed nutrients to achieve sustainable levels of cow performance. This is particularly the case with energy supplements.

The diversity of energy-rich by-products

There was a wide range of energy-rich by-products discussed in this E-Conference as listed below:

- Food waste which includes the traditional market rubbish such as vegetable and fruit trimmings; fish and poultry visceral, as well as out-of-specification (usually past the use by date) human food waste
- Waste bread (when the bread is unfit for human consumption) and bread waste (the residue/excess material available during bread making)
- Spent sugar syrup

- Rice gruel
- Tofu waste
- Whole *Prosopis juliflora* pods powder
- Mulberry fruit waste, which when mixed with water can be used as alternative to molasses
- Other fruit waste such as pineapple
- Citrus pulp
- Pineapple waste, which includes the skins (outer peels), crowns, buds, cores, waste from fresh trimmings and the pomace of the fruit from which juice is extracted
- Rice bran
- Sugar cane tops (although this would be considered by many as a fibrous rather than energy-rich by-product)
- Groundnut shells
- Sugar cane waste, which is the young shoots of sugarcane plants which are usually cut off by farmers to reduce the number of polls within a bunch of growing plants
- Sugar cane juice
- Residues from cassava processing
- Extracted juices from other forage crops such as Napier grass and sorghum
- Molasses
- Soybean hulls
- Sugar beet pulp
- Stillage, which is a distillation by-product containing the liquid remains after yeast fermentation and distillation of molasses for alcohol production
- Condensed distillers solubles results from evaporation of the stillage
- Shea (*Butryospermum parkii)* fruit residue. The green fruit of the tree is harvested and the oil extracted with the residue available for livestock feeding. The byproducts are sheanut cake, and after the oil extraction, expeller and solvent extraction residue
- Tamarind seed meal
- Mango seed kernel meal
- Reject bananas
- Banana stems and leaves
- Baby corn picks which are the stover from the "baby corn" which is harvested from specialized sweet corn (maize) plants, while the ears are very small and immature. These baby corn ears are hand-picked as soon as corn silks emerge from the ear tips or a few days after.
- Sweet corn stover, the residue after the cobs have been harvested for sweet corn
- Sweet corn trash, which is the by-product from canned sweet corn, namely cobs, leaves around the cob and some of the soluble maize from the kernels
- Corn cobs
- Maize grain and its many by-products
- Cassava slurry or juice, a by-product of cassava root processing
- Cassava peel and pulp, solid waste products from cassava starch extraction
- Cassava hay, the cassava leaves which are harvested every few months then sun dried to denature the hydrocyanic acid
- Cassava roots, although not a byproduct it is often fed as an energy supplement when cost effective against cereal sources such as maize grain
- Sugar beet pulp, the residue obtained after extracting sugar from shredded sugar beets
- Glycerol (glycerin) a co-product of biodiesel production from oils

- Vegetable oils (derived from rapeseed, mustard or sesame or cooking ghee)
- Bypass fats made from the calcium salts of palm oil or rice bran
- Oil seed cakes (such as soybean, groundnut, sesame, sunflower, cottonseed, castor oil, neem), after the oil is extracted by pressure; solvent extraction removes more oil thus reducing the energy content

Energy-rich by-products that were not specifically mentioned during the E-Conference include:

- Root crops (in addition to cassava), such as taro, sweet potatoes and yams
- Grape marc
- Groundnut shells
- Waste sweet corn normally destined for human consumption, which is consumed fresh either directly off the cob or already removed from the cob or preserved as frozen or canned sweet corn
- High moisture maize and ground ear maize, which are both wet products from maize harvesting, the first being grain only and the second a mixture of grain and cobs
- Maize stover, which is the leaves and stems of maize plants following its harvest for sweet corn. The stover remaining from crops grown for maize grain is very poor in quality because of its mature stage at harvest
- Whole crop forage maize, which is the entire crop harvested in a less mature stage than when harvested for grain.

Other less common by-products available in some tropical regions include condensed molasses fermentation solubles, the organic residues of microbial fermentation to produce monosodium glutamate and fermented soybean paste residue, produced after soy sauce has been extracted from soybean paste under pressure. Many Asian countries have by-products from medicinal herbs, such as ginseng, which may have potential for feeding livestock. However before using them, it would be advisable to obtain a full chemical profile of such residues to ensure they have no detrimental effect on cow performance or milk quality.

The pros and cons of urea molasses blocks

Quazi Huque (#51) summarised the studies undertaken in Bangladesh on urea molasses blocks (UMB) when combined with sources of bypass protein. These provide high levels of protein that are indigestible by rumen microflora and therefore permit direct and more efficient utilisation in the small intestines, leading to improvement in both the efficiency of forage utilisation and the level of production. This research concentrated on the use of fish meal and vegetable oil meal by-products. The benefits from the use of these protein meals, however are not well known by extension agents or at the farmer level. Bypass proteins that are presently used include til (sesame) oil cake, mustard oil cake, rice polish, and wheat bran. These are fed largely to improved crossbred cattle, predominantly for milk production. It is quite possible that, even with indigenous cattle, the use of UMB bypass protein could have major catalytic effects in lifting the level of animal production of a large number of unproductive animals owned by village farmers. Results from India have shown that such feeding practices among indigenous cattle have resulted in:

- average increases in milk production of 50%
- decreases in length of time to sexual maturity from 40 down to 24 months of age
- reduction in the calving intervals from 18 to 24 down to 12 to 15 months.

Thus UMB are primarily being used as feed supplements for high yielding crossbred dairy cattle. In general, farmers are of the opinion that their animals receive high benefits from these blocks. In some areas the farmers manufacture the blocks themselves. Most of the manufacturers of these regions are producing 1 kg blocks. A 1 kg block costs about Bangladesh Tk 4 (with current exchange rates of 77 Taka per $US) to produce, and is sold in the local market for about Tk 10. An adult cow licks up to 250 g/day of the block, while an adult goat requires only 50 g/day. If provided to indigenous daily cattle prior to calving or soon after and then continued throughout the lactation period, the extra milk produced and sold at Tk 10/L will provide a minimum profit of Tk 5/day per cow (assuming milk production is increased by a conservative 0.75 L/cow/day).

Different entrepreneurs are using different compositions for their blocks with the ingredients: molasses, wheat bran, rice bran, Til oil cake, mineral mixture, salt, vitamins, lime, and urea. It is observed that the composition used by some entrepreneurs is very low in urea. Production responses attributed to this block may not entirely be due to urea, but also to the minerals in the mineral mixture and the molasses. At least 3% urea is necessary to provide sufficient nitrogen to utilise other block components. It is only when the urea component of blocks surpasses 3%, is it able to contribute to increased feed utilisation of other dietary components.

The salt content of blocks (1, 2 or 3%) used by the farmers is also very low. Several authors suggested that 5% salt in the block is useful as a means to reduce palatability hence deter livestock from ingesting too much of the block at any given time. Cottonseed oil cake may also be used as an ingredient in the block as a bypass protein in the rumen. Wheat and rice bran can be used as additional sources of bypass protein. It should always be remembered that these multi nutrient blocks are used as a supplement to other feeds.

There is an urgent need to encourage private entrepreneurs to use formulas that are well-balanced and cost-effective. In addition, this technology needs to be extended to greater numbers of users. Attention should be given to the training of livestock officials on UMB production and feed supplement technology. Further research should be undertaken to develop a suitable method of block preparation to achieve more balanced, locally available ingredients which are economical, including stillage and rice bran. In addition, the technology of cold block manufacture needs to be further evaluated and promoted.

Some of the various reasons as to why farmers are not attracted to UMB technology are as follows:

- Any increase of milk production is not so attractive due to limitations of cow genetics in conjunction with feed efficiency
- The feeding system of the block
- The shelf life of the block
- Marketing draw backs
- The quality of UMB making and its ingredients
- Other feed supplementation with UMB

2. *Protein-rich by-products*

Oil seeds, both of major and minor economic importance are distributed throughout the world and are location specific. The quality of a protein in a particular oilseed is relatively constant but that the cake or meal derived from it may vary depending upon the conditions employed for the extortion of the oil.

