Proceedings of the

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PREFACE

The goat was the first animal to be domesticated by humankind. The global goat population currently stands at 921 million, of which over 90% are found in developing countries. Asia is home to about 60% of the total world goat population and has the largest goat breed share of 26%. Goats play a vital socio-economic role in Asian agriculture, particularly for resource-poor people living in harsh environments. Non-cattle milk accounts for approximately 15% of the total milk consumption by humans worldwide. Asia contributes approximately 59% to world goat milk production and Asia's demand for animal products, fueled by increasing populations and growing disposable incomes, is increasing at a high rate.

Despite their socio-economic importance, goat rearing has not attracted much attention of development practitioners, science managers and researchers or policy makers in Asia. However, lately, due to the emerging challenges of climate change and increasing pressure on natural resources and the high value of goat meat and milk across a number of Asian countries, the potential of goats with their high adaptability to a wide array of environmental conditions and „low quality' feed resources is being increasingly appreciated. Goats use poor quality roughages with high cell wall and low protein contents more efficiently than other domesticated animals.

In Asia concerted efforts are needed to address issues facing goat farmers and the goat milk processing industry to fully exploit the potential of goats. FAO joined with the Universiti Putra Malaysia (UPM), Department of Veterinary Science, Malaysia and the International Dairy Federation (IDF) in organizing the First Asia Dairy Goat Conference in Kuala Lumpur, Malaysia from 9 to 12 April 2012. The conference provided a platform to share technical information and experiences and to network for the promotion of dairy goat farming.

The conference was attended by 130 participants from 20 countries and 5 continents. These proceedings contained keynote and plenary addresses and research papers covering various disciplines including nutrition, breeding and genetics, milk and milk products and socio-economics of goat production. The deliberations and the information presented in the proceedings lead to the following conclusions and recommendations: a) there is a huge demand for goat milk in Asian countries, b) the sale price of goat milk is 2 to 4 times higher than that of cow milk in many Asian countries, c) the goat milk processing industry is not well developed in Asia and there is a need to address this issue through public-private partnerships, e) R&D work on goat production has been neglected and there is a need to generate knowledge in the areas of nutrition, health, reproduction and genetic diversity and to collate and disseminate the already available information, f) the extension work and training of goat farmers should be given top priority, g) development of sound and relevant policy options, institution building and linking farmers to markets should be addressed, leading to both increase in goat milk production and processing of goat milk, e) South-South and North-South collaboration should be promoted in areas that lead to increase in goat milk production and processing. The deliberations also stressed the need for an Asia Dairy Goat Network, and we are pleased to report that the Network, with secretariat based in UPM, and having the mission: a) facilitation, generation, collection, dissemination and exchange of knowledge on goat production, b) provision of technical, institutional and policy support to stakeholders involved in goat production and goat milk processing, and c) promotion of improved and sustainable dairy goat farming in Asia will be launched within this year.

With the publication of the conference proceedings, we hope that goat farmers, goat rearing and goat milk processing industry would attract the attention they rightfully deserve.

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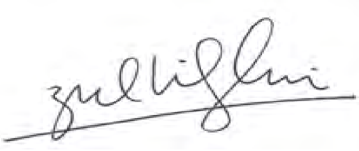

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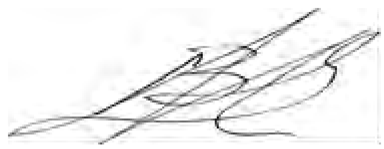

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Dairy Goats in Asia: Multifunctional Relevance and Contribution to Food and Nutrition Security

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Introduction

Improved animal production and productivity enhancement in Asia are justified in direct response to the need for more animal proteins which are currently inadequate. This is associated *inter alia* with the following: 1) Agriculture is declining and its share to the gross domestic product (GDP) in East Asia, the Pacific and South Asia, has dropped from 30% in the 1980s to a mere 10% in 2000–2003 (ESCAP, 2008), 2) Rapidly rising incomes in Asia are driving a concurrent surge in the demand for more foods of animal origin, 3) Exploding food prices and rising cost of production inputs are expected to push an additional 40–100 millions into poverty, 4) Inadequate productivity of dietary animal protein supplies are far more serious than energy from cereals which will exacerbate food and nutritional insecurity and 5) Projected requirements for milk in China, India and Southeast Asia (FAO, 2006) up to 2020: 100, 89 and 433%, respectively and to 2050 double the current requirements.

This paper discusses the potential multifunctional value of dairy goats, efficiency of milk production, development pathways for increasing their contribution to food and nutritional security and improved livelihoods in Asia.

Goat genetic resources: Diversity and distribution

The world population of goats is about 921 million, and includes a total of 570 breeds. In the developing countries there exist over 30 potentially important indigenous “improver breeds”, 15 of which are in Asia. Asia had the largest population of goats of about 60% (556 million), followed by Africa (311 million). India (35.2%), China (29.3%) and Pakistan (12.0%), together had 77% of the population and 42% of the breed share (Table 1). During the period 1986–2010 in Asia, the goat population growth rate was 2.3%/yr. Europe accounted for only 2% of the goat population, has 187 breeds and 33% breed share. Many of the European breeds have been widely introduced into many Asian countries. The majority of the goats are found dispersed in small farms which in Asia account for 67% of 470 million small farms worldwide of less than two hectares of land (Nagayets, 2005). This excludes several million landless farmers and agricultural labourers who rear goats. Concerted breeding and conservation of indigenous oat breeds is a means of mitigating climate change effects, with associated benefits to the trade of live animals and products.

“Improver breeds” are defined as potentially important breeds that are capable of making a special genetic contribution, have above average levels of performance, can enhance productivity, or are specially adapted to a particular difficult environment.

Dairy goat breeds

Asia has a 26% goat breed share in global terms, equivalent to 146 indigenous breeds (Table 1). About 94% of these breeds are meat breeds whose presence is consistent with the fact that meat is the most important product from goats in all countries without exception (Devendra, 2007).

Table 1. Goat populations, breeds and their global distribution (FAO, 2010)

Region	Year 1986	Year 2010	% (2010)	Average growth rate (%/yr)	Breeds	Breed share (%)
Africa	105.4	310.7	33. 7	2.8	89	16
Asia and Pacific	253.5	556.1	60.4	2.3	146	26
Europe	10.8	16.5	1.9	1.4	147	33
Latin America and the Caribbean	32.9	212.6	4.8	22.8	34	6
Near East	83.9	267.5	2.3	9.1	94	16
North America	1.8	3.0	0.1	1.7	20	0
Total	**488.2**	**920.6**	**-**	**7.0**	**570**	**100.0**

By comparison, dairy goats are significantly fewer, and only 13 in Asia are considered to be truly identifiable dairy breeds (Devendra and Haenlein, 2011) (Table 2).

Table 2. Asian Dairy Goats and Potential " Improver Breeds"

Nation	Dairy Goats and Potential "Improver Breeds"
China	Ma T`ou*
India	Barbari*, Beetal, Chegu*, Gaddi*, Jamnapari, Jakhrana, Malabar, Marwari*; Sangamnari*
Indonesia	Etawah (Jamnapari)
Pakistan	Bujri, Chapper*, Damani, Dera din Panah, Jattan, Jarakhell, Kachari*, Kamori, Koh-I Ghizer, Kacchan*, Kajli*, Kuranasari*, Kurri, Labri*, Patteri
Vietnam	Bach Thou

*Denotes that the breed is dual-purpose, usually producing meat and milk

In Asia only 13 dairy breeds or 9% of all breeds are identifiable. These breeds are also low-medium milkers. Many of the "improved breeds" have not been used outside of the country of origin. Additionally, 13 dual-purpose (meat and milk) goats exist, less well known and with variable milk yields. The potential of many of these breeds remains to be assessed.

Due to the presence of only a few indigenous dairy breeds with low milk yields, improved breeds with much higher milk yields have been introduced variously into Asia. These include Alpine, Anglo-Nubian, Saanen, Togggenburg and the Boer. Crossbreeding these with the indigenous breeds has been generally haphazard and gave variable results and a hotchpotch of crossbreds. In Malaysia and Trinidad for example, crossbreeding with the Anglo-Nubian up to F2-F3 generations has consistently given improved productivity.

Multifunctionality: Products and services

Goats contribute significant and extensive multipurpose functions of socio-economic and nutritional relevance. The products and services are especially important for socio-economic benefits, the stability and prosperity of poor farm households in Asia.

Products
The products from goats are meat (raw, cooked, blood, soup, goat meat extract – "Zeungtang" in Korea), milk (fresh, sour, yoghurt, butter, cheeses), skins (clothes, shoes, water/grain containers, tents, handicraft, shadow play in Indonesia, thongs etc.), hair (cashmere, mohair, garments, coarse hair rugs, tents, ropes, wigs, fish lures), horns and bones (handicraft) and manure and urine (crops, fish).

Services
Among the services that could be acquired from dairy goat production are cash income and investment, security and insurance, prestige in ownership, gifts and loans, religious rituals e.g. sacrificial slaughter, human nutrition, pack transport and draught power, medicine and control of bush encroachment.

Services from dairy goat production can be improved by promoting a wider use of „improver' breeds both within as well as in other countries with similar climates, recognising that there are disease issues that must be settled. The problem of dairy goat production is exacerbated by failure to identify the attributes with clear production objectives and improvement programs that can increase the level of production. In these circumstances there is an increasing tendency to resort to imports of one or more exotic breeds at varying costs with resultant genetic chaos. Controlled use of chosen introduced breeds is essential for efficient use of the natural resources to achieve specific socio-economic benefits.

Contribution to improve food and nutritional security

Meat
Given the drier and harsh environments that goats thrive in, their ownership by the poor and the landless provides food security and the principal means of survival. In these same environments, goats provide precious meat and milk for immediate family consumption to overcome both malnutrition and under nutrition. Small size of goats is significant in that it provides multifunctional socio-economic, managerial and biological advantages. Low individual values mean a small initial investment and small risk of loss, which is attractive to subsistence farming, especially for poor people. Managerially, they are conveniently cared for by women and children and occupy little housing space.

Milk
Total goat milk production in Asia as percentage of all milk is small and is about 3.6% (FAO, 2010). Goat milk is characterised by predominantly small milk fat globules widely referred to as homogenised goat milk, less curd yield, and weaker curd firmness which together aid digestion. The milk fat has significantly higher contents of short chain, medium chain and polyunsaturated fatty acids than cow milk and its cheeses. One litre of goat milk contains

about 32 g of proteins and represents 70% of the dairy requirement of a lactating or pregnant mother. It is adequate for a child up to 11 years of age. The calcium supply of 1.7 g/litre meets the daily requirements. Goat milk provides higher levels of 6 of the 10 essential amino acids: threonine, isoleucine, lysine, cystine, tyrosine, and valine compared to cow milk (Posati and Orr, 1976). Goat milk exceeds cow milk in monounsaturated, polyunsaturated fatty acids and medium chain triglycerides all of which are well known to be beneficial for human health, especially for cardiovascular conditions (Haenlein, 2004).

The various contributions of critical dietary nutrients are especially significant for resource-poor farming families living in the shadow of continuous subsistence and vulnerability. Most of the milk is marketed informally mainly in the rural areas. In China for example, less than 5% of the goat milk is marketed (Luo, 2009), the remainder of which is presumably used for household consumption. The multifunctional value of goats owned by farmers and entrepreneurs is enlightening and is greatly enhanced by exhibitions and goat shows. Central to this is the important role of goat societies in serving development, maximising total; milk production, and a positive response to meeting the national priorities.

Efficiency of milk production

The question of whether dairy goats are more efficient than buffaloes or cows is not clear at the present time and is one of conjecture. High producing dairy goats have a relatively large intake of feed and greater production of milk than lower producing dairy goats. This is related to a greater proportion of mammary gland and volume of secretary tissue in the total body mass. The uniform requirement of feed for maintenance implies that goats of the same size but higher milk yield will be more efficient because the maintenance overheads are spread over a greater volume of production. In India, based on the calories in milk as percentage of feed energy, dairy goats (21–30%) and dairy cows (25%) were found to have similar efficiency which was higher than that of the dairy buffaloes (Sundaresan, 1978). In Great Britain, Spedding (1975) reported that in terms of milk yield per 100 kg of digestible organic matter, the dairy goat producing 185 kg was more efficient than the lactating cow (162 kg) or sheep (36 kg). In low input systems in the rural areas, dairy goats may well be particularly more efficient, using the available feeds to maximum advantage, including high efficiency in the use of fibrous crop residues to produce milk. Present knowledge on the efficiency of milk production in goats is inadequate and merits much more research on the subject.

Goats or cows for milk production?

A development dilemma for resource-poor small farmers is the choice of dairy goats or cows for small-scale household milk production at the village level. With very resource-poor peasant farmers, the choice of goats as dairy animals is related to the following advantages: low capital investment and production costs, optimum use of meagre resources which favours goats rather than cattle in low-input systems and marginal environments, faster generation turnover and therefore earlier milk production compared to cattle, effective use of family labour including women and children, reduced problems of storage and distribution of milk, production of milk for mainly household consumption and nutrition and secondarily for commercial sale. Access to a ready supply of meat and milk provides a constant source of animal proteins for poor people who cannot afford to buy these products, or alternatively, are unable to produce these products from their farm.

At low levels, dairy goat production is about one to two litres per head. Goats do not require high levels of dietary energy and protein, and can in fact survive on browse, forage and crop residues. The cost of production is relatively low and only increases when purchased concentrate supplements are fed. Under these circumstances, it is more realistic, nutritionally appropriate and economic to encourage milk production from goats in rural and peri-urban areas parallel to urban milk production from cows. Direct investment to family goat herds in rural areas is therefore likely to have much more impact on the quality of lives of the rural poor. A two-pronged strategy that could be implemented is intensification of dairy goat programmes for the rural and peri-urban areas and commercial dairy cow milk for the urban areas. Realisation of the former is a challenging task for the future.

Development strategies

Development strategies for dairy goat production should be cognisant of 1) the relevance of listening to farmers, 2) the constraint analyses and priority setting, 3) ensuring appropriate research thrusts to serve development, 4) build-up the numbers of appropriate breeds, 5) clear production objectives, 6) improved utilisation of the totality of available feeds, 7) linking production to post-production-consumption systems and 8) improving marketing systems.

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Plenary 1

Linking Smallholders to Markets – Opportunities and Challenges

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Introduction

An estimated 2.6 billion people in the developing world have to live on less than US$ 2 a day. Of these people, about 1.4 billion are extremely poor, surviving on less than US$ 1.25 a day each. Asia harbours the majority of the world's extremely poor, with 933 million, while the incidence of extreme poverty is highest in sub-Saharan Africa, at one in two people (50%) (Chen and Ravallion, 2008; World Bank, 2007). The majority of the poor live in rural areas and many are smallholder farmers with livestock forming an essential component of their livelihoods portfolio. Much has been written about the „safety-net' function of livestock in subsistence-oriented rural households, and many development interventions have focused on safeguarding the livestock assets of the poor. Recognising the acceleration of demand for livestock products in the developing world, particularly in rapidly emerging Asian economies, this paper examines on the potential of livestock to act as „cargo-net' to lift households out of poverty via improved access to growing urban food markets. This perspective advocates a „market-led' approach to self-directed poverty reduction, a strategy that leverages private agency to complement other forms of development assistance.

Asia's food markets

Asia's food markets have been estimated to be in the order of PPP[1]US$ 2 to 2.5 trillion per year, by far the largest of any developing region (WRI, 2007). Approximately 10% of total food expenditure is spent on milk and dairy products (around PPP US$ 170 billion in South Asia and PPP US$ 50 billion in East Asia). Rising incomes of Asian households and high income elasticities of demand for animal source food (ASF) are projected to lead to tremendous increases in aggregate demand for livestock products over the coming decades. For milk and dairy products, the increase in consumer demand between 2000 and 2030 has been estimated to be in the order of 24 million tonnes (132% increase) for East Asia while for South Asia the corresponding figure stands at nearly 120 million tons (143%) (Robinson and Pozzi, 2011).

Despite the projected rapid income growth in Asia, the bulk of this demand for food originates in households with per capita incomes of less than PPP US$ 3,000 per year, consumers who still favour traditional and „fresh' produce offered at markets with supply chains that are mediated mainly by informal and customary networks of low income agrifood intermediaries. In these countries, only the top income decile currently presents a viable market for high-value processed cold chain products.

[1] Purchasing power parity

The current expansion of markets for ASFs in developing countries, and their large degree of diversity therefore represent enormous income potential for the rural poor, many of whom own livestock, as well as their urban market intermediaries. However, which benefits of growing urban food demand go to rural smallholders and which to expanding agrifood industries will depend to a significant extent on policy decisions. Without public commitment to promoting smallholders farmers' and agrifood intermediary market participation, it is likely that these groups will be economically marginalised, while urban growth masks continuously rising inequality.

Poverty incidence, poverty density and market access

Poverty incidence/rate describes how common poverty is in a given location but not how many poor people could be affected by a policy or programme that targets that location. As Figures 1a and 1b make this clear for the case of Vietnam, poverty incidence can be very high (i.e. poverty is common) in remote areas with little if any market access. Targeted market access policies for reducing poverty in these areas could be quite expensive, however, requiring large commitments per capita of scarce public investment funds for transport, communication, health and education infrastructure, without helping most of the poor. In low-income countries, public funds have high opportunity costs, which make such expenditures difficult to justify on the grounds of cost-effectiveness.

In contrast to poverty incidence, poverty density identifies the actual numbers of poor people in given localities across a country. Figure 1c displays poverty density and the results are visually arresting. Although poverty is very common in sparsely populated (remote) provinces, it becomes clear that the majority of the poor live in areas where poverty incidence is comparatively low, often in reasonable proximity to urban areas. This evidence suggests a different strategy for poverty reduction, one that promotes market access incrementally, radiating outwards from urban areas, rather than laying out extensive (and expensive) new corridors to remote areas. From and infrastructure perspective, such access can be facilitated with existing commitments to urban development. This permits development funds to be focused on the institutional barriers to market participation by the poor.