After oil extraction, these residues are rich in protein and therefore can be incorporated as a source of protein in the rations of dairy cattle based on their availability and palatability. Some residues such as castor and neem contain toxic constituents that limit their use and hence require necessary pre-treatment prior to their use. Three major factors that influence their nutritional value are the amino acid composition, their bio-availability and the presence or absence of anti-nutritional factors. Extremes of temperature and pressure developed during expeller processing may lead to lower digestibility besides causing denaturation of protein with a consequent lowered nutritive value.

Oil seed meals generally contribute to more than 50 percent of the total protein in the rations of dairy cattle. The increased demand for protein is likely to result in increased protein scarcity and feeding cost. Hence, there is a need to search for the alternate and unconventional protein sources to partially substitute the conventional protein sources. Improved processing methods in oil extraction enable quality protein-rich feedstuffs available for animal feeding. Oil seed meals obtained by conventional methods contain substantial quantity of residual oil resulting in spoilage due to rancidity during storage. Hence, in the recent past, oil has been removed by solvent extraction process using solvents such as hexane to minimise the residual oil content for safe storage and transport. Such materials are traded by the feed manufacturers as ‘extractions’.

These by-products are of vegetable and animal origin. The latter relatively contain higher protein with better balanced amino acid makeup hence preferred in the mono-gastric animal feeding. The preferred choice of vegetable protein sources in ruminants such as cattle and buffaloes. Based on the source of oil seed, the meals are of two types, those coming from major oil seed crops or from minor oil seed crops, the former being the major source of protein in Asia and many of the developing countries. However, the nutritional quality of an oil meal protein is affected by the processing conditions to which it is subjected.

The diversity of protein-rich by-products

There was a wide range of protein-rich by-products discussed in this E-Conference as listed below:

- Copra cake
- Palm kernel meal
- Oil seed cakes (such as soybean, groundnut, sesame, sunflower, cottonseed), after the oil has been extracted by solvents to removes more oil
- Azolla (*Azolla microphylla*) is an aquatic plant with high protein content (20 to 22 % on dry matter basis). It can be used as a protein supplement in a green form, but its very low dry matter content (5 to 6%) limits its potential to smallholder farms. Overnight drainage of the plant can increase its DM content to 10 to 12%.
- Moringa twigs and stems as well as leaves

- Tomato pommace, a mixture of tomato peels, seeds and small amounts of pulp remaining after processing
- Duckweed
- Algae, *Chlorella* and *Scenedesmus*, two widely studied unicellular algae
- High protein grasses such as Pakchong (a 2-way cross of Napier from Thailand) and Mulato (a 3-way cross of Brachiaria from Australia)
- Prickly pear (*Opuntia ficus-indica (L.) Mill*)
- Neem (*Azadirachta indica*) and karanja (*Pongamia sp.*) seed meals
- Brewers grain or sometimes known as brewers spent grain, usually barley
- The water can be drained out of brewers grain then mixed with rice bran and sold for livestock feeding
- Distillers grain; it can be derived from maize or wheat
- Corn gluten meal, a by-product of wet milling
- Tree leaves, both legume and non legume species
- Tumba (*Citrullus colocynthis*) seed cake, a by-product of oil extraction
- Liquorice (*Glycyrrihiza glabra*)
- Fish waste
- Poultry manure and litter
- Residues from soybean processing

Reducing the degradability of protein in the rumen

Protein meals can be protected by formaldehyde (HCHO) or through heat treatment to reduce their rumen degradability. Heat treatment, using the sun, could be applied on the farm but HCHO treatment requires mechanised technology so will only be economic at factory level.

Habib (#143) summarised the situation with regards protein supplements for dairy cows as follows:

The majority of the local dairy breeds in south Asia are low producers and the question arises "Do we need bypass protein supplementation for these cows?" The most practical and cost-effective approach would be to increase their rumen efficiency for maximum microbial protein synthesis. If the rumen of a dairy cow is used to its full potential by supplying microbial nutrients balanced in term of energy and protein, the nutrient output from that rumen will then satisfy nutrients requirements for low and medium level milk production.

In designing protein supplements, one has to realise that different rumen microbes have different N requirements. On fibrous diets, fermentable-N will be required to enhance cellulolytic activity while the growth of amylolytic bacteria will need amino acids and peptides. Most of the oil cakes are high in degradable protein and make good combinations with fibrous diets. Energy in the form of grains or molasses is required to enable microbes to capture ammonia for their maximum growth. In smallholder systems, the lack of energy in dairy ration constrains rumen microbial efficiency.

Habib (#143) makes the point that instead of costly chemical and physical treatments to render dietary protein undegradable, it will be more appropriate for low to medium milk producing cows to balance the rumen through less expensive locally available feeds for maximum microbial growth. Animal performance such as milk production is not simply related to feeding of undegradable protein. It is the function of availability of digestible protein in the intestine.

For high producing cows (>15 L/cow/day), intestinal supplies of amino acids from microbial protein alone may not be adequate and will then require undegradable protein supplement to complement their intestinal protein supplies. Formaldehyde treatment of protein feeds is no longer recommended because of associated health risk and damage to environment and it should not be left to farmers' practice. Heat treatment is not only costly but also there is risk of overprotection making proteins indigestible and wasted. Instead, naturally protected protein sources such as meals of oilseeds and animal origin should be used as bypass protein source if required.

Don't feed too much dietary protein to low producing cows

Habib (#144) of Pakistan argues that convectional feeding practices in peri-urban commercial dairy system have overfed dairy cows and buffaloes with protein when they fail to match the quantity and composition of concentrate supplements with seasonal fodder supplies. There are shortcomings in the traditional feeding practices.

For example, in Pakistan when berseem (Egyptian clover) is fed as the basal diet in winter, it is supplemented with conventional home-made concentrates containing equal parts of oilseed cakes and wheat bran and this can overload the animals with protein. Both these feeds are highly degradable which together with high intake of fermentable N from the berseem, results in excessive protein consumption over and above their requirements. This effect is more pronounced in low producers (<6 L/cow/day of milk) when cows irrespective of daily milk yield are fed the same amounts of concentrate as part of the traditional practice. Habib’s study with buffaloes in 32 private peri-urban farms in 8 different locations revealed that with the above feeding practices, low milk producer were receiving 1000 g protein/day above their requirements while buffaloes giving 12 L/cow/day of milk were deficient by 600g/day protein.

Blood urea concentrations were positively related to protein intake and buffaloes with blood urea levels above 31 mg/100 ml suffered from delayed oestrus resumption after parturition and low pregnancy rates.

Excessive consumption of soluble proteins fail to increase milk production, adversely affects reproductive performance and cause excessive excretion of N that adds to environmental pollution. There are also energy losses associated with high N excretion because urea synthesis from ammonia is an energy costing process. This energy cost may attribute to reducing milk yield, lowering reproductive performance and losses in body condition.
From the above, the take-home message for farmers and extension workers should be that, when dairy cows are fed berseem or other high protein forage, the proportion of oil cakes and other soluble protein stuff shall be reduced and instead grains or other energy feeds be included. Secondly the cows should be fed according to their target milk yield to avoid overfeeding of low producers and underfeeding of high producers. This will not only reduce the cost of feeding but it will also improve their productive and reproductive performances with reduced emission of greenhouse gases.

3. Fibrous by-products

Many of the feedstuffs of less commonly used by products which are classified as “low quality roughages” have been examined by many scientists from all over the world to find out the means of improving their nutritional quality. Asia is the highest producer of crop by-products contributing to about 46% of the total world production. Hence Asian animal nutritionists have paid more attention for improving the nutrient value of crop residues including by-products than those in other geographic locations.

Most of these by-products are high in fibre, lignin and silica contents. The major limiting factors associated with the use of these agro-industrial by products as cattle feeds are low concentration of nutrients and their poor palatability leading to low nutrient intake and subsequently reduced animal productivity.

Based on the efficiency of use of the available feed resources more pertaining to Asia, they can be classified to develop suitable feeding systems:

- Pastures; these include native and improved grasses, herbaceous legumes and multi-purpose trees
- Crop residues; these include such examples as cereal straws and maize stover (the dried stalks and leaves of the crop)
- Agro-industrial by-products such as cereal bran
- Non-conventional feed resources; this includes diverse feeds not traditionally used in animal feeding (palm press fibre and sugarcane bagasse, for example).

Cereal straw processing to improve its quality

The technology of chemical treatment of rice straw has been established from several decades (Khan Huque #167). However its adoption has been very slow. Treating straw with urea just to improve its digestibility seems to be mostly a waste of time, when we can easily feed urea and sugar to the animal and thereby improve the digestion of straw within the digestive tract (Sutherland #196).

There are many reasons for poor adoption of urea treatment of cereal straws and these include:

- It is seen by the farmers as a labor consuming and cumbersome process. Farmers are reluctant to put much effort into straw processing as they firstly have to take the dry straw out from stacks, mix it with fermenting agents, keep them in any sort of conditioned environment, and then chop it prior to feeding it to their animals.
- Molasses (ususally incorporated with urea treated straws, has often become in short supply and more expensive due to demands of the distilling industry, although Chowdery (#201) found that rice gruel and Habib found that mulberry fruit waste could be viable alternatives.
- Farmers do not like to double handle any forages they harvest. Once harvested, they would prefer to directly feed it to their stock.
- Farmers prefer not to want to use anything they could consider as a corrosive chemical. The breakdown of urea into ammonia can lead to unpleasant sensations in the eyes once the stack has been opened.

- Following the tortuous operation of treating the straw, farmers seek good milk response. If the rest of the ration does not provide the level of nutrients required by the cow that is not supplied by the treated straw, milk responses can be poor.
- Farmers depend on their own experiences and that of their neighbours and if anyone has experienced problems or their cows have only had a poor milk response (actual or perceived) then the farmers will be less motivated to want to try it again.

The response to urea or ammonia treatment is better in lower quality straw cultivars in terms of dry matter (DM) and organic matter (OM) digestibilities than the cultivars already having higher DM and OM digestibilities (Habib #191,Walli #194). Urea treatment may not be cost effective for straw that is inherently good quality. This emphasises strategic use of such treatment technology.

Generally speaking, urea treatment of wheat straw would increase in vitro DM digestibility (or IVDMD) by approximately 5 to 7 units, which means that a straw with IVDMD of 35% would increase to 42% following urea treatment (Habib #191). Alternately, such an improvement in straw quality can be successfully achieved through genotype selection without investing on urea treatment. Urea treatment is labour intensive, adds to cost and has low adoptability among small farmers.

Therefore there should be increased efforts to select cultivars of cereal grain that produce better quality straw without comprising on grain yield. Varieties that combine both high grain yield and better quality straw need to be identified. Farmers show a clear preference while selecting varieties of sorghum for those with good palatability and preferential selection by livestock. Searching for grains and oilseeds with low anti-nutritional factors is another area that requires joint efforts by animal nutritionists and plant breeders.

The use of fungi and other organisms on straws through fermentation is seen as a successful alternative to chemical and physical treatments to enhance straw quality. However, Sridhar (#73) concluded that the bulk of straw to be treated for feeding and chances of contamination with toxic fungi have posed impediments in wide adoption of this technology.

On a related aspect, despite legislations imposed, such as by Punjab State Government in India on burning of straw stubbles and other crop residues, farmers consider burning as the easiest and the most economical method to dispose of the rice straw; in Punjab more than 80% is burnt (Bakshi and Wadhwa #157). The options for the disposal of rice straw are limited, mainly because of its bulkiness, slow degradation in the field, harbouring of rice diseases, and high mineral content. The collection and removal of rice straw spread in the field after harvesting is a serious problem. It is time consuming, labour oriented, interferes with tillage and sowing of the next crop, for which there is very little time. Rather than burning, rice straw can be utilized by mulching in the field, composting with animal excreta and used as organic manure, pulp and paper industry, power generation, fuel for furnaces and gasifiers, building material, mushroom cultivation or as livestock feed has great potential.

Straw feeding to high yielding dairy cows

There was considerable discussion on the role of straw feeding for low, medium and high yielding dairy cows. Biswanath (#186) from India supported the view that the treatment of straw through chemical/physical/biological means was of limited use. The technologies have enormous scope for effective utilization of poor quality roughages by ruminants which are otherwise lead to environmental pollution. But, the technologies are not implemented at farmers' level because of uneconomic and poor acceptability by the farmers. In fact, nutritionists blame extension workers and vice versa, but collective and holistic approaches are required for effective implementation of these technologies. Straw feeding is recommended for low yielding cows and as a maintenance ration, together with some supplementation of critical nutrients. Mostly, straw with or without treatment is usually recommended as alternative feeds especially in lean periods and on hilly areas where green fodder scarcity is a major problem. For moderate to high yielding cows, feeding of green fodder/tree leaves (if green grass is not available) is a must. However, scope of straw (vast source of energy) treatment should not be ignored especially in tropical countries where poor quality roughages are used as a staple diet for ruminants.

Akbar from Bangladesh (#178) agreed, concluding that straw feeding is not advisable for the medium or high yielding dairy cows. For these types of animals, green grass of good digestibility is a must. Therefore, straw feeding to the low milk producing animals in small holders should be supplemented with green grass or tree forages, preferably legume forage and for the medium to high yielder cows it should be substituted with green grass.

Cost: benefit ratios of different cropping systems

In Bangladesh, Khan Huque (#185) reported the average benefit: cost ratio of rice cultivation was around 1.15. Sometimes it becomes negative, but farmers still had to grow rice because it was the staple food of the country. In comparison, the benefit: cost ration for the fodder crop Napier grass was 3.00, especially in the dairy farming areas. Some farmers cultivated fodder using even lease-hold lands, sold it in nearby markets, and supported their livelihood. In most of the cases they used Napier, Jumbo etc. Connecting these farmers with dairy producers through different mechanical processing and packing technologies helped development of a fodder market as well as a smallholder dairy industry. Many of these markets had temporary fodder selling corners. This highlights the fact that farmers are the best economists for their livelihood development.

Rangnekar (#132) emphasised that farmers need to know the total cost of each by-product "down the cows' throat". In other words, what was the total cost of each one, taking into account its purchase price, transport cost and any processing costs required prior to feeding it out.

4. Handling and storing by-products

Fruit, fish waste, vegetables and root crops are increasingly integrated into tropical farming systems and provide a wide range of valuable wet by-products and residues which are often underutilized or wasted. The ensiling of such by-products is a simple conservation method and the most effective way to improve animal feed resources through the rational use of such potential feedstuffs to small holder farming.

The major problems usually encountered are the seasonality of supply and their high moisture content. High moisture by-products often have high nutritive value. It is difficult and expensive to dry them so all too frequently such by-products often become contaminating wastes that quickly go sour, moldy and lose much of their soluble nutrients as effluent. The advantages of ensiling such material include:

- Conservation of such products and feeding when they are not being produced
- Increase in feed resource bases and an insurance for high nutrient demands, such as milking cows
- Reduction in demands on home grown forages
- If low cost, reduction in total feed costs
- Possible improvement in their palatability
- Possible reduction in toxicity to safe levels(e.g. in vegetables or cassava leaves)
- Can destroy harmful bacteria (e.g. in poultry litter or fish wastes)
- Can constitute a major proportion of diets

Ensiling and trading of silage mixtures

Habib (#220) reported that over the last few years commercial production of baled maize silage has emerged a popular business among dairy farmers in Pakistan. In one region about 10 large farmers prepare baled silage from maize crops on a commercial basis. Two approaches are used. Either the fresh maize chop is baled, wrapped in polythene and allowed to ferment to silage before feeding. In some places, silage is prepared from the maize and then baled and packed and sold to farmers as ready for feeding. The size of bales vary from 350 kg to 1000 kg. The buyers of baled silage are mostly urban and peri-urban dairy farmers who often do not have enough land to grow fodder or not enough farm space to build silage pits. Baled silage requires limited space to store and more importantly, it saves on labour. Farmer's experience with feeding high quality maize silage report increases in milk production and low feed costs due to reduced requirements for more expensive concentrates.

In Indonesia, Khaerudin (#228) reported on a silage mixture of maize stover and concentrates made in 200 L drums while Mathur (#214) from India reported on a silage mixture of water soaked dry fodder together with 2% urea, 10% molasses and 10% sour whey. Makkar (#211) reported a process developed in Morocco for making silage from fish waste and molasses and then converting it into blocks by adding cereal bran.