Barriers to market participation

Participation in expanding markets for livestock products does not occur automatically. Wherever there are profits to be made in an emerging urban consumption sector, larger commercial suppliers will compete to capture market share for any product. When household producers are unable to participate in the growing markets that attract larger commercial producers, it is generally because of barriers to market access or entry.

In agrifood supply at its smallest scale, from the smallholder farm gate, a household sells its product to a trader, initiating a chain of exchange relations across a market system that takes the product through a number of stages to reach final consumers. From the first step, this elemental agrifood supply chain is complicated by many market access barriers and information failures, which individually and collectively limit the livelihood potential of family farming. Smallholder livestock supply chains are plagued by the following imperfections: low input quality, including information and knowledge; low sanitary standards; low bargaining power; moral hazard; distrust. Each of these uncertainties undermines willingness to pay and contributes to serious adverse selection bias in such markets. Ultimately, this problem feeds back to producers, who have little incentive to invest in quality or expansion, actions that could lift them out of poverty by their own efforts. Unless these market imperfections can be overcome, the low investment trap will remain individually rational for smallholder farmers, and the livelihood potential of livestock markets cannot be realised.

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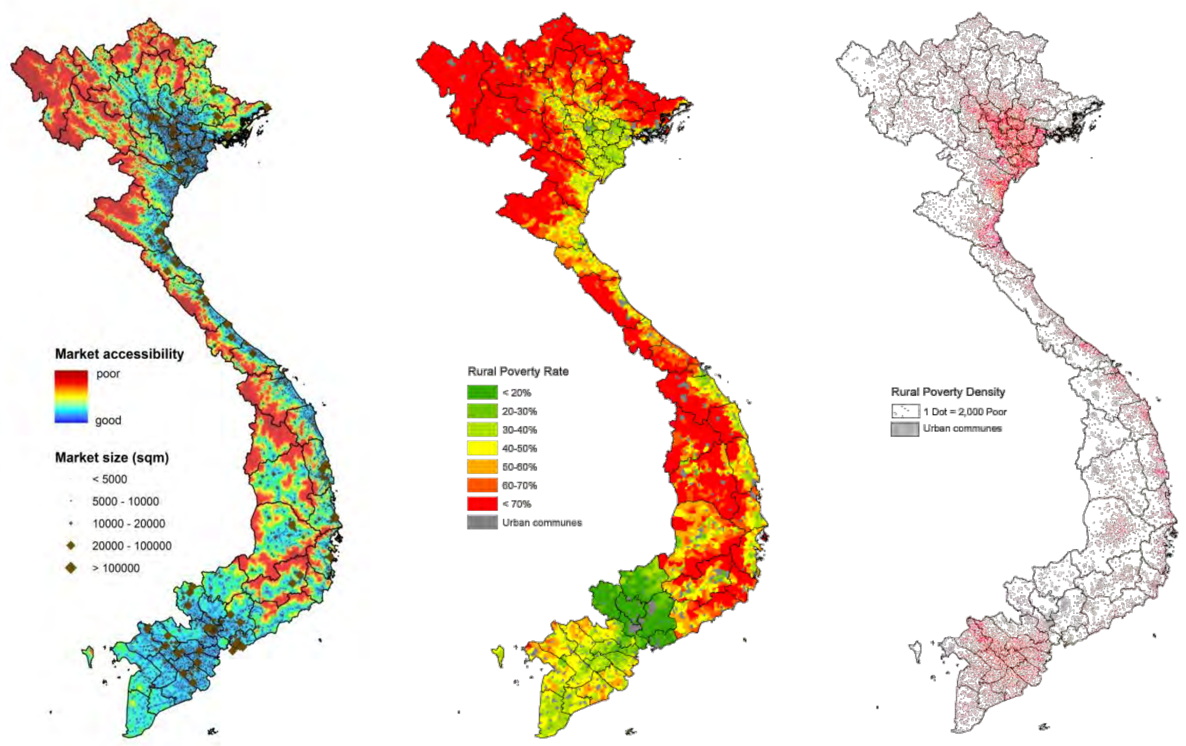

Figure 1. (a) Market accessibility, (b) Poverty incidence/rate, (c) Poverty density in Vietnam

Overcoming barriers to market participation

Diversification is a risk management strategy for smallholders, evolving from self-sufficiency and expectations that the burden of external shocks will be borne individually. For smallholders to emerge from this situation, they need a credible strategy of commercialisation, specialisation and investments in higher value added. Unfortunately, their conditions make smallholders unlikely to compete against established commercial agrifood enterprises in urban markets. To be successful, smallholder producers need to emphasise their strengths – traditional product variety and low resource costs – while policies for inclusive development are implemented to facilitate their market participation.

Willingness-to-pay surveys across a wide range of countries show that consumers put a significant premium on the traditional livestock varieties that have historically been produced by smallholders. The existence of this premium suggests that market access strategies can promote self-directed, privately financed long-term poverty alleviation. Moreover, smallholder producers are linked to downstream consumers through networks of low-income intermediary enterprises, so their continued viability secures pro-poor multiplier effects across the broader economy. Overcoming information and access barriers would improve incentives for individual enterprise investments from farm to fork, meaning that these poverty reduction initiatives could eventually be self-financed – a welcome substitute for open-ended fiscal commitments to public assistance. Finally, demonstrated willingness to pay for traditional livestock products also suggests that the general public has a distinct preference for them, countering the pressure from some commercial interests to phase them – and the associated production systems – out.

Governments can play a critical role in enhancing these pro-poor supply networks by supporting grassroots producer cooperatives and extension services and maintaining a general environment that is congenial to small enterprise development. Among other elements, this would include strengthening animal health services, protecting intellectual property rights, supporting the development of standards and reputation building through certification or branding programmes, improving existing market infrastructure, and developing small wholesale markets with registered slaughterhouse facilities in strategic urban locations.

Smallholder farmers' access to information and technology should be improved, particularly with respect to product quality, pricing, and other market conditions. On the financial side, micro-credit schemes can accelerate technology adoption and small enterprise modernisation, improving productivity and product quality/reliability and leading eventually to established brands and reputation that confer higher long-term value added at lower transaction cost. Education on contracting, negotiation, and conflict resolution would improve the extent and terms of smallholders' market participation. Governments can also reinforce the efforts of farming groups that already apply economically viable production practices, while recruiting farmers interested in emulating these examples. Such initiatives can be modelled on early strategies of Western agrifood producer cooperatives, which are now the primary guarantors of product quality and farm market access in OECD countries.

Conclusions

In many developing countries, rapidly emerging urban demand for livestock products presents an enormous opportunity for domestic agriculture, but there is also serious risk that smallholder rural majorities will miss this and be marginalised by agrifood industrialisation. It must be recognised that the majority of agricultural and rural households in developing countries are unlikely to be recruited directly into agrifood industrialisation; even intermediate stages of sector consolidation, such as contract farming, appear to be undertaken at a scale well beyond that of the average smallholder farmer. On the contrary urban demand must be more fully appreciated for its inclusive development potential, and more national livestock and other agrifood markets will only arise from determined policy commitments to overcoming existing entry barriers, information and agency failures, and historic bias in favour of integrated agrifood enterprise development.

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Plenary 2

Challenges Facing Dairy Goat Farmers in Malaysia

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Introduction

Malaysian agriculture sector in the year 2009 contributed 9% to the Gross Domestic Product. However, in terms of agriculture subsector, livestock contributed 27% to agrofood production. The current status of livestock industry shows 5.4% annual growth (2000–2009) with an ex-farm value of RM 11.26 billion in the year 2010, an increase from RM 5.56 billion in the year 2000. Trade of livestock products in the year 2009 was valued at RM 2.33 billion for exports and RM 9.06 billion for imports. The total number of farmers involved in the livestock sector in the year 2009 was 201,888. An estimated economic value for the livestock industry is RM 67 billion for the year 2010.

Production in the livestock subsector is accounted by poultry meat contributing 1,202,000 metric ton (59.37%), pork 206,000 metric ton (10.18%), egg 510,000 metric ton, milk 62,000,000 litre (3.08%), beef 42,000 metric ton (2.08%) and mutton 22,000 metric ton (0.11%). The production of mutton in the livestock subsector reflected the small number of goats in this country.

Malaysia has been producing goat's milk for some time. There has been a dramatic increase in the development of dairy goat farming in this country with large importation of dairy goats from various countries since goat milk has a significant niche market. In Malaysia scientifically based information on dairy goat farming is very limited. This paper discusses issues and challenges facing dairy goat farmers in Malaysia.

Issues and Challenges Facing Dairy Goat Famers in Malaysia

Dairy goat farming is a fast growing livestock industry in the country and a potentially profitable venture, although it is still in its infancy. However, there are issues and challenges in development and improvement of the dairy goat industry that farmers have to face. Among the issues and challenges facing dairy goat farmers in Malaysia are:

Dependency on imported breeding stock

There is insufficient quality breeding stock in this country and farmers have to rely mostly on importation of animals. Efforts have been made to develop the Germasia, a dual purpose breed, however the number of animals in the country is small. Multiplication of quality breeding stock locally is of paramount importance.

While importation of animals is explored, artificial insemination services should be carried out throughout the country to produce purebred and crossbred animals. Dairy Goat

Data Centres should be established and farmers should be encouraged to maintain individual farm records.

Ability of farmers to utilise comparative advantages concept

This concept is important for the reduction of production cost especially for feed and nutrients. Although green feeds are the main components of animal feed, farmers still use concentrate (goat pellets) extensively to feed their animals. The main ingredient of the concentrates is maize and this commodity has to be imported, the price of which fluctuates with the global market. Thus alternative feed sources have to be identified and made available within Malaysia.

Feasibility studies of alternative feed sources (energy and protein) available locally should be conducted and the findings should be made available to the farmers. More home plots planted with good quality pasture should be established, while forages under rubber and oil palm plantations should also be explored as another alternative source of green feeds.

Crop-livestock integration systems that have been studied by the Malaysian Palm Oil Board (MPOB) could be adopted to reduce operational cost. In 1999 MPOB [then Palm Oil Research Institute of Malaysia (PORIM)] developed a successful model of the integration of dairy goats (Saanen) with mature oil palm plantations and this could be adopted by the farmer. Apart from that, farmers and farmworkers should be trained so that their technical capacity may be improved to achieve high productivity. Zero-waste concept industry also should be explored in the dairy goat farming. Application of the comparative advantages concept on use of inputs, systems approach toward outputs is critical in the dynamic economic scenario for dairy goat farming.

Animal health and disease

Poor animal health and diseases are usually related to the cause of low farm productivity and indirectly to low profit margin. Zoonotic and infectious diseases such as brucellosis and foot and mouth disease, which can easily infect animals are a major threat to the animal industry. Thus actions should be taken to reduce the incidence of these diseases.

Farmers should be encouraged to practice good biosecurity standards through the adoption of Good Animal Husbandry Practice (GAHP) at farm level. They should also be trained to identify any abnormality that may surface in their herds and promptly report to the relevant authorities. While at the state level, efficiency in diagnosing diseases at an early stage by competent authority could also help in reducing economic losses.

Marketing and local consumption trends

In general, demand for dairy goat products in Malaysia is growing steadily. However, the demand for goat’s milk is very small because of the goaty odour. A supply chain in the marketing of goat’s milk in Malaysia from farm gate to consumer should be developed engaging wholesalers, retailers and customers. Grading of goat’s milk should be implemented to eventually deliver the quality of milk that meets customer satisfaction.

Conclusions

Dairy goats produce both milk and meat. Therefore it will be more viable to venture into dairy goat than meat goat farming. Dual purpose goats should be a breed of choice that will contribute greatly towards the development of the Malaysian dairy goat industry. Farmers using dairy goats would experience better viability and sustainability in their goat farming business simply because milk production will provide them a constant cash flow.

Availability and suitability of dairy goat breeds for this country will provide impetus for large-scale dairy goat farming in Malaysia. Involvement of the private sector is required to accelerate the transformation process and promote growth of the industry. The potential of value-added dairy goat products and recognition of Malaysia's halal accreditation system should be taken advantage of, to increase local and export market.

Plenary 3

Dairy Goat Farming in Australia: Current Challenges and Future Developments

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Introduction

Goat production in Australia is regarded as an emerging industry with production and farming of goats increasing annually (Abud and Stubbs, 2009). Goats were introduced into Australia in 1788 by the first settlers as a source of meat, milk and fibre and have since adapted well to the Australian conditions (Shim-Prydon and Camacho-Barreto, 2007). In Australia the focus of production has moved from small, localised farms to larger scale farms on more suitable land. Farmers have been able to establish partnerships, local markets have expanded and exports have increased to the extent that Australia is currently the largest goat meat exporter in the world (Abud and Stubbs, 2009). Even though it is expanding, the goat industry in Australia and the dairy industry in particular, are still relatively small when compared to the main livestock enterprises. The small scale of the industry (Figure 1) is the most likely reason for the paucity of research into the different aspects of dairy goat husbandry in terms of health and production. Facts sheets and general husbandry information are readily available and easily accessible to dairy goat farmers; however, as the industry is rapidly growing, the lack of research in dairy goat health, welfare and production could represent a serious limitation to the long term viability of the industry.

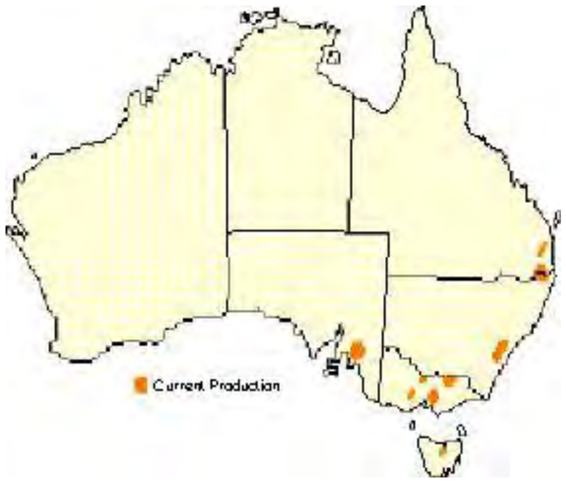

Figure 1. Dairy goat production areas in Australia (RIRDC).

The aim of this paper is to provide an overview of the dairy goat industry in Australia. Current issues and challenges that the Australian dairy goat industry has to face in relation to its growth and development will also be discussed.

The dairy goat industry in Australia

The dairy goat industry in Australia has traditionally supplied fresh milk to the local market. In the past farms were small (15 to 20 milking does), and operated as niche industries; however, this is rapidly changing. The increased popularity of specialty cheeses has created an unprecedented demand for goat's milk and the cheese market is typically easier to service than the fresh milk market. Farmers are no longer tied to land near city markets and do not have to self-manage the whole enterprise from production and packaging through to marketing and distribution (MLA, 2005). The industry has grown significantly since the beginning of the nineties, currently producing almost 5 million litres of milk a year (Shim-Prydon and Camacho-Barreto, 2007). There are approximately 50,000 milking goats in Australia. Victoria, the largest producer, has 14 commercial herds with an estimated annual production of 1.1 million litres for 2003–2004 (Shim-Prydon and Camacho-Barreto, 2007). New South Wales, Queensland and Tasmania also have milk-processing facilities. The dairy goat industry is predominantly pasture based and is therefore confined to the high rainfall, agricultural areas of the country. While this offers cost of production advantages, it represents a potential threat to the industry as it increases the susceptibility of goats to intestinal parasites and footrot. From a marketing perspective, the key challenge for the Australian dairy goat industry is being able to supply a consistently high quality product to meet year round demand (Shim-Prydon and Camacho-Barreto, 2007). Goat milk production in an Australian context is typically very seasonal, with low production in winter and surpluses produced in spring and summer. Significant farm management changes are necessary to facilitate year round milk production, all of which come at an increased cost (MLA, 2005). These changes must be paralleled by an increase in research in dairy goat health, welfare and production.

Health issues in dairy goat production

The major health issues that affect the dairy goat industry and are responsible for substantial production losses and decreased goat welfare include clostridial diseases, caprine arthritis encephalitis (CAE), caseous lymphadenitis (CLA), Johne's disease, and internal parasites (Abud and Stubbs, 2009). Some of these diseases can be controlled by vaccines however many farmers rely on strict biosecurity procedures in order to maintain a clean herd. A recent survey has indicated that the two most significant health problems identified by the members of the Dairy Goat Society of Australia (DGSA) are CAE and intestinal parasites (DGSA, personal communication). Similar results were reported by another survey recently administered to goat producers in NSW (Lemon and White, unpublished observations).

Caprine arthritis encephalitis (CAE)

Caprine arthritis encephalitis (CAE), also known as „big knee', is caused by a lentivirus or 'slow' virus associated with nervous disorder (encephalomyelitis) in kids and slowly-developing disease syndromes in older goats. This results when the cells carrying the latent virus mature and multiply in different body organs, such as the mammary gland, lungs, tendons sheaths, joints and nervous tissue and result in a slow and persistent inflammatory disease (Greenwood, 1995). It is clear that CAE is a major animal welfare issue that results in major production losses through mastitis, ill-thrift, arthritis, pneumonia, ascending paralysis and encephalitis in kids.

The main spread of the virus between goats is through the ingestion of infected milk by kids or adults. Adult goats can also become infected by exposure to infected milk droplets during milking. The virus can also be spread by respiratory secretions, saliva and tears when goats are kept in close quarters. Transfer sometimes occurs by blood on equipment such as vaccination needles, tattooing equipment, dehorners and foot/hair shears, or through exposure to open wounds. Venereal spread in semen and in utero spread to kids are less likely but still occur. The virus usually enters a clean property with the introduction of an infected goat. The goat may or may not be antibody positive for CAE at the time of blood testing because of the delay between exposure to the virus and the development of antibodies. At present there is no vaccine available for the prevention of this disease, therefore biosecurity measures are essential in minimising the risk of infection. Control programmes have been conducted in many countries but CAE is still causing problems in dairy goat populations world-wide, including Australia (Figure 2).