Forage conservation

Silage making and hay making are the two important methods of conservation of forages for feeding livestock during forage shortage periods in Bangladesh, particularly during dry and flood periods (Akbar #234). These are the times when the farmers in all areas of the country face problem of green feed shortage affecting productivity of livestock. Therefore it is essential on the part of the farmers, to conserve forage when it is available in order to ensure year round supply to their animals for better production.

However, unfortunately Bangladesh farmers do not practice forage conservation despite efforts made on various occasions through demonstrations and training and even by showing them the easy and low cost methods of silage making e.g. poly bag method, ground pit method, bamboo case method and drum methods. Even in the case of medium farmers, with 30 to 35 cattle herd and growing maize and Napier grass for feeding cows, they are not interested in making silage. The Bangladesh advisers initially thought that lack of awareness might be the cause, but even after providing training and building awareness among them, the farmers were hardly interested except for a few.

A survey study showed that the farmers found it easier, time and labour saving and had the idea that green fodders were more nutritious than silage. Therefore, our conclusion might be that the farmers are more interested in feeding green fodder rather than making silage and only when they will produce it in large quantities and much more than the requirement, they will be interested.

Densified feed blocks

Walli (#160) reported on a complete densified feed blocks with ingredients of chopped straw, concentrates (energy, protein and minerals, vitamins, antitoxins, and other herbal and other feed additives. The supplements and feed additives could be modified depending on the animal's specific requirements. The roughage:concentrate ratio of the feed could be set as per the average production level of the animal. A single block weighing 14 kgs could make a complete balanced feed for 24 hours for an animal yielding even up to 20 L/day of milk. In addition to rice and wheat straws, other crop residues incorporated in such feed blocks include sorghum stover, finger millet stover, maize stover and other unconventional forages like sugarcane tops, sugarcane bagasse (as a partial replacement for straw), dried forest grasses, dried tree leaves, gram straw and groundnut haulms.

Considerable research efforts have gone into making an efficient feed block machine, which is now in use in India. Whereas the bigger units can be set up mostly on community basis through cooperatives, the smaller units can be popularized among bigger dairy farmers in areas where green fodder shortage is a perennial problem. Because of densification, the transportation as well as the storage of these blocks and pellets is much easier compared to bulky fibrous crop residues. Apart from that, it also saves lot of labor at the farm, with regard to feeding of animals and cleaning of the paddocks. Ostri from Nepal (#161) has also found good milk production responses to such densified feed blocks.

Losses from long term storage of straw

Akbar (#218) from Bangladesh reported that damage from rain, fungal and reptiles can amount to 45% even in hay stacks on a raised platform to avoid rats and termites and ground heat. When storing moist straw, urea spraying, covering the stack with polythene, building sheds or stacking it on raised platform can reduce the magnitude of damage but farmers have been slow to adopt these methods.

Handling is another problem as straw is transferred from one place to another in trucks or trolleys in loose and open conditions without covering, especially in the dry season. "Box-baling" was designed and used for baling legume hays for storage and this could well be used for making bales of cereal straw using bigger size wooden boxes which could help in storing straw on small holder farms.

Small silage stacks

There was considerable discussion about the diversity of small silos for small holder dairy farmers. As well as pits in the ground in Bangladesh (Schultz #231), other containers included reusable plastic bags (or tubes) of capacity from 100 to 1000 kg in India (Aware #232, Bakshi #237) to ring silos made from old water tanks in Cuba (Inglesias #265).

The benefits of chopping, soaking and mixing complete diets for milking cows

In India, many resource poor farmers, especially in the southern and eastern states are still offering un-chopped crop residues/dry roughages to their animals, which results in energy losses due to the need for more chewing (Walli #152). The animal also gets the free choice to select more digestible parts of the plant leaving the less digestible parts, which results in wastage of the crop residues. Systematic research studies carried out in India have shown that chaffing of paddy straw results in increases in DM intake and decreased energy required for chewing. In fact, serious efforts have been made to educate farmers about the advantages of chaffing and the farmers are now being encouraged to purchase at least hand-driven chaff-cutters. In northern parts of India, even the poor livestock farmers feed chopped straw to their animals. In fact, they add chopped green fodder and some concentrate ingredients to the chopped straw, soak it in water for some time, mix the whole ration manually and then offer it as a complete feed to their animals. This is certainly a more desirable way of feeding crop residues, and the nutritionists and extension specialists should try to introduce these simple technologies in areas where the farmers are not aware of such beneficial feeding practice.

In conclusion

Khan Huque (#173) concluded that straw treatment has failed to create popularity at the farmers' level for the many reasons mentioned above. Therefore instead of treatment, alternative use of straw should be given preference, say for example, use in densified feed blocks or even supplementation with legume forages etc. However, ultimately we have to reduce gradually the inclusion of straw in the dairy ration and encourage the use of alternative better quality fodders.

Rice straw form the basis of the wet season forage feeding on small holder dairy farms in Bangladesh (Photo provided by Moran from Australia)

5. Challenges and possible solutions in technology transfer

Improving the processes of adoption

Rangnekar (#62, #74) considered that research or technology development should not only be technically sound but also economically beneficial to producers and adoptable by animal owners, most being small holders or resource poor. Recommendations on feeding livestock are commonly discussed between animal owners and extension officers and hence recommendations passed to extension officers should pass all the three parameters mentioned above. Another critical aspect is that majority of livestock producers from developing countries are resource poor and hence a “Pro-Poor approach” is crucial but is missing in much of the research projects (looking into the systems of production). This should be discussed around two aspects:

1. *Pre-testing of recommendations through 'On Farm testing with farmer participatory approach'* and this testing should not be scientist-managed. Wider application or passing these to extension/development organisations should occur after ascertaining that these technologies or recommendations are appropriate. Scientists should be open to consider/accept the producer's views. The final product should come out of a combination of scientific and farmer view point. The final product for different production systems should be different but, by and large, we have singular recommendations. In most cases this vital step is missing and adoption of the products of research is not assessed. Many times we blame the technology or the recommendation. A crucial aspect missing is to define the systems or conditions under which the results are applicable and hence the extensionists can propagate recommendations to all types of producers/situations.

2. *Planning of research and technology development.* There is a need to develop a system of regular and planned interactions between research and development organisations (GOs, NGOs, farmer organisations etc.) for scientist groups to understand the production systems, and all the problems and constraints faced by livestock producers. These problems and constraints may then be thoroughly analysed by both types of organisations after which the need for further research can be established. In many cases, only adaptive research may be needed while in other cases, basic research is required.

Convenience and risk perception affects adoption of improved technology

In #250, Rangnekar reported on several Focused Group Discussions with livestock owners, particularly women who had a major role in livestock production, to learn more about possible reasons of rejection, acceptance and adoption of recommendations and technologies. While economics was an important factor, they learnt that farmer perception of economics is different from conventional economics, and that there are two other equally important factors - convenience and risk perception. So, recommendations may be initially accepted if they are apparently beneficial but if they become too inconvenient or time consuming, they may not be adopted. Women said they had many other jobs to perform and responsibilities to handle - in a mixed farming, small holder situation. And in case they smelt some risk (such as spoilage during ensiling or treatment), the adoption was difficult since they could not afford to take further risks.

In conclusion, Rangnekar (#283) offered these words of advice on extension links with research:

- I have learnt as a development scientist that it is a "Blessing in disguise for small farmers that they resist change and it is a challenge for technical persons". I say this considering the way livestock extension works in India.
- Extension reviews clearly show that extension works sometimes but not other times. For example, it was effective for farmers growing crops in irrigated areas with uniform production systems but not for those in rain fed areas with complex farming systems
- The Policy Framework for Agriculture Extension formulated in 2000 in India recommends an adoption of farming systems and farmer participatory approaches to enable problem-solving skills of the farmers and to improve the research - extension - farmer interface. Unfortunately extension still remains an activity of transfer of technology and recommendations are undertaken in a mechanical and target oriented manner.
- I have indicated need for three kinds of changes:
  - The process of planning research, base it on study of production systems and constraints
  - Adopting a step of on farm - farmer participatory testing of research and technology before recommending for wider application
  - Involving related organisations (GO / NGO/ Farmer Cooperatives, Agriculture Technology Management Agencies) in Steps 1 and 2
- It would be useful if Directorates of Extension in various universities studied reasons of adoption and non - adoption of recommendations and technologies by small holder producers
- A major constraint is the virtual absence of any incentives for young research and extension workers to take up work that benefits the resource poor farmers

Chowdhury (#287) from Bangladesh expressed his thoughts slightly differently in that livestock professionals should be more on the "door step" of farmers. Farmers understand their ecological, ethical and financial aspects better than we do. So any technology must meet these basic criteria before they can be adopted. Therefore on-farm research and technology is the way forward towards meeting the basic needs of tropical dairy/livestock production.