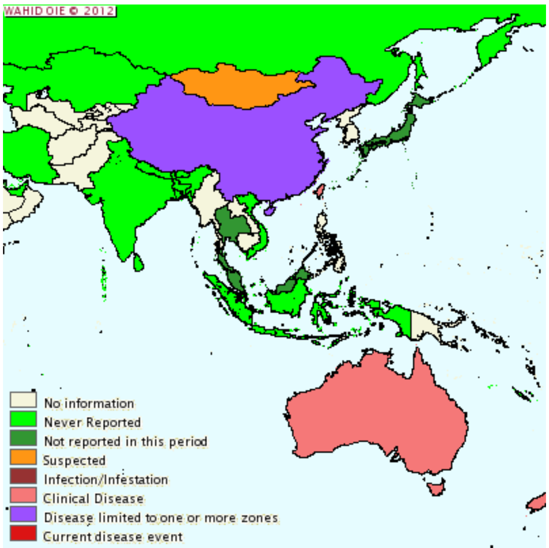

Figure 2. Caprine arthritis encephalitis distribution in Australia and Asia (World Animal Health Information Database).

CAE represents a major challenge to dairy goat farmers in Australia as it creates a significant market access issue. The International Organisation for Animal Health (OIE) has set a minimum standard for live goat imports: animals must not present clinical signs of CAE on the day of shipment; animals over one year of age must be subjected to a diagnostic test for CAE with negative results during the 30 days prior to shipment or, CAE must not be diagnosed either clinically or serologically in goats present in the flocks of origin during the past 3 years, and no goat from a flock of inferior health status was introduced into these flocks during this period.

Detecting sub-clinically infected goats is the key to preventing CAE spread. Infected goats are detected by serological testing. The most accurate test is the ELISA test although some countries still use the less specific AGID test. Repeated blood testing during a 12 month period will detect the majority of infected goats. The CAE status of goats should be determined in goats 6 months and older. Adult does should not be tested in the period one month either side of kidding as inconsistent results can occur. No goat should be tested within one month of any vaccination (Ryan, 2012). The tests currently available are expensive and Australian farmers do not have access to testing subsidies. The development of a CAE bulk milk diagnostic test would be of extreme benefit to individual farmers and to the dairy goat industry overall.

Intestinal parasites

Parasitic infections are generally regarded as the most prevalent and important health problems of grazing ruminants in Australia, with losses associated with nematodes, and ectoparasites causing a combined annual loss of approximately a billion dollars (McLeod, 1995). Despite considerable research being conducted into developing integrated parasite control programmes to minimise the use of anthelmintics, the goat industry continues to rely heavily on anthelmintics for effective internal parasite control. The role of anthelmintics in the control of gastrointestinal parasites is increasingly threatened by resistance in the target parasite species. Resistance of worms in sheep and goats to most anthelmintics is now fairly common in Australia (Besier and Love, 2002) and should be considered in the diagnosis and management of gastrointestinal parasitism. The control of gastrointestinal parasites needs to adopt a more strategic approach that involves the integration of control measures that will reduce reliance on anthelmintics and slow the development of anthelmintic resistance. Over the last 10 or more years there has only been one new worm drench registered for use in goats: Caprimec (Virbac Animal Health) has the same formulation as Virbemec and for marketing reasons this was relabelled for goats and sold in smaller containers at a higher price. It is not surprising that goat farmers largely refrained from purchasing the branded drug and purchased the cheaper Virbemec.

Representations to the Goat Industry Council of Australia (GICA) and their representations to Meat and Livestock Australia have failed to gain sufficient traction to effectively address the shortage of effective new chemicals. Recently the Australian Pesticides and Veterinary Medicines Authority (APVMA) acknowledged that goats metabolise veterinary products very differently to sheep, indeed the recommended dose rates should be 1.5 times the sheep dose. In the short term, one solution could be for the Australian dairy goat industry to obtain a minor use permit (MUP) for products registered in sheep. However, it has to be noted that for the granting of a MUP, much of the science still has to be done. Interestingly, goats are not in a separate list on the APVMA web site and there is no recognition of dose rate as an issue or any effect on withholding periods and export slaughter interval. It will only take one positive test on goat products going overseas to lead to a ban of goat products overseas export and that could result in the collapse of the Australian goat industry. In the long term, considering the rapid expansion of the goat industry in its entirety (goat, fibre and dairy), it is necessary for the industry to move outside the realm of a minor species and develop its own research, development and extension programme to address the management of gastrointestinal parasites.

Current and future developments

The main advantages of a CAE bulk milk diagnostic test are that the sample is easy to obtain and the test is reasonably cheap and therefore can be used as a routine indicator of subclinical infection. This test would also yield data for use in epidemiological studies and for studying the genetic background of CAE and other diseases. Milk composition (fat% and protein%, SCC) can also be used to study the heritability of diseases like ketosis and mastitis. Bulk milk tests would provide a solid starting point for differential diagnosis, in addition to their value for blood serological monitoring. The information from bulk milk tests should be accurately recorded and incorporated into preventive medicine programmes, particularly in relation to recently purchased animals. Regular testing of bulk milk samples will provide a simple low cost method of confirming continuing freedom from infection in known disease-free herds; including those at potential risk of introducing new infection, and thereby allow opportunity for prompt action if indicated.

Parasite management is a major problem for grazing goats. The use of drenches off-label, i.e. without the drench being registered for use in milking goats, has health, quality and export implications. It is clear that some action is urgently needed in this area. In the short term there is a need to undertake a survey within the industry regarding the chemicals utilised. This should include usage patterns, reasons why they are used, and dosages. In the long term, the sustainable control of gastrointestinal parasites requires a dramatic reduction in chemical use and increased thoroughness in monitoring for worm burdens, testing drenches for efficacy and incorporating browse and nutrition supplementation as a minimum standard for better worm control. Less reliance on chemical use is important in preserving those drench actives still providing good control.

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Plenary 4

Improving Dairy Goat Productivity with Concomitant Mitigation of Methane

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Introduction

The emission of greenhouse gases by livestock and potential abatement technologies have been the subject of many international studies in recent years. In ruminants, methane (CH_4) production represents a loss of between 2 and 12% of the gross energy intake (Johnson and Johnson, 1995). In particular, in high producing lactating animals it has been estimated to be equivalent to a loss of 6% of gross energy intake as CH_4 (Tamminga et al., 2007).

A variety of nutritional management strategies to reduce methane production in ruminants have been studied. Increasing the level of grain in the diet have been shown to reduce methane emission; mainly due to associated changes in fermented substrate from fibre to starch (Blaxter and Clapperton, 1965). The addition of lipids also mitigates methane production through a reduction in rumen organic matter fermentation (Johnson and Johnson, 1995). However, it is necessary to use high quantities of supplemental lipids (≥6% DM) and this is associated with decreased fibre digestibility and DMI (dry matter intake), negating the advantages of increased energy density of the diet (Beauchemin et al., 2008; Eugène et al., 2008).

Several rumen fermentation modifiers have been tested in vitro, but very few have been successfully used *in vivo* conditions and almost none in lactating animals (McAllister and Newbold, 2008). A major constraint of feeding additives to reduce methanogenesis is that *in vitro* effects observed may not persist *in vivo*. This may be related to the degradation of the active compounds by rumen microorganisms or to the rumen ecology system develops adaptive mechanisms able to revert changes (Hart et al., 2008).

In the present work we test bromochoromethane (BCM) that has been shown to reduce methane production by up to 60% in steers fed grain-based diets over a 90-d feedlot finishing period (Tomkins et al., 2009) with no signs of toxicity or residues in edible meat and offal. Although uncomplexed BCM has an ozone-depleting effect and therefore is banned for commercial use, the strong and persistent effect on methane reduction makes it as an interesting tool to investigate side effects of methane reduction in dairy goats.

The aim of this work was to investigate the effect of addition of BCM in the diet of dairy goats on animal performance, rumen methane production and fermentation pattern, and on milk yield and composition.

Materials and methods

Eighteen pregnant Murciano-Granadina goats [43 ± 1.7 kg body weight (BW)] were kept in individual pens (1.7 × 1.2 m) with free access to water. Animals were fed twice a day (0900 h and 1500 h) alfalfa hay *ad libitum* supplied with 600 g/d of a commercial compound feed. After parturition the experimental period commenced and lasted for 10 wk, goats were randomly allocated to one of the two experimental groups: BCM+, treated with 0.30 g/100 kg BW of BCM formulation, and BCM-, as control nontreated group. Bromochoromethane treatment was given twice a day at feeding times (as before). The kids remained with their mothers for 8 wk and after weaning methane emissions were recorded over two consecutive days (day 57 and 58 of treatment) in open circuit respiration chambers. On day 59, rumen fluid was sampled using a stomach tube and aliquots stored at -20 ºC for VFA analysis. Over the last two weeks of the trial, goats were put back to the individual pens and milked once a day before the morning feeding. On day 69 and 70 sampling periods, milk yield was recorded and samples taken for the determination of milk composition. Goats were weighed on day 1 and 56 of the experimental period.

Results

Dry matter intake and mean BW were not affected by the addition of BCM (Table 1). Although milk yield was higher (1324 vs. 901 g/d; P = 0.021) for goats in BCM+ group than BCM-, milk components were not modified by the experimental treatment (data not presented).

Table 1. Productive parameters, rumen characteristic and methane emission in experimental goats treated (BCM+) or not (BCM-) with bromochloromethane (n = 9 per treatment)

	BCM-	BCM+	SED[1]	*P*-value
Productive parameters				
Initial BW, kg	40.8	43.8	1.58	0.363
BW change[2], kg	-6.6	-6.4	1.41	0.76
DM intake, g/d	992	1041	53.3	0.366
Milk Yield (g/d)	901	1324	164	0.021
Rumen parameters				
VFA (mmol/L)	58.5	74.4	8.79	0.216
Acetate (mol/100mol)	61.2	60.3	1.15	0.59
Propionate	11.1	15.5	0.54	<0.001
Butyrate	13.5	13.5	0.66	0.974
Isobutyrate	5.2	3.8	0.21	<0.001
Valerate	2.5	2.3	0.22	<0.615
Isolvalerate	6.4	4.5	0.34	<0.001
Gas Emissions				
CH_4 L/d	22.4	15.1	3.0	<0.028

Rumen total VFA concentration was not modified by the experimental treatment although VFA profile was affected by the addition of BCM formulation, increasing the proportion of propionate and decreasing those of branched-chain-VFA (namely, isobutyrate and isovalerate). Methane production by goats over two consecutive days in the chambers indicated a significant reduction in methanogenesis in BCM+ animals compared to nontreated goats. Methane emissions expressed per kg of DMI was lowered by a 48% in BCM+ goats compared with BCM- ($P = 0.013$). The emissions per kg of milk produced were also lower in BCM+ goats ($P = 0.051$).

Discussion

The reduction in BCM+ goats in methane emission is in agreement with those reported with BCM in batch and continuous culture fermenters (Goel et al., 2009) or in non-lactating cattle (Tomkins et al., 2009). We observed almost a 50% reduction after 57 d treatment, which agrees with the 60 and 50% reduction reported by Tomkins et al. (2009), respectively, over 30 and 90 d treatment in steers treated with the same dose (0.30 g/100 kg BW, twice daily).

The lack of changes in intake and the rumen VFA concentration with the BCM treatment indicates that microbial fermentation in the rumen was not compromised as observed with other antimethanogenic treatments in which the reduction in methane emissions is, at least in part, related to decreases in DMI (Beauchemin et al., 2008). The reduction in acetate-propionate ratio due to BCM treatment agrees with that previously observed in steers (Denman et al., 2007) and it has been described as a common feature of several antimethanogenic compounds, the redirection of hydrogen from methane to more propionic metabolic pathways (McAlister and Newbold, 2008).

Goats on BCM+ group produced significantly more milk than BCM- goats and DMI was equivalent to approximately 2.5% BW and equivalent to that observed for BCM- goats. To our knowledge, this is the first report on the use of BCM, or other halogenated analogue, in lactating ruminants.

The 45% increase in milk yield in BCM+ goats involves 4.48 MJ/d energy cost in milk production as compared to 3.09 MJ/d in control goats. The energy balances that result from deducting methane losses to energy intake leaves extra 1.16 MJ/d available to the animal. In addition, and assuming a similar rumen contents volume in both experimental groups (around 11% of body weight, personal communication) and equal absorption efficiency of VFAs, BCM+ goats absorbed 91% more propionate than BCM- animals (55.6 vs. 29.1 mmol/d, respectively). Such an increase in propionate production would lead to an increase in glucose synthesis and hence in milk lactose, assuming a 70% efficiency in the conversion of propionate to glucose and a 40% conversion of glucose to lactose (Newbold et al., 2005). Thus the combination of less methane losses and the increase in glucose synthesis from propionate supply justifies the increase in milk production efficiency observed here.

The imbalance in the distribution of electrons in methane explains the higher molar proportion of propionate in rumen fluid from treated goats. An increase in propionate production could have led to a higher synthesis of glucose in the liver, which may result in an increase in the synthesis of lactose in the mammary gland (Newbold et al., 2005). Because milk is isotonic with respect to blood, and lactose contributes some 60% of milk osmolarity, an increase in lactose flow to the mammary gland would result in greater milk yield (Tamminga et al., 2007). Unfortunately, our results are not directly comparable with available reports in dairy cows because of the important differences in the strategies for methane mitigation tested. The addition of lipids in the diet of dairy cows has been shown to reduce methane emissions, but the levels of supplementation normally used can be associated with decreased DMI (Beauchemin et al., 2008). The reduction in methane emissions achieved by adding lipids is not necessarily accompanied by an increase in milk yield, even if they are combined with other type of additives such as organic acids (van Zijderveld et al., 2011).

The genetic potential for milk yield from the breed of dairy goats used in this study would be expected to be higher than the value observed in the control. This is due to the relatively low amount of feed offered to the animals to facilitate intake measurements during methane measurements in the chambers. It is reasonable to anticipate that the increase in lactose yield and, subsequently milk yield, would be accompanied by comparable increases in fat or protein yield and, probably, greater loses in BW during lactation. However, this was not the case, and neither was the dilution effect in response to higher milk yield (i.e. the reduction in the concentration of fat and protein) significant. The inter-animal variation observed in this study for milk variables was high, contributing to the lack of significant changes.

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Plenary 5

The Possibility of Controlling Flow of Metabolic H into Various Pathways in Rumen Fermentation to Improve Dairy Goat Productivity

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Introduction

It has been estimated that methane production by ruminants is about 15% of total anthropogenic methane emissions. Since methanogenesis in the rumen represents a 2–12% energy loss of intake, methane production from ruminants has to be considered from the perspective of both its global warming effect and feed efficiency of ruminants (Johnson and Johnson, 1995; Morgavi et al., 2010). The typical stoichiometry of rumen fermentation was proposed by Wolin (1979):

$$57.5\ C_6H_{12}O_6 \rightarrow 65\ \text{acetate} + 20\ \text{propionate} + 15\ \text{buyrate} + 35\ CH_4 + 60\ CO_2 + 25\ H_2O$$

This formula shows that methane is constituted of C and H supplied from hexose, and this relationship enables the understanding of methane production from the viewpoint of the carbon- and hydrogen-flow in the rumen. In the present paper, the possible pathways of hydrogen for methane production in the rumen are discussed.

Methanogenesis in the rumen is thought to be a consequence of the disposal of metabolic hydrogen (2H), which is mainly yielded from degradation of carbohydrate (e.g. cellulose, hemicellulose and starch) under strictly anaerobic conditions (Mitsumori and Sun, 2008; Morgavi et al., 2010). Since it is considered that reducing methane emission from the rumen provides the benefits of greenhouse gas reduction and results in improved feed efficiency, methods of estimating methane emission from the rumen and many strategies to mitigate methane production have been reported (Johnson and Johnson, 1995; Shibata and Terada, 2010).

It is known that the 2H from hydrogen-producing steps flows into hydrogen-consuming steps and pathways that produce propionate, acetate and methane and reduces sulfate and nitrate in the rumen. These pathways are integral parts of rumen fermentation. Although each hydrogen-consuming pathway needs 2H supplied from its intercellular metabolism, some microorganisms such as methanogens scramble for 2H excreted by other rumen microorganisms to obtain energy for their growth. It would however be difficult to understand the relationship between hydrogen-producing steps and hydrogen-consuming steps in the rumen, because information on metabolism of cultured rumen microorganisms is very limited and most of the rumen bacteria have not yet been cultured.

Approaches for mitigating methane have been applied in the ruminant production. Strategies or the approaches aim to depress activity of methanogens, enhance hydrogen-consuming steps excluding methanogenesis or depress hydrogen-producing steps. Hitherto, various feed additives, which are directly toxic to methanogens, exhibit antimicrobial activity, and/or produce undesirable changes in the rumen fermentation. It has been known that halogenated methane analogues such as bromochloromethane (BCM) have inhibitory effect on methane production (McCrabb et al., 1997; Goel, et al., 2009), because it reacts with coenzyme B (cobamine), which catalyses the last step of methanogenic pathway that leads to methane production (Wood et al., 1968). Currently, we investigated mechanisms of methane production in the rumen by administration of BCM to Shiba goats. Digestibility trials and measurement of methane production in whole animal were carried out using open-circuit respiration chambers equipped with gas analysers for oxygen, carbon dioxide and methane. Hydrogen gas production was calculated by formulas shown in Figure 1. Results of this study showed: (1) dramatic increase in hydrogen gas production when methanogenesis was strongly inhibited in the rumen, (2) decrease in feed intake and digestibility were not observed, and (3) >20% increase in the flow of 2H into short chain fatty acids (SCFA) and a marked increase in propionate production. These results provide a new insight into the methanogenesis in the rumen and will aid in the development of strategies to reduce methane production for improving ruminant productivity (Mitsumori et al., 2011).