The impact of herd size

Walli (#233) concluded that the economics of milk production varies with the herd size, the average milk yield of the animals managed by the farmers and the availability and the cost of feed resources. So, naturally we need to evolve different sets of feeding models/technologies for landless, small, marginal and for bigger farmers. While we must try to encourage progressive farmers to adopt newer technologies, we just cannot ignore the millions of small and landless resource poor farmers, and need to suggest ways and means, including some simpler technologies, for generating more income through livestock rearing.

Farmers with high yielding cows do adopt improved feeding technologies

In India, Bakshi (#236) noted that farmers with high yielding crossbred dairy cows, producing 15 to 20 /day of milk did adopt improved feeding technology practices of silage making, formulating their own nutrient balanced concentrate and supplementing the ration with minerals and even bypass nutrients.

Follow up training programs with better demonstrations and visits

Habib (#263) of Pakistan concluded that most extension training programs to date cover the communication aspect but never follows up with assessing behavioural changes in farmers for adoption. This requires continuous and strong technical backup visits to farmers after training which unfortunately is frequently missing in our extension systems. Once trained, farmers in Pakistan are generally left on their own and seldom revisited.

Training material supplied to farmers should be of low literacy level and explained with illustrations to help them better understood. Even a simple intervention such as providing free access to drinking water or keeping animals untied in barn needs several follow-up visits to answer farmers' queries for on-farm application.

We must admit that rural small farmers in developing countries are tradition and strongly believe in myths and misconceptions which they have received from their forefathers and fellow farmers. It is very hard to change them unless the innovation is demonstrated on their farm. Large numbers of NGOs in Pakistan are providing trainings to farmers everywhere, all the time and on different aspects of livestock farming, but with almost zero adoption. There is no regulatory mechanism or check because the extension services of livestock departments throughout the country are weak and health oriented. Perhaps we need institutional reforms.

In addition to follow up farm visits, other extension tools that are worthy of attention are:

- field days on representative farms to which farmers can easily relate (Khan #270, Habib #274)
- model farms and demonstration units (Quazi Huque #271)
- use of mobile phones for delivering targeted information to rural farmers that could be otherwise not reachable (Habib #272, Orskov #281, Walli #288)

Wheat pollard and rice bran are the basis of many milking cow concentrate formulations (Bangladesh)
(Photo provided by Moran from Australia)

6. Aspects of management of tropical dairy systems

The feeding management of by-products includes a lot more than just sourcing, transporting, storing and actually feeding out the diversity of by-products listed in the previous pages. It also covers formulating rations for different classes of dairy stock and integrating by-product feeding with other aspects of herd management such as forage production, sourcing formulated concentrates, reproduction, milk production and animal health and welfare. Many of these herd management practices, as discussed during the E-Conference, are synthesized in the following pages.

Quazi Haque (#19) considered that indigenous cattle and low yielding improved cows in Bangladesh, producing less than 7 L/day of milk did not return sufficient cash flow to be suitable for commercial dairy farming, even with 4 or 5 cows per household. After taking into account all the herd costs, such as rearing heifer replacements, he concluded that cows needed to be able to produce 10 L/day of milk to be profitable.

Factors limiting the performance and feed utilisation of the dairy herd

Quazzi Huque (#66) from Bangladesh and Moshood (#67) of Nigeria have both stressed the fact that that in addition to the nutrients consumed, the genetic quality of the stock will greatly influence their milk responses hence utilisation of available feed stuffs by them.

Surapoy (#179) from Indonesia considered that the genetic potential of cows in the country is already good and the major herd problems were:

- Calf rearing; farmers need to give more attention during calf rearing to factors such as the length of the milk rearing period, whether the farmers provided good quality roughage to the calf, and at what age they were first fed concentrates. When you have good calf development, you will get better cows in the future. Remember the calf today is the cow tomorrow.
- Mastitis; not many farmers in Indonesia implement good mastitis prevention programmes. This is very important to keep the cow in good production.
- Lack of protein feeding; the solution is to teach farmers about feeds (grasses or by products) with high protein contents, like tofu waste, brewery spent grain, lamtoro (leucaena) and gamal dill.

We feed nutrients not feeds to our livestock

Sutherland (#197) of Australia reminded us to forget about classifying and grouping items as by-products, commodities, forages, energy supplements, protein supplements, food wastes etc., but rather just look at them all objectively as ration ingredients available at the farm gate for a certain price. Whether they are local or imported, it doesn't matter, as long as they are regularly available, and their price is known. The next step is to look at the nutrient analysis if available, and then formulate the ration to the desired specifications. In addition, we must not forget to assess roughage value for each ingredient, to ensure continued support for the rumen microbes and for rumination.

Sometimes a small amount of crushed corn or wheat grain can be no more expensive than oilseed cakes and by-pass fat supplements. Sometimes it is even cheaper (and easier) to purchase sugar from the local store than to source molasses. Furthermore, 1-2% sugar in the diet can be very helpful.

Improving reproductive performance

Reproductive failure - is it more than just energy balance ?

Sutherland (#57) from Australia noted that we often assume poor reproduction to be the result of negative energy balance in early lactation. Therefore, if we improve nutrition, we should expect to see improvements in pregnancy rates. However he has encountered several tropical dairy herds, where even after improving energy balance to the point where cows are in good condition score and producing well in early lactation (15 to 20 L/day of milk), they are still difficult to get back in calf.

So he argues that it is time to re-evaluate this problem. Is it high blood urea nitrogen (BUN)? Is it something else, such as an imbalanced volatile fatty acid (VFA) ratio due to the carbohydrate profile in the feeds (low starch hence low propionate)? Could it be related to blood glucose, insulin, IGF levels? Is may be genetic, because in beef cattle we recognise that *Bos indicus* (Zebu) generally have longer postpartum anoestrus than *Bos taurus* (European breeds). In adapting temperate dairy cows to tropical climates, we have focused on *Bos indicus* genes. There is no easy simple answer to this problem and it should be a high priority for future activities in FAO/APHCA's Asia Dairy Network.

Akbar (#177) from Bangladesh also argued that breeding efficiency of cows is a big problem with nutritional deficiencies being the major cause. It can be improved by supplying balanced rations but this is not easy due to the fact that the animals are supplied with straw based rations because of the shortage of green fodder during wet season and flood period. The reality is that for cows with low levels of production, as in the case of small holders producing only 3 to 4 L/cow/day of milk, advisers can recommend tree forages or similar forages. However for those animals giving around 10 to 20 L/day of milk, it is not possible to meet the need for green forage with the quantity of available tree forage.

Dairying is becoming a preferred livelihood option for many resource-poor households in rural and peri-urban Bangladesh. The rapid expansion of artificial insemination throughout the country has stimulated the growth of medium to relatively large dairy farms with high yielding crossbred cows. Therefore, growing high yielding fodders and conservation as hay or silage for feeding during the fodder lean period are the preferred options for these dairy farmers. Clearly, fodder production and preservation should be given emphasis in order to correct the case of repeat breeding through increased supply of green fodders to dairy cows round the year.

Supplementing milking cows with raw eggs can stimulate their oestrus cycle.

Chowdhury (#164, #168) of Bangladesh also emphasised that one of the major problems in non-commercial subsistence dairy cattle (which comprise over 90% of Bangladesh's national dairy herd) is infertility and/or repeat-breeding. Field observations show that 80% of the calving intervals in non-commercial subsistence dairy herds are over 18 months and in some cases, as high as 36 months. His diagnosis in most cases was parasite and/or dietary induced protein under-nutrition.