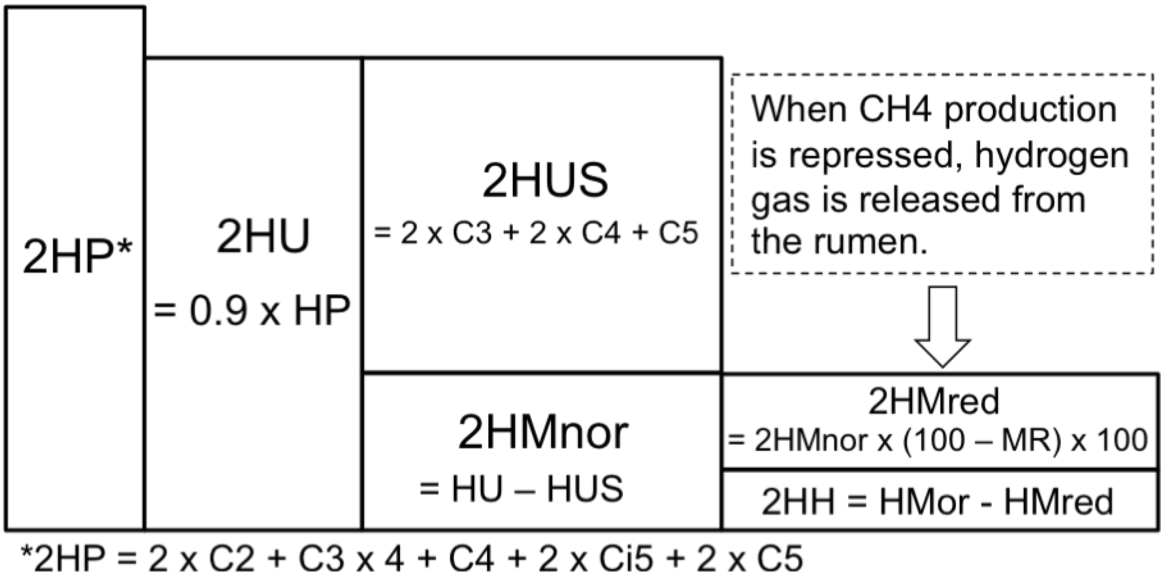

Figure 1. Calculation of 2H flowing into hydrogen gas.
[HP, 2H produced in the rumen; 2HU, the sum of 2H utilised in SCFA (2HUS) and in methane at normal level (2HMnor); 2HH, 2H utilised in hydrogen gas production; C2, acetate; C3, propionate; C4, butyrate; Ci5, isovalerate; C5, valerate; MR, methane reduction (%)].

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Plenary 6

IDF Perspectives on the Global Dairy Situation and Development Perspectives for Non-Cow Milk

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Introduction

The International Dairy Federation (IDF) represents approximately 80% of the world's milk production across 52 different countries serving all stakeholders involved in the dairy sector. There are more than 1200 experts participating in the work of IDF.

IDF's mission is to represent the dairy sector as a whole at international level by providing the best global source of expertise and scientific knowledge in support of the development and promotion of quality milk and milk products to deliver consumers with nutrition, health and well-being.

IDF addresses key concerns such as the importance of a well-balanced diet in all stages of life, environmental protection, milk production, animal health and welfare and food safety. IDF stresses the importance of dairy products, which provide a high quality nutrient package and are an excellent food source of calcium, protein and other essential nutrients, thereby contributing to improved health and an overall higher quality of life for everybody, and particularly for vulnerable populations such as malnourished communities. Dairy products are, and shall remain, of prime importance in meeting some of the most pressing nutritional challenges all over the world.

IDF promotes the exchange of new ideas with fellow specialists across national borders, helps resolving issues and spreads best practice. Its expert committees and working groups provide experts with a platform to meet and jointly develop scientific knowledge and applications for industrial practice. IDF organises annual World Dairy Summits, a number of high-level international symposia as well as numerous seminars and workshops which contribute to the progress and understanding of dairy issues worldwide and provide unrivalled opportunities for networking with peers, sharing experiences and establishing contacts for future use.

IDF has built a formal partnership and particularly strong collaboration with the Food and Agriculture Organisation of the United Nations (FAO) with a proven track record of numerous successful joint events and publications in the past five decades. Through a tripartite initiative, involving in addition to FAO also the Institute of Tropical Agriculture of Universiti Putra in Malaysia, IDF is very pleased to contribute to the further development of the dairy goat sector in Asia.

More information about IDF can be obtained from its website: http://www.fil-idf.org/ (The global dairy situation and importance of non-cattle milk production worldwide) (IDF Bulletin, 2011).

Development of milk production

Growth of world milk production for all species picked up again in 2010. For both cow and buffalo milk however, growth is still below average. Cow's milk growth stepped up compared to 2009 (1.6% versus 0.9%) and buffalo milk stepped down compared to 2009 (3.1% versus 3.9%). Higher milk prices have certainly stimulated production but bad weather conditions and natural disasters also had an adverse effect on milk production. Goat milk production increased steadily and sheep milk also increased slightly during the past year. During the first half of 2011 milk output increased strongly in most of the countries in the southern hemisphere and moderately in most of the countries in the northern hemisphere.

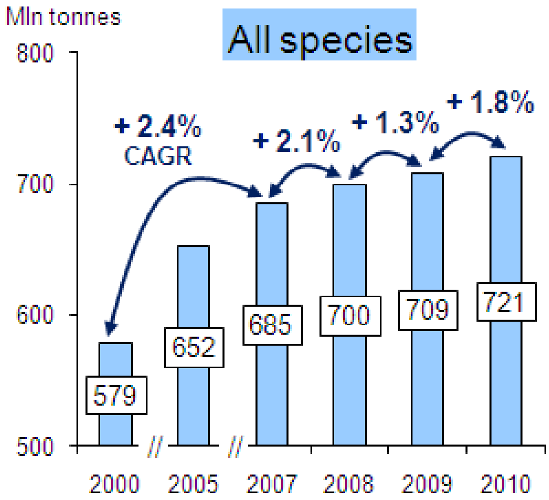

Figure 1. World Milk Production 2000-2010

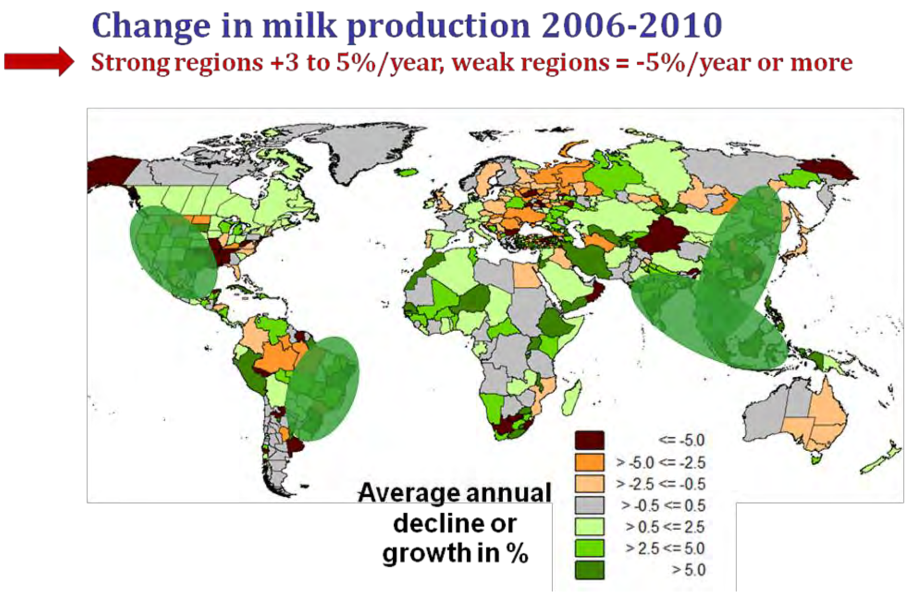

Figure 2. Development of World Milk Production by region 2006–2010 according to IFCN (Krijger et al., 2011)

Goat milk constitutes around 2.2% of total milk production, sheep milk 1.3% and camel milk 1.3%. According to FAO data for 2009, goat milk was mainly produced in Asia (59% of world milk production), in Africa (21%) and in Europe (16%); whereas sheep milk production is located in Asia (44%) and Europe (34%) and camel milk mostly in Africa (89%).

Goat milk production has been increasing regularly over the last few years, but this growth tends to be slowing. In 2010 the increase narrowed to 0.2%. Development differs widely from country to country. While goat milk production was rather dynamic in Turkey (+3.5%) and in France (+6.4%), a downturn occurred in Mexico (-1.0%), Spain (-2.9%) and the Netherlands (-8.6%).

Milk processing and consumption worldwide

World output increased last year for every dairy product, but growth was rather small for Skim Milk Powder (SMP). The large quantities of stocks stored in 2009 discouraged SMP production in Europe and did not stimulate production elsewhere, as international demand was also very strong for Whole Milk Powder (WMP) and cheeses. WMP production recovered after a drop in 2009, stimulated by firm demand in Asia and the Middle East. As for cow's milk cheese, industrial output recovered strongly, after two years of weak growth. World butter production kept growing last year, even if growth was not as sustained as in the previous year.

Global per capita consumption of milk in 2010 was 104.6 kg and recovered from the slight decrease in 2009. Asia is the most important consuming region with 39% of total world consumption, followed by Europe (29%) and North America (13%). Strongest growth occurred in South America, where Brazil and Argentina especially contributed to this increase. Strong growth in Asia is also reported.

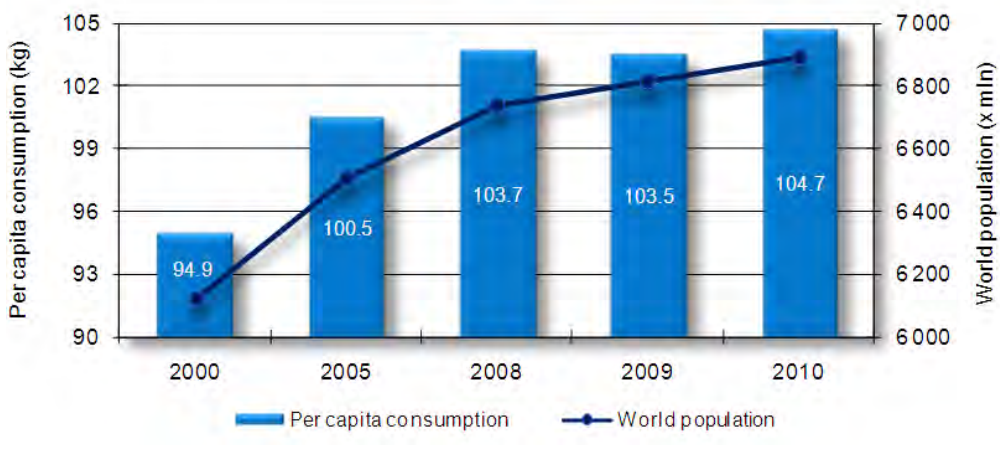

Figure 3. World Milk Consumption 2000–2010

In 2010, the overall share of world dairy trade in the global milk pool was well over 7%, which is still modest. Volume increased to 51.9 million tonnes.

Costs of milk production, prices and production outlook

The International Farm Comparison Network (IFCN) has analysed the costs of milk production based on the concept of a typical farm in 49 countries (Hemme et al., 2011).

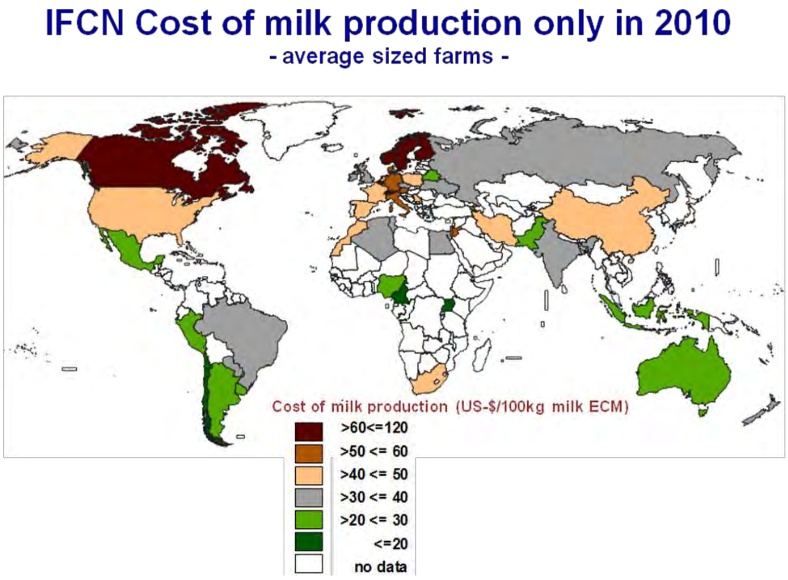

Figure 3. Average costs of milk production

Prices recovered during 2010. The first half of 2010 was a supply driven recovery due to a combination of tight dairy supply coupled with a modest recovery in the global economy. Short-term forecasts for global milk production from FAO and FAPRI look favourable.

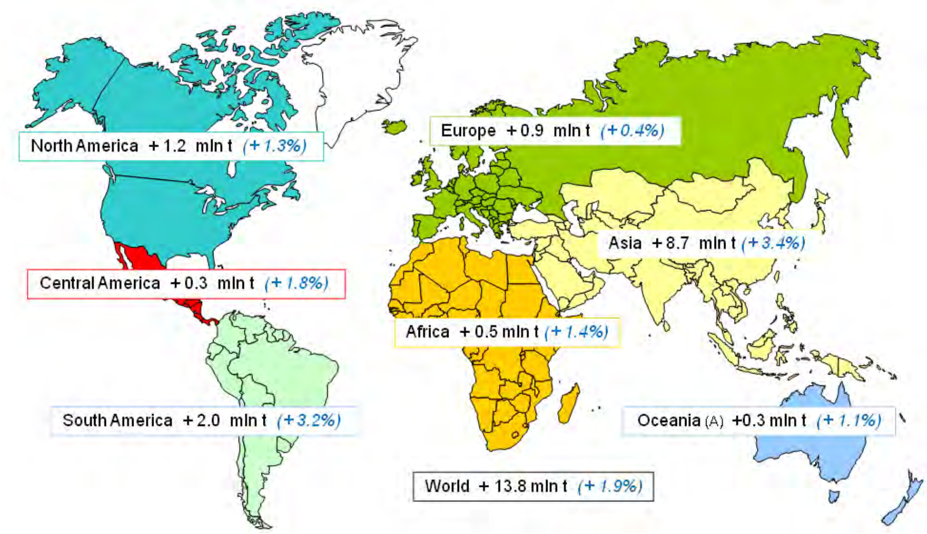

Figure 4. Milk production outlook in 2012

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Plenary 7

Goat Milk and Human Nutrition

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Introduction

The goat is a main supplier of dairy and meat products for rural people around the world. Goat milk plays an important role in nutrition and socioeconomic wellbeing of developing and underdeveloped countries, where it provides basic nutrition and subsistence to the rural people, which are the majority of their populations (Park and Haenlein, 2007). Although goats produce approximately 2% of the world's total annual milk supply (FAO, 1995), their contribution to the nutritional and economic wellbeing of mankind is tremendous in many parts of the world, notably in the Mediterranean countries and in the Middle East (Juàrez and Ramos, 1986; Park, 1994a; Park and Haenlein, 2007).

On the other hand, production of goat milk and its products of cheeses and yoghurt is also a valued part of the dairy industry in developed countries, where it provides diversity to sophisticated consumer tastes, and supports people with medical afflictions, such as allergies and gastro-intestinal disorders, who need alternative dairy products (Haenlein, 1996; 1997; Park, 1992; 1994a). These facts indicate that goat milk serves 3 general types of markets around the world, which are: (a) home consumption, (b) specialty gourmet interests, and (c) medical needs.

Since cow milk is not available or not affordable to millions of rural poor people, home consumption of goat milk is important in the prevention of under-nutrition and malnutrition, simply because milk is the superior source of calcium and protein. The purpose of the present paper is to review the nutritional, chemical, medical and socioeconomic importance of goat milk in human nutrition.

Compositional characteristics of goat milk

Caprine milk, on the average, contains 12.2% total solids, consisting of 3.8% fat, 3.5% protein, 4.1% lactose and 0.8% ash, indicating that it has more fat, protein and ash, and less lactose than cow milk (Table 1) (Park, 2006). However, goat milk provides similar level of calories (70 kcal/100mL) for human nutrition as cow or human milk do. A human infant fed solely on goat milk is oversupplied with protein, Ca, P, vitamin A, B_1, B_2, niacin, pantothenic acid, while deficient in iron, vitamin B_6, B_{12}, C, D, and folic acid (Jenness, 1980).

A daily minimum supply of 800 mg calcium per person is widely recommended, as is also a minimum of 60 g protein from animal sources (NRC, 1964). Table 2 shows how far below these recommendations the average supply of calcium and protein is estimated to be especially in Africa and Asia (Park and Haenlein, 2007).

Studies on the composition of different commercial goat milk products (Park, 1990; 1994b; 1999) revealed that goat milk and its products would be excellent sources of human nutrition comparable to cow milk products (Posati and Orr, 1976). However, there were some notable differences in nutrient contents of goat milk products between studies. These differences may be attributable to differences in sources of original milk used for processing the products, because the nutrient compositions of goat milk can be greatly influenced by several factors such as season, stage of lactation, breed, diet, individual animal, and environmental management conditions (Underwood, 1977; Haenlein and Caccese, 1984; Park and Chukwu, 1988; Park, 1990).

Table 1. Comparison of average composition of basic nutrients among goat, cow and human milk

Composition	Goat	Cow	Human
Fat, %	3.8	3.6	4.0
Solid-not-fat, %	8.9	9.0	8.9
Lactose, %	4.1	4.7	6.9
Protein, %	3.4	3.2	1.2
Casein, %	2.4	2.6	0.4
Albumin, globulin, %	0.6	0.6	0.7
Non-protein N, %	0.4	0.2	0.1
Ash, %	0.8	0.7	0.3
Calories/100 mL	70	69	68

Data from Posati and Orr (1976), Jenness (1980), Haenlein and Caccese (1984) and Park (2006).

Table 2. Average daily supply of calcium and protein per person (FAO, 1995) in relation to Recommended Dietary Allowances (RDA; 800 mg calcium and 60 g animal protein; NRC, 1964 and Park and Haenlein, 2007)

	Total Supply	From animal sources	
	mg	mg	% of RDA
CALCIUM			
Africa	384	132	16
Asia	329	125	16
Europe	896	684	86
N + C America	832	569	71
S America	490	317	40
PROTEIN			
Africa	56	12	20
Asia	64	16	27
Europe	101	58	97
N + C America	97	56	93
S America	67	31	52

Compared to cow and sheep milk, goat milk has its unique differences in several important constituents and physical parameters, such as proteins, lipids, minerals, vitamins, carnitine, glycerol ethers, orotic acid, enzymes, fat globule size, casein polymorphisms. These compositional and physical differences of goat milk play significant roles in human nutrition (Park and Haenlein, 2007).