Chicken or duck eggs are frequently the cheapest and mostly available source of high quality protein, vitamins and minerals available to poor farmers. After deworming with broad-spectrum anthelmentics, infertile or repeat breeder cows were given 4 to 5 raw eggs over a 7 to10 days span (generally at 2 to 3 day intervals). With few exceptions, almost all these animals started their normal breeding cycle and conceived within 30-45 days.

As each egg costs about Bangladesh Taka 8 to 10 (1 US$ = 80 BDT), the total cost per cow is then about BDT 40 to 50 (or US$0.50 to 0.62). One important issue is that each cow must be dewormed before being fed the eggs.

One possible explanation is that the combined impacts of deworming and egg therapy might increase the threshold levels of critical amino acids, minerals and vitamins levels in circulation which might help to induce the breeding cycle. However, these are only assumptions and we need conformation from scientists working in under nutrition-induced infertility? There may be other means of practical intervention that can be applied under such resource constrained and remote conditions.

Mineral supplements are also important for good reproductive performance

Bakshi (#169) of India reported that *Leucaena leucocephala* leaf meal can serve as an excellent protein supplements during lean period of fodder availability in India and Bangladesh. He observed that only 11% of the dairy farmers in Punjab offer mineral mixture to their animals. The lack of mineral mixture and common salt in diet could lead to various reproductive problems and failures, such as repeat breeding and anoestrus. Therefore, besides energy and protein, mineral supplements should be provided to check potential reproductive failures. Conventional urea molasses mineral blocks containing *Leucaena leucocephala* leaf meal could serve this purpose.

Improving the nutrient status of milking cows during the Bangladesh wet season

Sourcing green forages during the wet season in Bangladesh

Moran (#163) of Australia reported that on a recent trip to Bangladesh, he was regularly confronted with dairy farmers and advisers who told us that repeat breeding is one of the major problems amongst small holder farmers in Bangladesh, particularly during their wet season. This is likely to be due to the poor nutrient status of cows in early lactation, primarily a lack of green feed or quality forages forcing the cows to repartition their body energy reserves which led to lengthy negative energy balances hence poor reproductive performance. This is a similar problem in many tropical countries where "the genetic quality of the many of the dairy cows is better than the farmer's ability to feed them properly".

Being on the delta of rivers and hence under water during the wet season, the only forages available for dairy feeding in the wet season are the thousands of stacks of rice straw, conserved from the dry season rice crops. One of farmers’ common requests were "What can we grow during the wet season to provide our milking cows with some nutritious green feed?" As strongly expressed by other contributors to the E-Conference, rice straw, even urea treated rice straw, may be adequate for low yielding dairy cows, but not for cows that are genetically capable of peaking at 18, 20 or even 25 L/cow/day, given the right balanced supply of feed nutrients (that includes digestible fibre as well as energy and protein).

There are several options available to provide wet season green fodder and these include, include firstly, tree legumes growing along the road sides and any areas not likely to go under water, secondly, Para grass and other grasses that can take a bit of inundation, along the water's edge around the floodplains, and thirdly to make silage from sweet corn crops grown during the previous dry season. Other possibilities would be to develop highly productive grass swards during the dry season then regularly conserve them as hay or silage or grow Azolla, although this may not be easy to grow on a large scale of many thousands of small holder farmers. However, the milk processors could develop Azolla farms for their farmer suppliers. Perhaps there may be other more fibrous but relatively high energy and protein by-products that the milk processors could source on behalf of their suppliers.

Providing green fodder during the Bangladesh flooding season

Tinnberg (#165) of Bangladesh agreed that roughage feeding these cows only with rice straw is not an option if you want to take advantage of their productive capacity. The flooding (wet) season is not the main problem, but the winter season, (which lasts from late Nov to mid Mar), due to that fact that most of the cows give birth during this period and there are seasonal shortages of green grass like Napier, Jumbo and Gama during these months. Advisers in Bangladesh encourage the progressive farmers to grow surplus grass during the rest of the year then make silage of the surplus for feeding back during this winter period. This has been a good outcome and silage making has increased among the farmers he works with.

Traditionally the farmers feed these fresh cows with straw and they also grow Keshari, (legume), to feed the cows during this winter period. However, Keshari has quite high levels of protein but it is too low in sugar and energy to be an optimal roughage alternative. This winter his group is undertaking forage trials by growing hybrid maize during the winter and also testing oats or wheat forages mixed with 30% Keshari for green feeding and silage making.

Some areas in Pabna also have problems with flooding during the year and strangely some of these areas are traditionally milk producing areas and heavily populated with cows. In these areas, straw is the main source of roughage and large quantities are transported there by boats.

Suitable green fodders for the Bangladesh wet season

Samad Khan (#166) from Bangladesh has the following comments on this problem. Urea treated straw, urea molasses block, high yielding varieties of Napier grass, *Latharus sativus* (khesari) a legume hay, *Sesbania aculeata* (dhaincha) a fresh legume and tree legumes such as ipil ipil (*Leucaena leucucephala*) are the appropriate feeds for dairy cattle during wet season in Bangladesh. The problem is that the country's livestock extension services in dairy cattle feeding management are extremely weak. There needs to be a massive training program to improve farmer awareness.

Summarise the existing knowledge on supplying green fodder for Bangladesh

Dugdill (#170) of England was concerned that there is "much re-inventing of the wheel" going on in the vast Bathan (which is under water in the wet season) dairying lands of Bangladesh. Plainly these earlier interventions have not taken root nor have the right messages reached the typical milk producers. Someone should consider collecting the many manuals, guidelines, resource books and the like that dairy interventions (project and research) have "churned out" over the past half century since independence and distil them into user-friendly, area-specific, best feeding practices for Bangladeshi milk producers - small, medium and large.

Overcoming reproductive problems during the Bangladesh wet season

Khan Huque (#173) of Bangladesh makes the following comments on Bangladesh's wet season feeding problems. Almost 50% of the total breedable dairy cows in Bangladesh are crossbreds while average full lactation milk yields have increased from around 600 L for the local to 2000 L for the crossbred cows, through introducing better genes, especially Friesians. Average post-partum heat periods in different production system varies from 4.0 to 7.5 months, and repeat breeding is an added economic load for the farmers.

Farmers produce enough roughage to feed their cattle, but it is not readily available to all animals. The major challenges are then how to make it available in different seasons and different regions. Protein-rich fodders should be grown and marketed cost-effectively, thus competing with other crops. Farmers are now willing to share their cropping land for growing livestock fodder because dairying has become their major source of income.

What is the solution? Is it genetics, nutrition or herd management or all of these? Here is little opportunity for increasing milk production vertically through the introduction of quality genes when the average diet quality is only around 7.7 MJ/kg DM of metabolisable energy and 2.3% digestible crude protein. In addition, the availability of concentrate is about only 20% of the total annual requirements. The farmers' slogan of "Produce more milk from each cow" needs to be revised to "Produce more milk plus have a calf every year from each cow".

Growing leguminous fodder trees for livestock fodder in preference to paddy rice

Akbar (#180) from of Bangladesh has some ideas on other forage sources. It is possible to grow leguminous fodders in the farmers' rice fields by integration with rice production, without adversely affecting (in fact actually increasing) rice production. It has been found that growing leguminous fodders such as *Lathyrus sativus* with dry season rice as a relay crop and *Sesbania rostrata* as an intercrop with wet season rice, yielded considerable quantities of fodders which increased milk yield of cows by 20 and 25% respectively. In addition, rice production of these fields increased by 7% and 13% respectively, since these fodders are legumes hence improved soil fertility by increasing mainly N and slightly OM.

Regarding farmers' opinion on their willingness to cultivate fodders in rice fields, results of a survey study showed that 70% of the rural farmers were willing to grow fodders with minor changes in cropping patterns. At present, there are a number of dairy farmers (medium and above) growing fodders in their rice fields instead of rice. Some farmers are growing fodders to sell out in the market which can earn more than selling the harvested rice. The price of paddy is very low and production cost are currently very high. Numbers of farmers are growing vegetables or undertaking fish or poultry farming on their lands instead of growing rice. Therefore production of fodder sources is undoubtedly increasing for the dairy farmers of Bangladesh.