Nutritional and therapeutic values of goat milk

Compared to cow or human milk, goat milk reportedly possesses unique biologically active properties, such as high digestibility, distinct alkalinity, high buffering capacity as well as certain therapeutic values in medicine and human nutrition (Walker, 1965; Devendra and Burns, 1970; Haenlein and Caccese, 1984; Park, 1990; 1991; 1994a; Park and Haenlein, 2007).

The nutritional advantages of goat milk over cow milk do not come from its protein or mineral differences, but from the lipids, more specifically the fatty acids within the lipids (Babayan, 1981; Park, 1994a; Haenlein, 2004). Average goat milk fat differs in contents of its fatty acids significantly from average cow milk fat (Jenness, 1980), being much higher in butyric (C: 0), caproic (C6: 0), caprylic (C8: 0), capric (C10: 0), lauric (C12: 0), myristic (C14: 0), palmitic (C16: 0), lilnoleic (C18: 2), but lower in stearic (18: 0), and oleic acid (C18: 1). Owing to the high amounts of short and medium chain fatty acids (MCT), goat milk fat may have at least three significant contributions to human nutrition: (i) it may be more rapidly digested than cow milk fat, because lipase attacks ester linkages of short or MCT more easily than those of longer chains, (ii) these fatty acids exhibit beneficial effects on cholesterol metabolism such as hypocholesterolemic action on tissues and blood via inhibition of cholesterol deposition and dissolution of cholesterol in gallstones, and (iii) they have been therapeutically used for treatment of malabsorption patients suffering from steatorrhea, chyluria, hyperlipoproteinemia, and in case of intestinal resection, coronary bypass, childhood epilepsy, premature infant feeding, cystic fibrosis and gallstones. The short or MCT have the unique metabolic ability to provide direct energy instead of being deposited in adipose tissues, and lower serum cholesterol and inhibit cholesterol deposition (Kalser, 1971; Alferez et al., 2001).

Cholesterol and fatty acid concentrations among different species were compared using the data published by the Royal Society of Chemistry, UK (Holland et al., 1989) (Table 3). This table shows that the respective cholesterol contents of normal fluid goat, cow, sheep and human milk are 10, 14, 11 and 16, respectively, indicating that goat milk actually has the lowest cholesterol content among the milk from these 4 species. There is some similarity in the cholesterol values reported in the USDA Agricultural Handbook No. 8-1 (Posati and Orr, 1976; Jenness, 1980). Human milk appears to have the highest cholesterol content among the milk from the 4 species, and human colostrum has 31 mg/100 g. Cow milk powder has substantially higher cholesterol (120 mg/100 g) since it is a dried and concentrated product (Park, 2000).

Concerning fatty acid composition, the normal goat, cow, sheep and human milks contain 2.3, 2.4, 3.8, and 1.8 g/100 g saturated fatty acids, respectively, suggesting that human milk has lower saturated fat than the milk from the 3 major dairy species. The opposite trend is observed for the mono- and poly-unsaturated fatty acid levels in human milk compared to the milk from the other three species milks (Table 3). The significantly higher unsaturated fatty acids and cholesterol in human milk compared to the 3 animal species appears to be interesting and may need future investigations on certain health issues such as coronary heart diseases.

The USDA Handbook shows that goat milk has higher levels of 6 out of the 10 essential amino acids: threonine, isoleucine, lysine, cystine, tyrosine, valine than cow milk (Posati and Orr, 1976; Haenlein, 2004) (Table 4). In addition, goat milk proteins are believed to be more readily digestible and their amino acids absorbed more efficiently than those of cow milk. Caprine milk forms a softer, more friable curd when acidified, which may be related to lower contents of α_{s1}-casein in the milk (Jenness, 1980; Haenlein and Caccese, 1984). Smaller and more friable curds of goat milk would be attacked more rapidly by stomach proteases, giving better digestibility (Jenness, 1980). Goat milk is also shown to have greater buffering capacity, which would be beneficial for treatment of stomach ulcer, due to higher levels of major buffering components, such as proteins, nonprotein N and phosphate (P_2O_5) than cow milk (Park, 1991), which would be important in human nutrition.

Table 3. Cholesterol and fatty acid composition of milk from different species[a,b]

Milk	Fatty Acids (g/100 g)			Cholesterol (mg/100 g)
	SFA	MUFA	PUFA	
Cow				
Whole	2.4	1.1 (0.96)[c]	0.1	14
Skim	0.1	Tr	Tr	2
Dried whole	16.5	7.6	0.8	120
Goat	2.3	0.8 (1.11)[c]	0.1	10
Sheep	3.8	1.5	0.3	11
Human				
Colostrum	1.1	1.1	0.3	31
Mature	1.8	1.6	0.5	16
Soya	0.3	0.4	1.1	0

[a]Data taken and organised from Holland et al. (1989). [b]Park and Guo (2006). [c]USDA Handbook No. 8-1 (Posati and Orr, 1976). SFA = Saturated fatty acid; MUFA = Monounsaturated fatty acid; PUFA = Polyunsaturated fatty acid.

Table 4. Average amino acid composition (g/100 g milk) in proteins of goat and cow milk[a,b]

Essential amino acids	Goat milk	Cow milk	Difference (%) for goat milk
Tryptophan	0.044	0.046	
Threonine	0.163	0.149	+9
Isoleucine	0.207	0.199	+4
Leucine	0.314	0.322	
Lysine	0.290	0.261	+11
Methionine	0.080	0.083	
Cystine	0.046	0.030	+53
Phenylalanine	0.155	0.159	
Tyrosine	0.179	0.159	+13
Valine	0.240	0.220	+9

[a]Posati and Orr (1976); [b]Haenlein (2004).

Scientific studies with goat milk in human nutrition

Nutrition studies on goat milk

In addition to providing basic nutrition and subsistence to goat producing populations in the globe, goat milk has significant value in human nutrition especially for children and milk allergic patients. In a nutrition study involving 38 children (20 girls and 18 boys) aged 6 to 13 years, Mack (1953) fed one-half of them 0.946 litre of goat milk and the other half 0.946 litre of cow milk daily for 5 months. Children fed on the goat milk surpassed those on cow milk in weight gain, statue, skeletal mineralisation, bone density, blood plasma vitamin A, calcium, thiamine, riboflavin, niacin and hemoglobin concentrations. However, the differences were minimal in blood hemoglobin, various other biochemical and structural measurements between the two groups.

Most milk, including human milk, are deficient in iron. In a Fe bioavailability study of goat and cow milk using anemic rats, Park et al. (1986) reported that rats fed on goat milk grew significantly better, had higher liver weights, hemoglobin iron gain, and higher iron absorption rates than those on cow milk. The anemic rats receiving the whole goat milk diet showed significantly greater hemoglobin regeneration efficiencies than those on the cow milk diet.

In comparative absorption studies with rats in Spain (Barrionuevo et al., 2002), 50% of the animals' distal small intestines were removed by resection to simulate the pathological condition of malabsorption syndrome, and goat milk was fed instead of cow milk as part of the diet. The animals fed goat milk had significantly higher digestion and absorption of iron and copper than the cow milk fed group, and anemia was prevented in the goat milk fed group. Alferez et al. (2001) found the utilisation of fat and weight gain was improved with goat milk, compared to cow milk, and levels of cholesterol were reduced, while triglyceride, HDL, GOT and GPT values remained normal. Consumption of goat milk reduced total cholesterol levels and the LDL fraction, because of the higher presence of MCT (36% in goat milk vs. 21% in cow milk), which decreases the synthesis of endogenous cholesterol. In an Algerian study of 64 infants with malabsorption syndromes, Hachelaf et al. (1993) observed that the substitution of cow milk by goat milk also led to significantly higher intestinal fat absorption.

In Madagascar in another comparative nutritional study, Razafindrakoto et al. (1993) fed either cow or goat milk in addition to their regular diet to 30 hospitalised malnourished children between 1 and 5 years of age. The results showed that the children fed on goat milk outgained the children on cow milk in bodyweight by 9% (8.53 g/kg/day ± 1.37 vs. 7.82 ± 1.93) over the 2-week trial period, and fat absorption tended to be better in the goat milk children, indicating an apparent advantage of goat milk over cow milk for rehabilitating undernourished children in developing countries.

Hypoallergenicity studies on goat milk

In 1,682 allergic migraine patients, Walker (1965) found that only one in 100 infants who were allergic to cow milk, did not thrive well on goat milkfrom. Among the 1,460 patients with food allergy, 92% were due to cow milk or dairy products; 35% to wheat; 25% to fish; 18% to egg; 10% to tomato; 9% to chocolate. Some patients were allergic to more than one food.

In French clinical studies over 20 years with cow milk allergy patients, these were found to be sensitive to cow lactalbumin and α_{s1}-casein, which are species specific. The major whey protein, β-lactoglobulin, is reportedly to be responsible for cow milk allergy (Heyman and Desjeux, 1992). Substitution of cow milk with goat milk resulted in "undeniable" improvements (Sabbah et al., 1997). In other French clinical trials with children allergic to cow milk, 93% of the goat milk treated children produced positive results, and goat milk was recommended as a valuable aid in child nutrition, because of its hypoallergenicity and better digestibility compared to cow milk (Reinert and Fabre, 1997).

While some caprine milk proteins have immunological cross-reactivity with cow milk proteins (Restani et al., 1999), most studies reported that infants suffering from gastrointestinal allergy and chronic enteropathy against cow milk were cured by goat milk therapy (Walker, 1965; Van der Horst, 1976; Park, 1994a). Much more clinical studies are called for as goat milk research in clinical trials has not been well supported by the cow milk driven societies.

Guinea pigs had allergic reactions to goat milk with α_{s1}-casein, similar to cow milk, which only has this protein polymorph, and which may explain the commonly found cross-immune reaction between cow milk and some goat milk. However, only 40% of guinea pigs fed goat milk without this polymorph but instead with α_{s2}-casein showed an allergic reaction, indicating goat milk lacking α_{s1}-casein is less allergenic than other goat milk (Haenlein, 2004).

Conclusions

Caprine milk and its products are important sources of nutrition and economic wellbeing of humanity in many parts of the world. Production of caprine milk is highly important in developing countries, where it provides basic nutrition and subsistence to the rural populations. In addition, dairy goat products including fluid milk, cheeses and yoghurt are also valued parts of the total dairy industry in developed countries, by providing connoisseur consumers with diversified and exotic tastes, and by supporting people with medical afflictions, such as allergies and gastro-intestinal disorders, who need alternative dairy products. Because of its unique nutrient composition and physicochemical characteristics, goat milk has highly important nutritional, therapeutic and medical values in human nutrition and health. Further clinical and nutritional trials on human subjects are greatly needed to substantiate and confirm the reported nutritional, hypoallergenic and therapeutic significance of goat milk in human nutrition.

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Plenary 8

Microbiota of Goat's Milk and Goat's Milk Cheese

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Introduction

Sheep and goats have been raised for milk, meat and wool for thousands of years. In fact, small ruminants are the most efficient transformers of low quality forage into high quality animal products with unique chemical composition and organoleptic features. The total world population of sheep and goats, 1024 and 768 million, respectively, is found mainly in semi-arid areas or areas with temperate pasture. Asia and Africa, together, account for the 64.5 and 91.5% of the world's sheep and goats, respectively. The respective numbers for Oceania and Europe, combined, are 27 and 2.4%. Sheep and goat meat production represents 10.8 and 7.3% of the world ruminant's meat production, respectively, with 64 and 90% of that being produced in Asia and Africa (Zervas and Tsiplakou, 2011).

Sheep and goat milk production represents 1.3 and 2.1% of the world's milk production, respectively, with the world's major commercial part being concentrated in the countries of the Mediterranean basin. Apart from France and Southern European countries, where the industrial processing of sheep and goat milk is well developed, exact statistical data on the production of these types of milk is not always available or reliable. It is estimated that the European production of sheep and goat milk ranges between 4.5 and 5.0 million tonnes, while around 6.0 million tonnes are produced in India and China. The remainder of worldwide production is 13.3 million tonnes that are produced in North Africa, Middle East and Latin America (IDF, 2009).

Sheep and goat milk is utilised for direct consumption and the manufacture of a wide range of cheeses and fermented milk products. The yield but also the quality of these products depends, among others, on milk composition, which is, in turn, influenced by the animal breed as well as the animal nutrition. A number of studies have shown that milk from sheep and goats raised on pasture is enriched with substances of natural origin like phenolic compounds, fat soluble vitamins, flavours terpenes, bioactive lipid components, such as conjugated linoleic acid, in addition of being naturally high in medium chain fatty acids, compared to milk from animals fed conventional concentrate-forage diets (Zervas and Tsiplakou, 2011).

Microbiota of goat milk

Nowadays, goats of dairy breeds highly selected for milk production are receiving increasing attention regarding milk yield and quality. Hygiene in milking and milk handling is of obvious importance to regulations for somatic cell counts (SCC) and bacterial numbers that vary among countries. The primary source of microbial contamination is post-milking handling due to poor hygiene or improper milk refrigeration. Both bacterial numbers and

SCC can be lowered by improved management conditions, including sanitation of the farm, animals and equipment along with timely transportation of milk to the storage tank.

Somatic cells in goat milk are composed of different types of leukocytes, including neutrophils, macrophages and lymphocytes. In infected udder halves, neutrophils increase with infection. High percentages of polymorphonuclear neutrophils were found in goat milk with low SCC and they increased with the stage of lactation and age, while levels of lymphocytes and macrophages decreased. It has been shown that throughout lactation streptococcal infections are rare in goats in contrast to dairy cows. Mastitis related pathogens in normal goat milk samples include *Staphylococcus* spp., *Bacillus* spp., coliforms, *Micrococcus* spp., *Streptococcus* spp., *Corynebacterium* spp. and *Pseudomonas* spp. Infection by *S. aureus* causes high SCC, while numbers decrease in the case of coagulase negative staphylococci and are certainly lower in non-infected udder halves. On the other hand, SCC were found slightly higher in milk from udder halves with subclinical infection of *S. epidermidis* than in milk with other staphylococcal infections. Interestingly, histological and pathological tests on fresh udder half tissues of goats with low, medium and high SCC revealed no changes in the mammary glands or other evidence of mastitis, indicating that healthy dairy goats with healthy udders may produce milk with SCC $> 1.0 \times 10^6$/mL, particularly in late lactation. Thus, elevated SCC alone is not necessarily a valid indication of mammary infection in dairy goats (Goetsch et al., 2011).

Microbiota of goat milk cheeses

France has a long tradition in the production of cheeses. The main ripening strains in French soft cheeses made with goat's milk are yeasts, namely *Geotrichum candidum* and *Penicillium*, although other species, such as *Candida lipolytica* and *Candida intermedia*, also seem to be involved. It has been observed that *G. candidum* is able to lower the bitterness caused by *Penicillium* in goat milk cheeses, thus confirming findings obtained for cow milk Camembert cheese. Moreover, the specific lipolytic behaviour of ripening strains and the predominant role of *G. candidum* in ripened goat milk cheeses, in comparison to *Penicillium candidum*, with respect to goat flavour development by releasing not only C18: 1 but also the goat flavour marker 4-ethyl-octanoic acid, has been highlighted. Besides fatty acids, many other compounds have been implicated in the flavor of goat milk cheese, such as alcohols, ketones, esters and lactones. It should be stressed, however, that the aromatic potential of these strains depends also on the cheese manufacturing conditions. The behaviour of various ripening strains has recently been studied more systematically in an edible goat milk cheese model, before testing them in real cheese production. The model gave a rapid and discriminatory evaluation of the flavouring potential of *Penicillium, Geotrichum* and yeasts, such as *Debaryomyces* and *Kuyveromyces*. It also provided evidence about interactions between lactic acid bacteria and ripening yeast strains (Raynal-Ljutovaca et al., 2011).

For the major Italian goat milk cheeses, namely Canestrato di Moliterno and Robiola di Roccaverano, data about the microbiota exist only for the latter. DGGE results showed that lactococci and streptococci were the main lactic acid bacteria present in Robiola di Roccaverano. Species such as *Lactococcus garviae, Streptococcus parauberis* and *Streptococcus macedonicus* were found only in artisanal products, while lactobacilli were not detected. Yeasts belonging to *Geotricum* spp. and *Kluyveromyces lactis* were present in almost all artisanal and industrial samples, while *Candida catenulate, Candida silvae, Saccharomyces exiguus, Saccharomycete* spp. and *Yarrowia lipolytica* were detected only inartisanal cheeses and *Penicillium* spp. only in the industrial products (Pirisi et al., 2011).

Almost the majority of Greek cheeses are produced from mixtures of sheep and goat milk, the latter being about 20–30% of the cheese milk mixture. Most of them are designated as cheeses of Protected Designation of Origin (PDO) and include Feta, Kasseri, Graviera, Kefalograviera, Kefalotyri, Batzos, Touloumotyri, Kalathaki of Limnos, Sfela, Teleme, Anevato, Galotyri, Katiki, Kopanisti, Pichtogalo Chanion, Krassotyri, Ladotyri, Manoura, Xinotyri, Melichloro, Manouri, Mizithra and Xynomizithra. There are several literature reports on the microbiota of Greek cheeses. In general, the predominant microflora throughout ripening consists of non-starter lactic acid bacteria (NSLAB) that proliferate and contribute by their biochemical activities to cheese ripening and the development of cheese organoleptic features. Microorganisms indicative of hygienic quality, such as enterobacteriaceae and coliforms, decline during ripening and are usually found at negligible levels in the final product (Litopoulou-Tzanetaki and Tzanetakis, 2011).

In Portugal, for the two most important cheeses prepared with mixtures of sheep and goat milk, namely Picante da Beira Baixa Rabaçal and Amarelo da Beira Baixa, lactic acid bacteria have been reported as the predominant group, while no microbiological data exist about Cabra Transmontano, which is produced with goat milk solely. Moreover, a mixed strain starter, comprising of *L. plantarum*, *E. faecium* or *E. faecalis* and *D. hansenii* and/or *Y. lipolytica* has been proposed for goat milk cheese production, based on the proteolytic and lipolytic activities of the above strains (Reis and Malcata, 2011).

In Spain, among the most important 32 goat milk cheeses, the microbiological characteristics have been studied and described for Acehuche, Armada, Camerano, Cendrat del Montsec, Gredos, Ibores, Majorero, Palmero, Tenerife and Valdeteja. Moreover, data exists about cheeses produced with mixtures of goat and sheep or cow milk, such as Cabrales, Gamonedo and Valdeon (Martinez et al., 2011).

In Turkey, several cheeses are prepared with the use of goat milk, either as a whole or as mixture with sheep or cow milk. These include Izmir brined Tulum, Cimi, Ezine, Carra or Testi and Sepet. A recent study on Sepet revealed high numbers of mesophilic aerobic bacteria and yeasts while coliforms and staphylococci were present at low levels and moulds were not determined. On the other hand, for various types of yogurt prepared from goat milk, no data from microbiological analysis have been reported so far (Hayaloglu and Karagul-Yuceer, 2011).

In the Middle East, the main dairy products from sheep and goats are yogurt and cheese, mostly produced in households or small-scale production units using traditional methods. Yogurt is the most common product. The main cheese, produced from sheep milk or a mixture of sheep and goat milk, is the fresh cheese Bayda with a high fat content. There are also low fat cheeses, such as Mushallaleh and Halloumi, which are addressing the demands of urban, more health conscious consumers. Studies on composition and characteristics of these dairy products are available, not in the international scientific literature though (Hilali et al., 2011).

In South America, the most important sheep and goat dairy products are milk, yoghurt and cheeses, with the most known cheeses being Boursin, Moleson, Chevrotin, Chabichou and Frescal, produced mainly in Argentina and Chile. Sheep and goat dairy products are artisanally manufactured using raw milk and without the addition of starter cultures, taking advantage of the autochthonous milk microbiota. Recent studies have shown that lactic acid bacteria, such as lactobacilli, enterococci and pediococci, are present in Argentinean goat milk and goat milk cheeses (Medina et al., 2011).

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Plenary 9

The Welfare of Dairy Goats

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Introduction

Goats were domesticated about 10,000 years ago, making them one of the first species to be brought into man's „inner circle' of animals selected to provide for his needs. In contrast to cattle and sheep, their domestication was focused on developing a species suitable to thrive in the dry tropical and sub-tropical regions, mostly marginal lands. Their small size and efficiency as milk producers rendered them particularly suitable for this purpose. Most goats are dual purpose for milk and meat production and are kept by the rural poor in pastoral nomadic systems, providing the potential to provide a limited amount of high quality food in regions that would otherwise offer limited capacity to support humans (Ayele and Peacock, 2003). Milk supplies are typically just a small cup of milk per day from each doe and this is likely to be either sold in local markets or shared with family or other tribe members, who reciprocate with help to the pastoralists. Human and livestock survival are closely connected, and survival traits are highly sought after in the animals by the pastoralists (Omondi et al., 2008). There is little potential for artificial selection, but the pastoralists value disease resistance, fecundity, drought tolerance, body size and good milking traits in their animals. Assisting them to restock with suitable animals after a drought could improve both human and animal welfare. However, over-reliance on improvement with introduced genetics is without benefit unless accompanied by improvement of the husbandry system (Ayalew et al., 2003).

As goats predominate in less favoured areas, the inherent instability and susceptibility to variation in climate makes sustainable production difficult. There is potential for frequent and major impact on the animals' welfare. Drought, floods, political and environmental instability and competition from other agricultural sectors all challenge the welfare of goats, and the continued management of rangeland operations deserves more attention from scientists, politicians and agricultural development agencies (Devendra, 2012). Limited infrastructural funds in particular hinder improvement of goat management systems.

In the developing countries, goat flocks are small, typically about three animals, and managers of the goats are often women, e.g. about 66% in Kenya (Bett et al., 2009). Children also play an important role in husbanding the goats. Advisory services and veterinary programmes must reach the women and children to be effective in improving husbandry standards (Ayele and Peacock, 2003). Veterinary services are most likely to be utilised by large productive flocks and less likely to be used by those that keep dairy goats for social reasons, such as insurance against emergencies and risk and for prestige.

Drought conditions

Dual purpose goat production systems offer the potential to increase food security and human nutrition, but the livestock management has to be sustainable in order to survive long-term. Fodder supplies are variable and prone to drought and salinity, leading to goats consuming tree fodder, which potentially degrades the landscape. Furthermore, pressure on rangelands by increasing human populations, in Africa and Asia in particular, have placed the pastoralists in competition with farmers in dryland regions. In Asia increasing affluence in many regions, especially urban ones, is increasing demand for animal-based food. Increasing livestock populations exacerbate the shortage of fodder during the dry seasons and droughts.

Destocking during drought is hard to time effectively without accurate meteorological forecasts. Overstocking during periods between droughts makes destocking even harder. Ensuing fodder shortages may require pastoralists to purchase supplementary feed, and the resulting financial pressure is driving younger family members, especially men to become itinerant urban workers. Governments have a role in making small-scale loans available to enable pastoralists to maintain their flocks during drought or to restock afterwards. Governmental and other agencies should monitor and research the pressures on land use in pastoralist zones to be able to provide support to pastoralists under pressure.

Water availability may also be a serious constraint to flock survival during drought, especially to lactating does. Better utilisation of crop residues and improved nutrition through crop residue improvement, as well as the use of fodder trees and cacti all offer hope to provide feed supplies during drought periods (Ben Salem and Smith, 2008). However, the technologies for such simple methods to alleviate the impacts of drought and water shortages have been known for several decades, but the resource-poor pastoralist is often unable to implement them in severe droughts, leading to serious welfare concerns for the animals. Government assistance is vital to support the welfare of the goats as well as the pastoralists.

Behaviour of dairy goats

Goat behaviour is different to that of the other major domesticated ruminant species, sheep and cattle (Miranda-de la Lama and Mattiello, 2010). Although like cattle and sheep they are highly gregarious and therefore stressed by isolation, they are more likely to be aggressive than sheep and less likely to flee in the presence of a perceived aggressor. Aggression is particularly common at the feeding troughs and enriching a feedlot will reduce the aggression and increase weight gain (Flint and Murray, 2001).

The presence of horns increases the risk of injury during agonistic behaviour. Most housed goats are disbudded without anaesthetic or analgesic, which causes extreme pain, as evidenced by heart rate, cortisol and behaviour responses (Alvarez and Gutierrez, 2010). Stakeholders in the goat and sheep industries of Australia believed pain control to be more important in invasive practices than the practice itself (Phillips et al., 2009).

Health in housed and other intensive management systems

Of the 800 million or so goats in the world today, only about 9% is housed (Alvarez and Gutierrez, 2010). Of all the diseases that can afflict housed or intensively farmed goats, the most common is lameness, the pain from which has a major impact on welfare. The prevalence is often about 10%, and the risk factors include the feet being consistently wet in excreta with bacteria (Olechnowicz and Jaskowski, 2011). A welfare assessment scheme for British dairy goats, based on animal records, found that there was lameness in approximately 19% of goats, and severe claw overgrowth in 32%; other welfare issues included udder asymmetry, suggestive of mastitis, and knee calluses (Anzuino et al., 2010). Skin and udder lesions were of sufficient regularity to be a concern and the report highlights the lack of measurement techniques, for example for lameness, in comparison with dairy cows. Routine foot trimming helps to treat overgrown feet that often arise from feeding highly concentrated diets to goats that do not walk on hard ground to abrade the horn tissue on their feet. Aggression between goats is also common in intensive housing systems, but proper housing system design can help to mitigate the impact on individuals (Nordmann et al., 2011).

Helminth infection is a major concern for intensively pastured dairy goats (Hoste and Torres-Acosta, 2011). Parasite control has been rated by stakeholders in the industry as one of the most serious welfare concerns for goats and sheep in Australia (Phillips et al., 2009), however, no distinction was made between the two species. Goat farmers tend to be less likely to use prophylactic medication than cattle or sheep farmers, rendering the animals more susceptible to infectious diseases (Elbers et al., 2010). This may be due to the cost of medication, a less advanced advisory service or the type of people keeping goats, compared with cattle or sheep. The emergence of resistance to parasiticides will make this an even more important influence on welfare in future (Coles and Roush, 1992).

Transport

Some of the biggest welfare problems often occur off-farm in both developing and developed countries. For example, African goats are commonly transported south from the Sahelian zone of northern Nigeria and neighbouring countries in open-topped vehicles. Adequate standards to protect goats from heat stress during hot, dry conditions in long distance transport do not exist. If there are delays during the journey animals frequently are dead on arrival. Some benefit of administering ascorbic acid as an anti-stress agent has been demonstrated (Minka and Ayo, 2012).

Conclusions

Goats occupy a niche in dryland agriculture and are utilised to provide some high quality nutrition to pastoral nomads. Their welfare is closely tied to that of their goats. Increasing human population, environmental degradation and pressure on feed resources is putting pressure on the pastoralists' ability to maintain the welfare of their animals. Increased government intervention is warranted to assist them through provision of small loans and other benefits that will enable them, and their animals to survive in the face of these adversities. In the long term a better ability to forecast pressures on pastoralists and their goats, and the impacts that they will have, will enable action to be taken to ensure the welfare of the goats and their owners.

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Country Report 1

Dairy Goats in Indonesia: Potential, Opportunities and Challenges

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Potential

Indonesia has the world's second largest animal biodiversity. Farmers in Indonesia have been introduced to animal agriculture that includes dairy goats. In fact the population of goats in Indonesia has increased gradually at an average rate of 4.6% in the last ten years, from 12 million in 2000 to 16.8 million in 2010, involving 3.5 million households (BPS, 2010). The goats are spread throughout 33 provinces with the highest population of 3.5 million heads (20%) in Central Java followed by East Java with 2.7 million heads (16%) and West Java with 1.6 million heads (9.5%). Goats offers good business opportunities in Indonesia because they are very well-adapted to the tropical environment and require low investments. Farmers usually rear a few animals without intensive management, as a living bank for emergencies and expenses and as a source of fertiliser for crops. Also, they play an important role in the social life of the villagers. Goats are usually reared to produce meat and milk. In Indonesia there are many goat breeds for example the bali, boerawa, etawah, gembrong, jawa randu, kacang, kosta, marica, muara, samosir, kapra, etawah crossbreds and saanen. Among them only etawah, etawah crossbred (etawah × local kacang goat) and saanen goats are dairy goats. The breeding center of dairy goats in Indonesia is in Kaligesing-Purworejo, Central Java. From the centre, animals are distributed to areas, which have potential to improve their performance, like Yogyakarta, Bogor, Bandung and Pasuruan.

The nutrient composition of goat milk is 17 to 13% DM, 3.3 to 4.9% CP, 4 to 7% fat, 4.6% carbohydrate, 129 mg Ca, 106 mg P, 185 mg vitamin A and 0.3 mg niacin. Moeljanto, et al. (2002) reported some benefits of goat milk over cow milk including flouride concentration being 10 to 100 times higher in goat than cow milk, thus it can be used as natural antiseptic, alkaline and healthy food. The milk is safe to consume and could neutralise stomach pH, digestible smooth proteins, easy to digest small size of fat particle, high sodium, calcium and phosphorus minerals content, white color with no odor and protective properties against osteoporosis.

Milk production in Indonesia has increased in the last five years from 616,549 tonnes in 2006 to 927,838 tonnes in 2010, with an average increment of 9.25% per year, but most of the milk comes from dairy cattle. In a few regions, the dairy goat has contributed to the total milk supply, especially in big cities such as Jakarta and Surabaya fetching high prices of US$ 2.5 to 3.0 per litre.

Opportunities

The population of Indonesia is on the increase and consequently the need for healthy food has also increased. In 2008, the consumption of meat was 7.75 kg/capita/year, an increase of 7.4% over the previous year. Egg consumption was 17.42 kg/capita/year while milk consumption was 6.92 kg/capita/year. The infant milk powder and sweet canned liquid milk are the major contributors to the overall milk consumption. Thus the production of fresh milk could potentially increase to meet increasing demands for either processed or fresh milk. Milk consumption in 2009 (0.17 L/capita/d) increased compared with that of the previous year (0.13 L/capita/d), the demand cannot be met by local production. Thus to meet this requirement, the government had to import milk powder. To overcome the lack of local milk supply, goat milk can play a role as an alternative source. Deficit of fresh milk supply from the cow is equivalent to approximately 750,000 lactating goats, which means an estimated 75,000 small farmers or households can contribute to the dairy farming business. This certainly will provide opportunities for the dairy goat farmer. Goat milk however is still not as popular as cow milk, although it is consumed for health purposes even at a high cost of US$ 5/L. The dairy goat industry in Indonesia needs to be supported by the business and research community.

Business

One good example of a dairy goat small business in Indonesia is at Unggul farm in Bogor District. In this farm, in 2007, the dairy goat population increased by 129% compared to other districts in Bogor. A case study of a smallholding dairy goats in Unggul farm in the Ciampea district, Bogor, which has 50 animals showed that it has good business indicators, with Net Present Value (NPV) of Rp 359,966,477 or US$ 36,000, an Internal Rate Return (IRR) 127%, a Net Benefit Cost Ratio (Net B/C) of 5.77 and a Payback Period (PBP) of 2 years. Another farm in West Java is the Ciangsana farm specialising in breeding dairy goats. They breed the SAPERA goat, which is a crossbred of a male Saanen with a female Etawah.

At Turi District-Yogyakarta, a cooperative dairy goat farming named Suyadi Farm supervised by the Faculty of Animal Science, Gadjah Mada University, has been running an intensive dairy goat farm over the past ten years. In this farm, milk production from the lactating goats is 0.5–1.2 L/d at market price of US$ 2.5 to 3.0/L. In this district, the goat population is around 250 heads with 38 households and the average milk production is 2.7 L/head/d.

Another district, Kemirikebo in Yogyakarta, has 623 goats involving 65 households. Urine and feces of the animals are used as fertilizer at market price of US$ 1.5/L and US$ 5/zak, respectively. The „wastes' are sold to the Salak fruit plantation in the vicinity of the farm. This business has improved the income of the goat farmers. In case of overproduction, the excess milk is processed into caramel milk candy, ice cream, milk crackers, „dodol' and yoghurt with a variety of flavors including strawberry, apple and coconut.

Rosyidi from the Pakem district of Yogyakarta is a progressive farmer who has a milking machine for his goats and a mini-factory for making yoghurt. Another farmer, Bondan from the Condongcatur district of Yogyakarta, has introduced a special way to sell the fresh milk by a door-price system (Kompas, 2011).

Research

Universities and research institutions of the Department of Agriculture have provided information and technology on good farming practices to improve production performance of dairy goats. Feed is the most important in production animals. One study determined the requirement and utilisation of traditional rations (native grass plus rice bran) in digestion, metabolism and dynamics of nutrients for lactating goats, as shown in Table 1 (Astuti et al., 2000). This study also developed equations to calculate the energy and protein requirements of the lactating etawah crossbred goats using multiple regression analysis of independent metabolic and performance parameter data as follows:

$$ME\ (Mj/d.kg\ BW^{0.75}) = 0.50 + 0.068\ RE\ (Mj/d)\ \text{or}$$
$$ME\ (Mj/d) = 4.23 + 0.71\ RE + 0.003\ ADG + 0.006\ RP + 0.002\ MY$$
$$Protein\ (g/d.kg\ BW^{0.75}) = 10.81 - 0.02\ RP\ (g/d)$$
$$Protein\ (g/d) = 85.05 - 5.36\ RE + 0.055\ ADG - 0.16\ RP + 0.068\ MY$$

Table 1. Digestion, metabolism and glucose kinetics of lactating Etawah crossbred goats

Nutritional parameters	ad lib	90% of ad lib	80% of ad lib	SEM
DM intake (g/d)	865^{a}	765^{b}	620^{c}	38
Protein intake (g/d)	158^{a}	152^{ab}	135^{b}	17
Energy intake (MJ/d)	16.0^{a}	14.0^{b}	11.4^{c}	0.70
DM digestibility (%)	70	69	65	7
Protein digestibility (%)	66	63	62	5
Energy digestibility (%)	69	67	68	5
ME intake (MJ/d)	7.8^{a}	6.6^{ab}	6.5^{b}	1
ME/DE (%)	83	82	84	3
HP (MJ/d)*	6.3	5.5	5.2	1
Retained Energy (MJ/d)	1.6	1.2	1.3	0.6
Retained Protein (g/d)	32^{a}	25^{b}	14^{c}	3
Glucose kinetics:				
Plasma glucose (mg/dl)	104	99	98	5
Pool glucose (g/head)*	3.3^{a}	2.2^{b}	1.9^{c}	0.4
Glucose flux (mg/min.head)*	29^{a}	24^{b}	15^{c}	3
TQ (%)*	14.7	13.6	14.7	2
GNG (mg/min.head)*	26^{a}	20^{a}	13^{b}	6

Values are means
[a,b,c]Means in the same row with different superscripts are significantly different (P<0.01); * isotope technique. SEM = Standard error of mean.

Tempe (fermented peanuts) is one of the popular Indonesian foods. Tempe waste, which is produced as a by-product of the home industry, has potential to be used in dairy goat rations. Solid waste still has a good quality with 16% crude protein and liquid waste is available as a drink. Processing technology has introduced ways to improve the quality of tempe waste by using *Aspergillus niger* to ferment the waste to be used in dairy goat rations. A study on the use of tempe waste (Table 2) was conducted in the field on dairy goats at Yogyakarta under the supervision of the IPB-Gadjah Mada University collaboration project (Astuti et al., 2003). Nutrient uptake by the mammary gland was determined, based on the mammary artero-venous difference (Sastradipradja et al., 1996).

Table 2. Milk yield and nutrient uptake in the mammary gland of Etawah Crossbred goats fed with tempe waste.