Several Bangladesh wet season and dry season rations are described in the E-Conference proceedings but they are for cows producing only 6 to 7 L/day of milk in the wet season (Baset #181, #184) and 6 to 7 L/day of milk in the dry season (Baset #192, #193, #198). Additional case studies were presented of Bangladesh (Khan Huque #241, #246) and Indian dairy systems (Bakshi #189, #262) but these were also for low yielding cows, producing 4 to 6 L/cow/day.

Is there a role for hydroponics in tropical dairy farming?

A rather lengthy electronic conversation was held about the potential benefits of hydroponic technology on tropical dairy farms. Basically, hydroponics is a method of growing plants using mineral nutrient solutions rather than soil. In addition by controlling the climate, that is the temperature and hours of sunlight, large quantities of plant material can be grown independent of season. Hydroponic fodder is generally grown directly from trays of grain that are allowed to germinate and grow for a week or so in a temperature controlled chamber.

Hydroponics is now an established method of growing high value crops throughout the world, with cut flowers and tomatoes being two good examples of commercially viable industries. The high crop yields and the independence to ambient temperatures and rainfall, hence season, allow such crops to be competitive with crops grown out in the open air, under more natural climatic conditions. However the potential role of hydroponics for less valuable crops such as livestock fodder has been queried by many cropping specialists.

Scientifically controlled studies have shown hydroponic barley fodder to lead to high growth rates in beef steers, with stock growing faster than predicted from their consumed nutrients, which indicates additive effects from the various feeds consumed. However other studies have found no growth rate advantages in feeding beef cattle hydroponically produced fodder over cereal grain. In virtually every case, these studies have not included economic analyses of the costs and returns from this cropping innovation.

Hydroponically grown maize has been evaluated in India and positively reported on by Walli (#183, #188) and Naik (#190). Moran (#187) provided an alternative view based on Australian studies with beef cattle. The feedback from the Indian dairy farmers revealed that there was increase in the milk yield by 0.5 to 2.5 L/cow/day with higher fat content leading to increase in the net profit by Rs. 25 to 50/ cow/day. Feeding of hydroponic maize also improved their health and conception rate, besides economising the feeding of the dairy animals.

One private company in India is supplying the full infrastructure for setting up this controlled, continuous and quick method of this fodder production system. But so far, the scientists (agronomists and animal nutritionists) have not paid much attention to verify all these claims. There is an urgent need to conduct more research on the different aspects of hydroponics, such as quality and yield of fodder, the whole economics of this process and ultimately its cost effectiveness vis a vis the end user, i.e. the farmer.

Walli (#221) concluded that, it appears that in spite of providing a good quality green fodder all-round the year, the initial cost of setting up the unit and also the recurring cost of growing fodder in this manner does not make it an economically feasible technology, more so for the countries in the tropical region.

In conclusion, hydroponically produced fodder for livestock is a highly palatable (and nutritious) feed but, despite some current promotional material, it is not cheap. When considering such a venture, dairy farmers should “do their homework” and fully investigate the economics of such an investment.

Keeping good herd records

How do we get farmers to keep good records of their stock management?

Hasan (#240) from Bangladesh is concerned about the serious lack of small scale dairy producers who keep good farm records. They do not record when their stock receive any veterinary treatments, vaccines, AI & other services. They think that they need not keep such records because they can easily call on any extension worker for these services. But the problem is that different extension workers may provide such services to different farmers for the same problem or disease treatment. Farmers have this tendency in that they may not trust all service providers as some take some time to cure their sick cattle. Because of this situation, it is very important to make farmers familiar with the keeping of good records for any services. This is more likely to occur if they know the actual benefits of record keeping.

What type of record keeping systems should be introduced to rural communities? Should it be a single page for individual stock? Or should they use a book which will bear all data for all their animals?

Health record cards are used by Grameen in Bangladesh

Bari (#243, #248) of Grameen Fisheries & Livestock Foundation Bangladesh replied to this query, providing a copy of their record card which is regularly updated by their Community Livestock Officers and Livestock Field Assistants. Every Grameen farmer member uses these cards which are available on each visit to provide the total records on any particular animal.

COMMUNITY LIVESTOCK AND DAIRY DEVELOPMENT
GMF/UNDP/FAO PROJECT - BGD/98/009

ANIMAL HEALTH CARD

Name of Animal:	Code No of Animal:
Name of VGM:	Code No of VGM:
Name of Center:	Code No of Centre:
Date of Birth of Animal:	Born on Farm/Purchased from:

VACCINATION RECORD

Type of Vaccination	Dates of Vaccination					
Foot and Mouth						
Anthrax						
Black Quarter						
Haemorrhagic Septicaemia						
PPR						
New Castle Disease						
Fowl/Duck Cholera						
Fowl/Duck Plague						
Infectious Coryza						
Fowl Pox						
Fowl Typhoid						
Egg Drop Syndrome						

TREATMENT RECORDS

Date	Clinical Symptoms	Diagnosis	Treatment	Medicine cost (Tk.)

Traditional buffalo calf rearing systems in Pakistan

Traditional urban and peri-urban dairy farm management in Pakistan

Habib (#254, #256) described the traditional way in which buffalo herds are managed in parts of Pakistan

- After completing their lactations, buffaloes are disposed with 70% of them going to the slaughter houses. Farmers are also not interested in breeding these buffaloes hence they are sold close to drying off and then replaced with fresh lactating buffaloes. Thus the valuable genetic pool of buffaloes is wasted.
- New born buffalo calves, especially male calves in their first week, are sold to butchers for slaughter. They are never kept because of the limited farm space and problems of managing them properly.
- Letdown of milk from the cows is induced by injecting with oxytocin. Farmers oppose calf suckling for milk letdown because it is too time consuming.
- The overall feeding is unbalanced with respect to both energy/protein and minerals. Feeding management is faulty and based on myths. The resultant feeding practices are not cost-effective and add to both suffering of animals and contamination of the environment.

- The farmers frequently use bovine somatatrophin (BST) or growth hormone, with it being promoted by feed supply companies.

Even though milking cows do not need oxytocin or calf for milk letdown, buffaloes are more difficult to deal with as they mostly need oxytocin in the absence of calf. However this could just be a reflex action response as a simple needle prick which would elicit the milk letdown.

Qureshi (#257, #260) considered that the use of oxytocin for milk let down damages the farm economics through delayed ovulation, early embryonic death, abortions and addiction of the lactating animals to the oxytocin. He also noted that when the size of the farm increased, hired labor was engaged, often with little interest with the farm economics or animal welfare. The farmers under this system, face larger expenditures on labor and fodder as compared to those situated in the remote rural areas. Hence, they prefer to keep only lactating animals for cash income and do not like to rear calves or even to rebreed their animals, leading to the genetic drain. So, the farmers lose the calf of the lactating animals and opt for oxytocin. His group has investigated the post-conception decline in milk yield in buffaloes and found it a manageable issue, through feed supplementation. They then advise appropriate feeding of lactating buffaloes to achieve better milk yields and maintain fertility. Proper check on the hired labor will also reduce the use of oxytocin.

The new born calves on these peri-urban dairy farms are not considered feasible by the farmers, to be reared due to higher input costs and higher milk cost. These calves are not fed properly and are sold to the butcher within first or second week of life. The meat quality and social acceptability or religious restrictions do not qualify such calves for meat production; however the meat is offered to the consumers as mutton.

Problems with commercial calf rearing in Pakistan

Habib (#261) reported that small holder farmers can milk their buffaloes without calf or oxytocin but is not possible in farms with more than 50 milking buffaloes because of the management problems.

Regarding rearing of calves on milk replacer, farmers in Punjab were motivated with incentives to purchase newly born buffalo calves and rear them on milk replacer under the program "Save the calf" supported by a government agency. Up until now this has met limited success. The problem is that the required level of hygiene and proper feeding of milk replacer and care of calves is seldom met in these farms. So the calves suffer from heavy mortality and stunted growth. Hopefully these problems will be addressed while expanding the program to enhance Pakistan's beef production.

Walli (#273) reported that research on milk replacer rearing of calves was carried successfully in India almost 4 decades back, but till today the technology has not been transferred to the field. This is because farmers still do not practice weaning, especially in buffaloes. Apart from that, it is perhaps partly due to problem of let down and partly the farmers wouldn't like to spend extra on the purchase of milk replacer. Where ever cross breeding is done on a large scale, male calves are not looked after well, and may end up in slaughter houses. With regard to buffalo male calves, some farmers do take care as these calves, as some meat exporting companies are offering certain incentives for raising these calves under contract farming system.