		Tempe waste	
Parameters	Control	Fresh	Fermented
Milk yield (mL/d)	1070[b]	700[c]	1545[a]
Total milk protein (g/d)	51.45[b]	29.90[c]	74.90[a]
Total milk fat (g/d)	42.90[b]	29.00[c]	63.30[a]
Total milk lactose (g/d)	37.50[b]	27.30[c]	57.76[a]
Nutrient uptake:			
Glucose	51[b]	35[c]	72[a]
Triglycerides	45[b]	30[c]	54[a]
Total protein	45[b]	38[c]	60[a]
Acetic acids	30[b]	2[c]	45[a]

Values are means
[a,b,c]Means in the same row with different superscripts are significantly different (P<0.01); Control = ration with 50% grass: 50% concentrate; Fresh tempe waste = ration with 50% grass: 25% concentrate: 25% fresh tempe waste; Fermented tempe waste = ration with 50% grass: 25% concentrate: 25% fermented tempe waste.

Challenges

Government Support

The number of dairy goats in Indonesia is still small compared to total animal agriculture. Information on the population, milk production and on dairy goat business centres is still scarce and not common knowledge. However, the industry can blossom if both the government and private sectors provide support and focus on increasing dairy goat production. Presently Indonesia is still improving strategies to promote dairy goat industry by increasing goat population (breeding), counseling and applying high technology production.

Breeding centre

The biggest breeding centre of etawah goats in Indonesia is in the Kaligesing district, Central Java, which is supported by the government. Presently, the activities and breeding programmes in the centre have decreased due to changes in the government roles, increase in capital requirement, lack of market priority (export), high rate of sterile doe slaughter and limited post-harvest technology and facilities, among others.

Drinking fresh milk goat culture

The low milk consumption in Indonesia is not only caused by low milk production and the high price of the product, but also by culture and preference. Very few Indonesians like and can afford goat milk. Although the government had attempted to promote drinking of goat milk through programs such "Milk Day", it has not been sustainable.

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Country Report 2

Dairy Goat in Vietnam: Potential, Opportunities and Challenges

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Introduction

Vietnam is a monsoon tropical country located in Southeast Asia. The total area of country is 331,114 sq km, with a population of 90 million, of which 55 million are farmers, comprising of approximately 67% of total labour force. The cultivated area is small, about 11 million ha. Agriculture is based mainly on rice production at about 37 million tons per year from 77% of the cultivated area. Rice production is supported by crops such as maize, potato, cassava, groundnut, soybean, sugarcane, fruit trees and other perennial commercial trees as coffee, tea, rubber and coconut. The agriculture output value contributes 25% of GDP, of which food production is 77% and livestock production is about 20%, mainly pigs, cattle, chicken, ducks and goats.

Goats have long been raised all over the country in an extensive free-range system with low animal performance. The total number of goats in the country is about 1.3 million of which 200,000 are dual purposes dairy and meat goat breeds. However, in the recent years, goat production has begun to receive more attention from the farmers and the Government. There have been some achievements in the area of goat breeding, nutrition, processing and disease prevention. Under the support of the government and international organisations, some programmes and projects have been carried out with satisfactory results. It is clear that goat production has played an important role in the improvement of the incomes for poor farmers in the hilly and mountainous areas and contributing to the alleviation of poverty and hunger in Vietnam. In this review, we discuss the current situation of the dairy goat industry in Vietnam, its potentials, opportunities and challenges.

Situation of dairy goat in the whole livestock production of Vietnam

As Table 1 shows, the goat population in 2006 was approximately 1,525,300 heads, while the number of dairy goats was only 150000, of which 67.5% were in the North and 32.5% were in the South of Vietnam. The number of goats in 2010 was approximately 1,288,700 heads of which 200,000 were dairy goats. The role of goat production including dairy goats is increasing and plays an important role for smallholders in poverty alleviation.

Table 1. Livestock population and production trends

	Number of animals by year ($\times10^3$)				
Livestock	2006	2007	2008	2009	2010
Pig	26855.3	26560.7	26701.6	27627.7	27373.1
Cattle and buffaloes	9431.9	9721.1	9235.4	8989.8	8829.7
Poultry	214600.0	226000.0	248300.0	280200.0	300500.0
Dairy goat	150.0	160.0	170.0	180.0	200.0
Total Goats	1525.3	1777.7	1483.4	1375.1	1288.7

Potential

Dairy goat breeds

Local indigenous dairy goat breed

The local dairy goat breed is Bach Thao, a dual purpose goat used for meat and milk. This is the main dairy goat breed in Vietnam and found mainly in Ninh Thuan province (Central Vietnam). Recently, the Bach Thao goat has been introduced to many other provinces of Vietnam. The origin of Bach Thao goats is not clear; however, it is believed that these goats came from Europe a long time ago. The Bach Thao has a black coat with white spots and big and pendulous ears. The body weight is 75 to 80 kg for males and 40 to 45 kg for females. Milk yield is about 1.1 to 1.4 kg/day with a lactation period of 148 to 150 days. The Bach Thao can reproduce 1.7 to 1.8 litter per year. The breed has been found to perform well under improved management conditions.

Imported dairy goat breeds

Besides the local dual purpose goat breed, Vietnam has imported some exotic dairy goat breeds, the Saanen and Alpine goats from France, as frozen semen and live goats. The first batch was imported in 1998 and a second batch was imported from the US in 2002. In 1994, Vietnam imported three more dairy goat breeds, the Jumnapari, Beetal and Barbary from India. These exotic breeds have good milk yield and adapt very well to the grazing farming conditions of the country. Most of the imported goat breeds are used to cross with the local Bach Thao to improve milk yield.

Management, feeding system and feed resources

There are three main methods of goat management in Vietnam; intensive, semi-intensive and extensive management systems. In the intensive system, animals are kept in cages (Devendra and G.B. Mcleroy, 1982) and the animals are hand-fed. The kids are separated from their mothers10 days after kidding and the does milked twice daily (with milk recording). The kids are allowed to suckle after milking, and milk consumed by the kids is estimated by weighing kids before and after suckling. The kids are weaned at three months of age.

In the semi-intensive system, goats are grazed, and supplied feed at the goat house at night. This system is found suitable for the existing goat production system in Vietnam.

In the extensive system, animals are grazed without supplementation. This system is common in the rural areas of Vietnam. In remote areas, children or elder people normally take care of the goats on free-range during the day and herd them home in the evening

The average flock size in Vietnam is about 5 to 20 goats per family. There are large farms in Binh Thuan and Ninh Thuan provinces, where goat flocks reach one hundred head. Goats are kept in cages supported by pillars at a height of about 50 to 70 cm.

There is a Goat and Rabbit Research Centre (GRRC) belonging to the National Institute of Animal Sciences (NIAS), located in Hanoi, which coordinates the breeding programme under the national and international research cooperation projects for Vietnam. Dairy goat production is also under the extension programme of the Ministry of Agriculture and Rural Development (MARD) to help the smallholders in the country.

Beside the natural grasses, cultivated forages are also being introduced to farmers such as *Flemingia macrophylla*, *Trichanthera gigantean*, *Leucaena, Panicum Maximum* cv likoni, *Brachiaria ruziziensis*, and Elephant grass. Available local feed resources are also being investigated for use as goat feed including Mulberry (*Morus alba*), Bananas (main stem), cassava hay (cassava sterm and leaves) and cassava roots.

Three-quarters of Vietnam are mountainous and hilly covered by trees, which is a huge source of agro by-products that can be used as goat feed. Goats are integrated in the animal farming system so that feed that is not used by the other animals is consumed by them.

Disease situation

Some major diseases reported among goats in Vietnam are internal parasites, ecthymatosis, diarrhoea and pneumonia. The important and dangerous infectious diseases with high mortality like pasteurellosis, enterotoxaemia are effectively controlled by vaccination. The other infectious diseases that can spread rapidly like ecthymatosis, keratoconjunctivitis are treated effectively with local medicines.

Product processing and markets

At present, the products derived from goats (meat and milk) receive higher prices than other types of milk and meat and these products must compete with products from pigs, chicken, and cattle in the market. However, the signs suggest that the environment is now favourable for the promotion of goat products. During the period of 1998–2000, one project (FAO/TCP-VIE 6613) was implemented by the Goat and Rabbit Research Centre (GRRC-NIAS), which developed new methods for collecting goat milk from small farmers to small processing units for the pasteurisation and processing to make cheese and yogurt. This project has created new markets for these products and provided farmers with opportunities to increase their incomes and further improve their dairy goat production system.

There is a potential market for goat milk in Vietnam. The price of goat milk is 30,000VND per litre while it is only 20,000 VND for cow milk. There is now a big demand from consumers for goat milk, especially in the cities.

Opportunity

In the Livestock Development Strategy to 2020 of the Government of Vietnam, the outlook on livestock sector development is as follows: To develop livestock production into commodity production, reorganise livestock production and facilitate linkage between production and markets, ensure food safety, veterinary hygiene, environmental protection and improvement of social welfare, increase productivity, quality, efficiency, food safety and hygiene and encourage organisations and individuals to invest in the development of livestock industry. Recently, one national project on improvement of meat and milk in goat and sheep production in Vietnam has been approved and will soon be implemented. Together with international programmes, Vietnam now has the opportunity to expand its dairy goat systems.

Challenges

The main indigenous dairy goat breed is a dual purpose goat breed, which is mainly used for meat because milk yield is low. Farmers lack knowledge of milking technology and dairy goat farming. Free range for grazing goats in Vietnam is limited, but goat rearing is mainly extensive. Milk collection and processing systems still need be established, while the market for milk and milk products is mainly in the big cities.

Future activities

In the livestock production strategy, Vietnam aims to increase the total number of dairy goats to 300,000 head. In order to attain that target, we plan to conduct studies on improver breeds by importing high-performance dairy goat breeds from Europe and other countries in the region to cross with the local indigenous breed. This should improve the quality and quantity of goat milk. Studies will be conducted on feeding and management, product processing and marketing. We will establish pilot farms as show-farms for farmers to learn in provinces where the dairy goat projects will be implemented.

Country Report 3

Dairy Goats in Thailand: Potential, Opportunities and Challenges

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Introduction

Thailand is one of the largest food producing and exporting countries in the world with a GDP of US$ 584 billion in 2010 (NESDB, 2011) and a population of 68.1 M. The agriculture and livestock sectors account for 11.4% and 2.5% of the GDP. In 2011, there were 3.14 million livestock farmers and 41,582 of those raised goats. The major livestock species in Thailand are chicken, ducks, swine and cattle (Table 1). Broiler chicken is the main commodity for export while other species are produced for domestic consumption and small scale trading. The numbers of all ruminant species increased in the last ten years except buffaloes. There has been a rapid increase in number of goats (140%) from 178,000 in 2002 to 427,000 in 2011. The distribution of goats is related to the Thai Muslim community. More than 60% of all goats are found in the villages along the Thai-Malaysian border where the proportion of Thai Muslim people is high.

Table 1. The number of important livestock species in Thailand from 2002 to 2011.

Year	Total Goat	Meat Goat	Dairy Goat	Dairy Cattle	Beef Cattle	Buffalo	Swine	Chicken	Duck
2011	427567	394204	33363	560659	6.6 M	1.2 M	9.7 M	317 M	32 M
2010	380277	350851	29426	529572	6.5 M	1.2 M	8.3 M	266 M	29 M
2009	383796	366998	16798	483899	8.6 M	1.4 M	8.5 M	282 M	27 M
2008	374029	344516	29513	469937	9.1 M	1.4 M	7.7 M	256 M	23 M
2007	444774			489593	8.8 M	1.6 M	9.3 M	283 M	25 M
2002	177944			358440	5.5 M	1.7 M	7.0 M	229 M	25 M
%Change*	140%			56%	20%	-29%	39%	38%	28%

Source: Information and Statistics Group, Information Technology Centre, Department of Livestock Development (DLD, 2011); *the percentage of livestock numbers in 2011 compared to those in 2002; M: Million

Distribution of goats in Thailand

The distribution of goat populations in Thailand by region in the last 10 years is shown in Table 2. The changes in numbers of goats are different in each part of the country. The number of goats in the central part has increased by 289% and this is associated with commercial dairy goat farms. Its percentage of total goat population changed from 21% to 34% in 2011. Fifty-two percent of the total goat population is raised in the South, most of which are Thai indigenous goats. The North and Northeast are not significant for goat production in Thailand.

Table 2. Goat populations in Thailand by region from 2002 to 2011.

Year	Central	%	Northeast	%	North	%	South	%	Total
2011	145517	34	16320	4	42802	10	222928	52	427567
2010	137813	36	17453	5	43163	11	181848	48	380277
2009	160278	42	20363	5	61368	16	141787	37	383796
2008	158487	42	20901	6	53702	14	140939	38	374029
2007	162926	37	21423	5	86373	19	174052	39	444774
2006	111742	34	15014	5	56149	17	141245	44	324150
2005	109681	32	13974	4	55310	16	159390	47	338355
2004	62950	25	12354	5	39729	16	135043	54	250076
2003	52967	25	5021	2	43410	20	112519	53	213917
2002	37356	21	4573	3	29579	17	106436	60	177944
2002→11	289.5%		33.3%		-41.2%		-13.3%		140.3%

Source: Information and Statistics Group, Information Technology Centre, Department of Livestock Development

Statistics and trends of dairy goat production in Thailand

There were 33,363 dairy goats in 2011 which represent approximately 8.5% of the total number of goats (see Table 3). The proportion has remained approximately the same in the last 5 years. Dairy goats are more common in the central region, comprising 61% of all. The average numbers of dairy goats per farm are higher in the central part than in the rest of the country. The higher number of goats per farm is indicative of larger farm size and more intensive and developed farms. Small scale goat farms are found mostly in the South with the average number of goats ranging from 5 to 7 heads per farm compared to 43, 14 and 24 goats per farm in the central, northeast and north regions of Thailand, respectively.

Table 3. Dairy goat rearing in Thailand by region from 2008 to 2011.

Year	Central	%	Northeast	%	North	%	South	%	Total
Number of dairy goats									
2011	20403	61	1338	4	3405	10	8217	25	33363
2010	17597	60	1344	5	3529	12	6956	24	29426
2009	12105	72	915	5	1447	9	2331	14	16798
2008	19476	66	3379	11	4387	15	2271	8	29513
Number of dairy goats farmers									
2011	471	25	96	5	144	8	1203	63	1914
2010	434	25	103	6	133	8	1035	61	1705
2009	463	54	27	3	70	8	304	35	864
2008	461	38	173	14	161	13	431	35	1226

Goat genetic resources and performance data of dairy goats

Goats in Thailand are predominantly used for meat (90%). Milk production is a smaller industry (10%). Native goats are genetic resources that can be crossed with exotic breeds to produce rangeland goats for more extensive production. There are 10 goat breeds existing in Thailand: 2 indigenous and 8 exotic breeds. There are 4 meat breeds and 4 dairy breeds. The 2 local goat breeds are the Northern Thai referred to as „Bangala', which has a large but thin body, long pendulous ears (similar to the Anglo Nubian) and a straight face profile, and the other is the Southern Native Thai goat which is small in size with short upright ears (similar to the Katjang goat found throughout Southeast Asia). Four imported breeds of meat type are

Anglo Nubian, Boer, Black Bengal and Jamnapari and the four dairy goat breeds are Saanen, Alpine, Toggenburg and Laoshan. Saanen is the most popular among dairy goats in Thailand due to its high milk yield, mainly found in the central and southern regions. Other dairy breeds are found in small numbers.

Performance data of dairy goats of Saanen, Toggenburg, Alpine and Anglo Nubian and their crossbreds with Thai native goats from one of the Government farms in Pattani province was collected and reported as follows; from 1438 records of years 2004–6 the average overall milk yield per day was 0.9 kg, starting from 1.10 ± 0.43 kg in the first month of lactation to 1.05 ± 0.41 and 0.89 ± 0.34 kg in the 2nd and 3rd month, respectively (Thongchumroon et al., 2011). The weaning weights of purebred Saanen, Anglo Nubian, and Thai native goats were 16.4, 14.6 and 8.5 kg, respectively. A private organic dairy goat farm in Phuket reported a higher daily milk production of 2–3 litres with a lactation period up to 200 days.

Potential of dairy goat production

There is some potential in improving dairy goat rearing in Thailand through genetic and breeding improvement in the national policy on goat production of the Department of Livestock Development (DLD) together with feeding, reproduction and biotechnology development.

The strategies on genetics and breeding for dairy goat production and management practices are integrated with traditional farming practices in order to improve the performance of locally adapted breeds. Emphasis is on increasing body weight, improving reproductive efficiency and reducing losses due to mortality through better nutrition and breeding. With regards to genetics, specific strategies for genetic improvements in goat breeding are as follows: a) collection of productive and reproductive performance records; b) genetic evaluation and genetic parameter estimation using BLUP technique; c) use of statistical models and adjustment of environmental factors to determine a suitable animal model to estimate important genetic parameters; d) development of breed planning to avoid losing advantageous traits such as disease resistance, and optimal use of genetic resources for comparative efficiency of different crossbreeding systems to exploit dominance of favorable effects; e) use of molecular techniques for selection assistance to increase accurate genetic progression such as selection of the gene for parasite resistance. With the national goat breeding programme initiated and eminent efforts from experts, dairy goat production in Thailand will progress to its full potential.

Dairy goat management in organic farming and integrated crop-livestock farms

Thailand is among the biggest producers of palm oil and rubber. The plantations of oil palm and rubber have been predominantly in the southern part. The total planting area is expanding very rapidly in the northeast and eastern provinces. This would give a great potential and opportunity to incorporate dairy goat farms into the palm and rubber plantation-goat integrated farms or organic farming. Goats can provide manure and weed control to the plantation while goats receive shady areas for resting, housing and shelter from the plants. These mutual benefits already realised in an organic dairy goat-rubber plant farm in Phuket where Phuket organic goat milk is produced.

Opportunities

Goat milk is more expensive than cattle milk and very rare in most parts of Thailand. The price of a 250 cc bottle of fresh goat milk is 15–17 Baht (1.5 RM) compared to 18 Baht per litre of fresh raw cow milk. The price is almost 4 times higher than cow milk. This can become an incentive for promotion of dairy goat production in the country. Dairy goat production fits well into the rural areas and in the resource capacity of small holder farmers from low-input production to business model. The goat industry in Thailand has continuously grown as local demand for milk increases. There is also another demand for goat's milk from people and children who have cow milk allergy or are unable to digest cow milk. Moreover, Thailand has run a School Milk Programme aiming to support the dairy industry, by providing milk from local producers to the young school children. This will hopefully develop a taste for milk and hence a market for the future. Milk drinking habits of Thai children will eventually lead to positive consequences for dairy goat milk production in terms of demand and technology development.