Ranade (#280) from India reported on a successful heifer calf rearing scheme. His group developed a low cost calf milk replacer incorporating Indian traditional medicinal plants which was patented by Gokul Dairy, a dairy cooperative.

The farmers sold their milk to the cooperative then use the lower cost milk replacer to feed their calves. Since 2006, Gokul Dairy has been paying farmers Rs 22 to 24/L for milk against that the cost of milk equivalent from milk replacer of Rs 3.0 to 3.5/L. As of today, the female calf rearing scheme is continuing with Gokul Dairy selling 12 to 15 T of milk replacer. Such a scheme has been established in other dairy Indian cooperatives.

Peri-urban farming of dairy buffalo in India
(Photos provided by Dr Bakshi from India)

7. Lessons learnt and Conclusions

Developments with by-products

The most common processing methods used to improve the nutritional quality of fibrous and nonconventional feed resources include physical, chemical and biological methods. Unfortunately, these are often beyond the reach of small farmers. Furthermore, the costs and returns, hence the economic benefits of using these approaches have not been well documented. The search is continuing to develop alternative and more cost effective and easily adoptable technologies.

Poor acceptance rates by the small farmers for majority of these techniques is attributed to the lack of extension facilities, unavailability of inputs and the time and labour involved under small farm situations. A simpler robust cost effective and eco-friendly viable technology will be the key to maximize the gains from dairy cattle.

Further attempts should be made by the plant breeders to develop genetically modified crops with enhanced forage quality without comprising on their grain yield. Research is in progress in developing toxin-free/low-toxin containing plant varieties that are safe for animal feeding. Therefore, enhancing of "Nutritional quality traits" using biotechnology and conventional approaches will play an important role in improving the quality of by-products from grain crops.

Farmers generally do not have easy access to many of these improved and appropriate technologies. Every effort needs to be made to ensure effective delivery systems that can potentially impact on total production increases, socio-economic benefits, improved livelihoods and sustainable development. Associated with this is the strengthening empowerment of women and youth by providing training and effective dissemination of information. It is equally important that the farmers have the necessary resources and capacity for technology adoption. When fully developed, milk co-operatives can contribute significantly to rural development, and enable smallholder systems to respond to market dictates and consumer needs.

The availability of energy and protein-rich by-products varies considerably over season and region. The best way to assess their suitability is based firstly on their year round availability and secondly, the relative costs of their energy or protein when fed to the small holders' milking cows.

Many small holder farmers do not have the resources to purchase large quantities of by-products for subsequent storage until required by their stock. They then have to depend on the vagrancies of the market place with regards their availability and cost. Lending agencies, milk processors or dairy cooperatives could provide such finances with repayment schedules based on additional milk income when they are actually fed out. This would require detailed financial analyses of the current and future costs of these by-products together with their storage until required.

Future research areas with by-products

In his background paper to this E-Conference, Krishna listed the following areas for future by-product research:

- Laying emphasis on inter-disciplinary approach and further investigate the nutritional implications of feeding genetically modified crops and their by-products on the performance and health status of cattle and buffaloes.
- Animal nutrition research needs to be reoriented to meet the nutritional challenges being faced under varying agro-climatic conditions by the smallholder farmers in the developing countries.
- The environmental dimensions also need to be considered while addressing issues of intensification and efficiency in relation to the increasing use of scarce natural resources.
- A combination of food-feed crops, agricultural by-products, introduced high yielding forages and balanced ration formulation are among the important options for exploiting available feed resources to the maximum advantage in the developing countries. More work is required on realisation of these options.
- Opportunities related to better market access for feeds, use of smart supplementation and novel feeds, and engagement of private sector to upscale laboratory based processes especially for detoxification of unconventional feed resources, need to be considered for strengthening livestock production as more remunerative enterprise.
- There is a need to develop innovation systems approach that helps to ensure that technologies are relevant and delivered to the end users, thereby contributing to the livelihoods of the poor.
- In many institutions, natural resource management issues are neglected and disciplinary barriers between the soil, plant and animal sciences which preclude application of a holistic approach. There is an urgent need to remove these barriers.
- Research should involve both production and post-production components and be based on a response to ex-ante analysis while the research should address major constraints, real needs and generate new knowledge and products.
- There is an urgent need for an institutional commitment to demand-led research that is multi-disciplinary and farming-system oriented.

Developments with improving the management of tropical dairy systems

Perhaps the biggest constraint to improving the utilisation of by-products is their technology transfer. A published research paper may be the end product of a research scientist's work load but it will not be read and acted on by the farmer. Even though there are still large gaps between "what exists" and "what is known' by the *information generators,* they are even larger gaps in what the farmers know about current research from which they could directly benefit. A more coordinated approach is required, firstly for the *information disseminators* to document current knowledge in more farmer friendly ways, secondly to seek feedback from the *information assessors* so that the *information users* can convert this new knowledge into dollars, baht or rupees.

Another management problem discussed during the E-Conference was the lack of herd data collection using printed recording sheets. The best approach to stimulate interest is for the farmers to see for themselves, the benefits of having their own documented records instead of simply depending on their memory. As with any technology transfer, the farmers need to be convinced of the benefits.

Although genetics is frequently a constraint to tropical dairy production systems, the impact of cow quality on farm productivity becomes a real issue when other constraints are largely addressed. Most Friesian type cows are capable of 10 to 15 L/day of milk when properly fed and managed whereas 5 to 7 L/day is more common in current tropical dairy systems. Hence the take home message should be “don’t blame the cow as she is doing the best she can under her current management”.

Another topic of little relevance to practical feeding management discussed at the E-Conference was hydroponically-produced feeds but these deliberations provided few positive conclusions about any economic benefits to the small holder dairy farmer.

Although low milk yields are a feature of tropical dairy systems, farmers are often more concerned about poor reproductive performance, particularly repeat breeding. Once it was mentioned during the E-Conference, it created considerable discussion, much of which was not closely related to by-product feeding management. As it was considered to be primarily nutrition induced, by-product feeds are very relevant, even utilising foods normally consumed by humans, such as duck eggs and purchase sugar.

The problems of poor reproductive performance are magnified during the wet season in flood prone areas such as in Bangladesh, primarily because of the inability of farmers to source forages other than low quality rice straw. This problem has been researched for several decades and the answers may have already been discovered but not yet incorporated into improved production systems that have been demonstrated at the farmer level.

The final herd management topic that was briefly discussed was the appalling management systems of buffaloes and their calves in Pakistan. Slaughter of week old heifer calves and using oxytocin and growth hormone to stimulate milk let down seems incomprehendable in modern day tropical dairy production, but it is occurring.

Following on from this E-Conference

In its final few days, discussions were had on what sort of follow up activities should occur after the E-Conference.   For example, Rangnekar, (#150) stated that “I feel one of the useful outcomes of this E-Conference would be establishment of links between scientists and development persons from various developing countries to take benefit of work already done on by-products and their use for feeding dairy animals. It may also be useful to compare results of studies.

Over 78% of the respondees to the evaluation process considered the conference subject matter to be very relevant to their needs. There were many suggestions for topics for future E-Conferences conducted by the Asia Dairy Network. With regards herd management, 6 people requested reproduction and 6 requested rearing young stock.

With such a receptive audience, a good opportunity arose for us to advertise our next innovation on improving the understanding and practices of improved feeding management of tropical dairy stock. In this case it was a series of free four week E-Learning programs to be help during 2014. These are based on a 16 module course associated with a virtual classroom to help clarify specific queries about tropical dairy feeding and herd management. Full details are available on the website www.dairyasia.org.

To date (Feb 2014) a total of 20 E-Conference participants have registered for the E-Learning program, being from Indonesia (5), Bangladesh (4), India (3), Australia, Iraq, Pakistan, Philippines, Sri Lanka, Thailand, United States and Zimbabwe.

Appendix: Email addresses of the multiple contributors to the E-Conference

India

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Green leafy material can be conserved as silage in a 10 to 12 feet long 6 feet in diameter tubes using 60−80 μ thick, low density polyethylene. Each one can hold up to 0.5 tonnes of green forage (Photos provided by Dr Bakshi from India)