Challenges

Despite a great opportunity and potential for dairy goat rearing in Thailand, there are some challenges to overcome. Firstly, goat milk is not a common part of the meal for most Thais other than Thai Muslims. Most people have aversion against the strong smell in goat milk. Secondly, there is a lack of suitable land and feed resources in some parts of the country. Thirdly, most farmers have inadequate knowledge of goat husbandry. Finally, marketing is the weakness to be overcome for the promotion of goat product consumption and a variety of value-added products to the markets.

In order to solve the problems mentioned above, Thailand needs to increase the goat population both in quantity and quality. Establishment of effective goat breeding improvement programmes is a key to success for the accuracy of identifying the best bucks and does through well-planned breeding objectives, selection and mating programmes specifically suitable for the environment and management in each part of the country.

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Country Report 4

Dairy Goats in Pakistan: Potential, Opportunities and Challenges

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Introduction

Pakistan is the fourth largest country in terms of goat population following India, China and Bangladesh and third largest in terms of goat milk production in Asia (FAO, 2010). Pakistan has about 34 goat breeds with a total population of 61.5 million heads found all over the country. There are about six million people who keep goats but most of them are landless or have marginal land holdings. The population of goats is increasing at 1.3 million goats per annum in the country (Livestock Census, 1996 and 2006). The goat breeds are categorised as meat, dairy and hairy types; but the major objective of goat rearing is production of meat. However, milk obtained from goats is also important in some parts of the country and goat milk contributes to the health and nutrition of several million people in Pakistan, especially those below the poverty line. Goat milk is of particular significance for the most vulnerable groups like pregnant and nursing mothers and babies who do not like their mother's milk and so we call the goat the poor man's cow. Among the different breeds of goats, Beetal, Dera Din Panah (DDP), Nachi, Kamori, Kacchan and Damani, are classified as dual purpose, i.e. both for milk and meat. Among these breeds Beetal is more popular in Punjab because of milk and meat production. Kamori is popular in Sindh province and similarly Damani in Khyber Pukhtunkhwa (KPK). Its production potential is not fully explored which necessitates more research for the exploitation of its potential.

Goat population and distribution

According to the Economic Survey of Pakistan (2010–11) there are 61.5 million goats (Table 1). From 1996 to 2006, the population of goats increased by 1.3 million/year which is the second highest growth rate after cattle (4.4%) population in the country. This trend shows the popularity of goat rearing among the people. The growth rate of the goat population was higher during the period 1996–2006 than that for the period 1986 to 1996 reported previously by Khan (2004).

The annual growth rate of the goat population is 3.1% which is higher than that for sheep (1.25%). This trend shows the preference of goats over sheep. Punjab has the largest population of goats (37%), followed by Sindh (23.7%), Balochistan (22.7%) and KPK (16%). In some parts of the country, where cow and buffalo milk are not available or limited in supply, goat milk is the main supply for home consumption.

Dairy goat population

The dairy goat population is depicted in Table 2. There are about 11.08 million dairy goats producing about 759,000 tonnes of milk annually which is about 2% of the total milk supply in the country. The population of Kachan goat is not included because no data is available.

Table 1. Goat Population (million heads) and its distribution in different provinces of Pakistan.

Province	Year			Share (%)
	1996	2006	2011	
Punjab	15.30	19.90	22.76	37.0
Sindh	9.73	12.37	14.15	23.7
KPK	6.76	9.68	11.07	16.0
Balochistan	9.36	11.83	13.53	22.7
Pakistan	41.16	53.79	61.50	100

Source: Livestock Census (1996 and 2006), Economic Survey, 2010–11

Table 2. Dairy Goat Population (million head) by province in Pakistan

Breed	Province of Pakistan				Total
	KPK	Punjab	Sindh	Balochistan	
Beetal	0.65	3.10	0.24	0.21	4.20
Kamori	0.05	0.04	3.90	1.30	5.29
Damani	0.90	0.05	0.03	0.33	1.31
DDP	0.05	0.08	0.02	0.01	0.16
Nachi	0.02	0.03	0.03	0.04	0.12
Kachan	N/A	N/A	N/A	N/A	N/A
Total	1.67	3.30	4.22	1.89	11.08

Livestock Census (1996 and 2006): N.A: Data is not available

In Punjab, Beetal is the dominant goat breed with 3.10 million head because of its preference as dual purpose animal, i.e. both for meat and milk. According to the livestock census conducted in 2006, Kamori was the number one dairy goat breed in Sindh and had the highest population among dairy goats at the national level. Damani was the third dairy goat breed on population basis, found in the KPK province. Dera Din Panah and Nachi are famous as dairy goats of southern Punjab. Nachi is also found in the southern Punjab in the canal irrigated tracts.

Production systems

Small ruminants raised under different production systems are depicated in Table 3. There are four main systems of production for small ruminants, namely nomadic, transhumant, household and sedentary in various regions of the country since unknown times. As described by Ishaque (1993), the prevalence of household and sedentary system was highest in the Punajb, 47 and 27%, respectively and lowest in Balochistan (3%). The study conducted by FAO (2003) presents a different picture than that of Ishaque (1993). According to the latter, small ruminant production is mainly under sedentary and transhumant production systems.

However, it seems that due to degradation of rangelands, drought and flood over the last 5–6 years, production systems of small ruminants might have further changed. Due to limited grazing land, shepherds are currently keeping more small ruminants under sedentary and household systems.

Table 3. Distribution of sheep and goats by production system

Production system	1993 (%)	2003 (%)
Nomadic	44	6
Transhumant	38	32
Sedentary	6	40
Household	12	22

Ishaque (1993), FAO (2003)

As shown in Table 3, a major shift of small ruminant production is observed from nomadic to sedentary and household systems. The sedentary and household systems are more common in Punjab and Sindh provinces whereas, about 59% of sheep and goats under the transhumant system and 30% under the nomadic system are found in Balochistan (Afzal, 2003). Similarly, transhumant system is also more common in KPK.

Goat milk production

Goat's milk, total milk and share of goat's milk in total milk production in Pakistan is presented in Table 4. Milk production from goats and total production were both on the increase over the last few years, which was because of an increase in number of animals but not per animal productivity. Most of the milk produced in the country comes from buffalo and cows but a reasonable amount of milk also comes from goats.

Table 4. Goat Milk Production in Pakistan

Products	1996	2006	2011
Goat Milk	527	675	759
Total Milk*	23580	31246	37475
Percentage	2.23	2.20	2.01

*Total milk production from cattle, buffalo, sheep and goat.
Source: Agricultural statistics of Pakistan (2005–2006), Economic survey of Pakistan (2010–11).

In Arid and semi-arid areas where buffalo and cattle milk are not available, people depend upon the goat's milk (Khan and Ashfaq, 2003).

Milk production potential of different dairy goats

The average milk yield of selected dairy goat breeds of Pakistan is given in Table 5. Beetal goat is the highest producer (2 L/d) of milk followed by Kamori (1.8 L/d), Kacchan (1.7 L/d), DDP (1.6 L/d) and Damani (1.3 L/d).

The genetic potential does exist for milk production in these breeds of goats in Pakistan. It needs to be exploited through selective breeding and better management.

Table 5. Average milk yield of selected dairy goat breeds of Pakistan

Breed	Lactation milk yield (L)	Lactation length (d)	Average daily milk yield (L)
Beetal	272	140	2.0
DDP	205	130	1.6
Damani	115	100	1.2
Kamori	204	115	1.8
Kacchan	190	110	1.7
Nachi	214	160	1.3

Source: Isani and Baloch (1996), Rehman and Shah (2003) and Iqbal et al. (2003).

Recommendation

Pakistan has some important dairy goat breeds but no comprehensive research work has been done so far to enhance their productivity. These breeds need improvement through better nutrition and long term selective breeding. Continued selection as dual purpose animals could lead to improve productivity by developing the best dual breeds of the world.

Challenges and constraints

There are many challenges for goat production in the country. One of the major challenges is inadequate feed that has limited animal productivity to 60–70% of genetic potential. To increase the productivity of animals, it is important to expand and make efficient use of available feed resources. The other constraint is non-availability of genetically superior breeding bucks of these dairy goats, although in the private sector shepherds are keen to keep quality bucks. The third major constraint to productivity of goats is the presence of contagious diseases in the country, particularly peste des petits ruminants (PPR), pneumonic pasturellosis and enterotoxaemia. The availability and quality of vaccine is very important for controlling health problems to exploit the full potential of dairy goats.

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Lead Paper 1

Perspectives for Increasing Nutrient Use Efficiency in Dairy Goat Production

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Introduction

Goat was the first animal domesticated by man. Over 90% of the 921 million goats in the world are found in developing countries and Asia has the highest proportion of about 60% of the total world goat population (FAO, 2010). Also Asia has the largest global goat breed share of 26%. Non-cattle milk consumption contributes to approximately 15% of the total milk consumption by humans worldwide and a large part of the production occurs in developing countries where the demand of animal products, fueled by increasing population, urbanisation and growing economies, is increasing at a high rate. Asian goat milk contribution to total world goat milk production is approximately 59% (FAO, 2010). Goats play a vital socio-economic role in Asian agriculture, particularly for resource-poor people; while in other parts of the world (e.g. Europe) goat milk and its products are luxury foods.

Unfortunately, goat rearing for milk production has not attracted attention of policy makers, science managers and researchers in Asia since goat production has largely been in the hands of resource-poor farmers who are politically and economically marginalised. However, lately, due to emerging challenges of global warming – higher ambient temperatures in the future, decrease in animal productivity and increase in pressure on natural resources – the role of goats is being increasingly realised and appreciated due to their high adaptability to a wide array of environmental conditions and feed resources. Goats use poor quality roughages like straws or stovers with high cell wall and low protein contents more efficiently than other domesticated animals, which is associated with factors such as longer retention time in gastrointestinal track and more efficient nitrogen utilisation in goats.

Feeds and feeding is the foundation of an animal production system since growth, reproduction, health and welfare of livestock hinge on efficient use of feeds. Moreover the release of environmental pollutants also depends on what, how and how much is fed. Perspectives for efficient use of natural resources including novel feeds, feed additives and animal germplasm that could result in increased productivity and conserve the environment and biodiversity are presented. The focus is on achieving feed-efficient dairy goat rearing in intensive and semi-intensive production systems.

Availability and nature of feeds and efficiency of nutrient use

Most goat farmers use a conservative strategy of feeding whatever is available, which may vary with season. In most situations this results in imbalanced feeding, which is non-commensurate with the objective of keeping dairy goats. For economic viability and sustainability of the dairy goat production system, the farmer must have control over what and how much is fed. A pre-requisite for this is the access of the farmers to the information on availability of feed resources in the region, their chemical composition and nutritive value. Also, the farmers need to possess adequate skills and knowledge to use this information and prepare a balanced diet. In this context, the guidelines for establishing national feed assessments developed by FAO (2012a) would help generate information on the availability of feed resources in a region or a country and lead to rational use of feed resources. Equally important is the generation of reliable information on chemical composition and nutritive value of feed resources (FAO, 2011) and collation of this information in the form of a user-friendly database, e.g. a national level database similar to FAO's Animal Feed Resource Information Systems (AFRIS) that gives information on feed resources (what, where and when in a country and their nutritive value). FAO's efforts to promote ration balancing approach initiated by National Dairy Development Board, Anand, India could possibly be extended to intensive and semi-intensive goat production systems. Application of ration balancing approach at farmers' doors for dairy cattle has been found to increase income of farmers by 10 to 15%, decrease methane production per kg of milk by 15 to 18% and increase feed conversion efficiency by over 50% (Garg, 2011). For semi-intensive goat production system the application of ration balancing approach would require information on feed intake and nutritive value of the feeds consumed during the grazing period. Simple tools to obtain this information would be required.

Novel feeds and strategies for increasing nutrient use efficiency

Goat production especially under intensive and semi-intensive systems require good quality fodder, which must be produced in high amounts from small land area; since arable land is decreasing and pressure on the available land is increasing due to increase in requirement of grains for increasing human population. *Moringa oleifera* is an under-exploited plant that grows at a high rate and can produce as much as 100 tonnes of dry matter per hectare when grown as a fodder plant by seeding the plant very closely. The plant could be harvested every 45 to 50 days on reaching approximately one metre in height. The protein content of *M. oleiera* leaves is as high as 25% and the amino acid composition of the protein is as good as soyabean meal (Foidl et al., 2001). The leaves of mulberry also have amino acid composition and protein content similar as those of Moringa and hence could also be good feed resource for dairy goats. The use of Leuceanea, Calliandra and Gliricidia leaves, as good feed supplement for dairy goats, is well established. Lesser-known feed resources (FAO, 2012b) that are adapted to harsh conditions could also be considered for integration in dairy goat production systems.

Mineral and nitrogen deficiencies especially when goats are reared on low quality roughages constrain production. Urea-molasses blocks supplementation with fibrous roughages increases goat productivity (FAO, 2007); however, in some situations making the goats consume the blocks has been a challenge, and hanging of the blocks at an appropriate height (above the height of goat's head) increased their intake by goats.

Lately, the biofuel industry has generated a number of co-products that could be valuable feed resources for dairy goats. The co-products such as distillers grains; oil seed cakes/meals from unconventional oilseeds e.g. *Camelina sativa*, non-toxic *Jatropha curcas* and *J. platyphilla*, Pongamia and Neem; and residues from sweet sorghum and cassava could be used in the production of goat rations. An extensive review on evaluation of these co-products as livestock feed (FAO, 2012c) illustrates the potential of these co-products as feed ingredients in dairy goat rations; however, use of these co-products in goat rations still needs to be demonstrated.

Some distiller grains, due to their specific processing conditions, have high rumen bypass protein and are expected to increase milk yield from high-yielding goats. Similarly, rumen protected amino acids, starch and fat could be considered for inclusion in the diets of high-yielding dairy goats.

Feed additives and supplements and nutrient use efficiency

Multi-purpose tree leaves (MPTLs) besides being rich in useful nutrients such as protein and minerals also contain plant secondary metabolites (PSMs) e.g. tannins, saponins, glycosides and terpenes having potentially useful bioactivities. Consumption of plants containing higher levels of PSMs are known to produce adverse effects; however, compared to other herbivoures, goats are more resistant to PSMs. Feeding of MPTLs and agroindustrial byproducts containing PSMs offers a number of advantages to goats, e.g. reduction in the load of internal parasites by tannins from quebracho, *Quercus coccifera*, *Caprinus orientalis* and *Chicorium intybus*. Saponins, lactones and glycosides are also reported to possess anthelmintic activity (Athanasiadou et al., 2009). Addition of pineapple leaves in the diets has also been shown to reduce internal parasites (attributed to the presence of bromalain in pineapple leaves) and its effectiveness was found to be comparable to albendazole (Makkar et al., 2007). Decrease in methane emission on using tannins and saponins in dairy goats could also be expected (Goel and Makkar, 2012).

The use of tannins and saponins as feed additives has been shown to affect meat colour, antioxidation potential of muscle, muscle cholesterol and fatty acid profile and meat colour stability (Vasta et al., 2011). Also tannins affected rumen biohydrogenation and decreased vaccenic acid and rumenic acid and increased linoleic acid and linolenic acid in the milk from ewes fed *Hedisarum coronarium* foliage containing condensed tannins (Cabiddu et al., 2009). No effect on fatty acid profile in goat milk on administration of monoterpenes blend has been observed (Malecky et al., 2009).

Linseed supplementation has also been shown to increase polyunsaturated fatty acids, the omega fatty acid and the conjugated linoleic acid fatty acids in goat milk (Delmotte et al., 2009). Enrichement of n-3 polyunsaturated fatty acids in goat milk by dietary inclusion of fish oil or microencapsulated fish oil has also been achieved (Safari et al., 2011). These changes are further expected to enhance the market value of goat milk and milk products. Systematic studies on the use of PSMs, essential oils, simple phenolics as feed additive and their effects on fatty acid profiles are required in order to generate sustained and high level desired changes in goat milk and milk products.

Performance of animals and efficiency of nutrient use

Transformation of feed into animal products requires energy and nutrients; however, this conversion is associated with losses of nutrients into the environment as excretion of nitrogen, phosphorus and trace elements and emission of methane and carbon dioxide. The efficiency of conversion of feed in animal food chains is quite variable, depending on animal species and performance status. At high levels of production, the output of edible protein in milk per kg of body weight per day from a dairy cow (body weight 650 kg) with high level of performance (40 kg milk per day) is 2 g while this value for a high performing goat (body weight 60 kg) giving 5 kg milk per day is 2.8 g. The output of edible protein per kg of body weight increases with increase in performance of the animals. Conversely, nitrogen and phosphorus excretion and methane emission per unit of edible protein output decreases with increase in performance (Niemann et al., 2011). These effects are attributed to the proportionate reduction in energy and nutrient diversion for maintenance of animals as the performance increases, provided intake of animals is not restricted. These observations suggest that for feed-efficient production systems, in addition to the good quality of feed, high genetic potential of animals is also of paramount importance.

Animal breeding for increasing nutrient use efficiency

Genomics and reproductive biotechnologies offer potential to improve goat productivity by producing goats having both higher intake and feed conversion efficiency and lower emission of methane per unit of feed digested, greater absorption of the digested nutrients, higher efficiency of anabolic processes and lower of catabolic processes, lower fat content in animal body, lower fat and lactose secretion and higher protein secretion in milk, and improved animal health with higher resistance against biotic or abiotic stress and reduced losses during production (Niemann et al., 2011). Little is known about how to achieve these traits in goats and extensive research is required in these areas.

In conclusion, to achieve feed-efficient in dairy goat production systems an integrated and holistic approach targeting feed and feeding in addition to improving animal breeding, animal health and management practices is required. This holistic approach should also include appropriate policy formulation and institutional building that support dairy goat farming, provide attractive market for goat milk and encourage milk processing industry to develop niche products for local use and for export. These key developments can boost income of resource-poor goat keepers and take them out of poverty.

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