Vol 16 No 2, p 139-142

AMMONIA EMISSION FROM CAMEL DAIRY IN THE NETHERLANDS

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ABSTRACT

The emission of ammonia is an important environmental drawback of animal husbandry in most European countries. Emission factors form the basis for emission inventories, e.g. in the framework of the National Emission Ceiling Directive. The emission factor for ammonia emission from commercial camel keeping is unknown. Because of the many health promoting properties of camel milk, several European farmers consider to start milking camels. In the Netherlands, until now this is not possible as municipal (local) environmental permit to keep camels commercially cannot be obtained, because of ammonia emission from camel husbandry.

Based on the way dairy dromedary camels are kept in the first commercial camel husbandry in the Netherlands, Europe, we calculated their ammonia emission using literature data, and an assessment of the impact of the housing system, including manure management. Literature was assessed for ammonia emission data from camel husbandry in general and camel housing in particular. Literature data were compared with dairy cows and horses, which are typically based on measurements. Generally, ammonia emission of a barn for adult camels is estimated to be typically 5-6 kg ammonia/head/year, corresponding with about 50% of ammonia emission of dairy cow barns. However, when urine and faeces are directly separated and removed, as occurs in the Dutch camel barn, camel ammonia emission factor is assessed to be 1.5-2.0 kg/head year, corresponding with 10-20% of cows ammonia emission.

Key words: Ammonia emission, camel barn, dromedary camel, environmental permit

One of the legal issues for animal keeping in most European countries is the emission of ammonia. In countries like the Netherlands, maximum ammonia emission factors are determined for newly built animal houses (pigs, poultry, dairy cows). These emission factors need to be met to get an environmental permit. Moreover, measurement based emission factors are used in national and international emission inventories, like under the National Emission Ceiling Directive (NEC). The legal aspect is regulated for most farm animals that are kept for commercial purposes, like dairy cows, pigs, and poultry. Dromedaries, amongst others, are not included, meaning that no emission factor for ammonia emission from commercial dromedary keeping exists. For the reason of a municipal (local) environmental permit, ammonia emission needs to be assessed.

Because of the many health promoting properties of camel milk (Yagil, 1982) a Dutch farmer started the first dromedary dairy in Europe in 2007. From that time an increasing number of farmers considers to milk camels in Europe. As long as the ammonia emission from camels is unknown, milking camels in Europe is facing legal difficulties.

The European Camel Research Society (ECRS) stimulates the health control of European camels and promotes the adequate application of their products. To facilitate European farmers to keep dairy dromedaries the ECRS performed an estimation of the ammonia emission from (mostly) indoor housed animals.

Materials and Methods

The way dromedaries are kept and milked in the first Dutch dromedary dairy was studied by observation. Furthermore computerised literature databases including Pub Med, were searched using the words camel, dromedary, ammonia, NH_3 and emission and leading authorities in the field of environment and ammonia emission were consulted.

Results

During the first 3 months of 2009 the Dutch camel diary (www.kamelenmelk.nl) housed 40 dromedaries, of which 22 adult animals were kept for milk production. They are milked with a

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Fig 1. Dutch camel barn.

Fig 2. Camels in the Netherlands.

specially adapted milking machine (Westfalia). The dromedaries stay usually indoors on a sand bed with direct and complete separation of urine and faeces (Fig 1). From April until November they stay a few hours a day outside (Fig 2), but only in dry weather.

Theoretical aspects of ammonia emission

Ammonia from mammals, like cows and pigs, is mainly produced following the enzymatic conversion of urea excreted in the urine (Monteny, 2000). The enzyme urease, being the catalyst converter of urea, is produced by bacteria present in the faeces. Urea conversion is a very fast process (within 2-4 hours after urine production of fouled floors inside the animal barn, all urea is converted into NH_3), occurring when urine is deposited on manure (faeces) and on surfaced that are fouled with faecal bacteria (e.g. floors in barns). Urease producing bacteria are also commonly present in soils. The ammonia produced from urea decomposition is present in the liquid (slurry e.g. in manure storage, urine deposited e.g. on floors) in both ionised (ammonium; NH_4^+) and unionised form (ammonia: NH_3), mainly depending on the pH (acid: more NH_4^+; basic: more NH_3). The emission of ammonia is basically the process where unionised ammonia is transferred from the solution to the ambient air. This mass transfer process depends on temperature and air velocity; the higher the temperature and the air velocity, the more NH_3 will emit from the urine and slurry.

Birds, like chicken (poultry), excrete uric acid. To become ammonia, uric acid needs to be decomposed to urea first. This is a relative slow process, mainly depending on the water activity (dry matter content) of the excreta (droppings).

Other nitrogen compounds, mainly being organic nitrogen (e.g. undigested protein in the faeces), will also contribute to NH_3 emission, but in a less pronounced way since the conversion of those type of nitrogen compounds to NH_3 is relatively slow.

Literature about ammonia emission from dromedary (camel) husbandry

According to IPCC (IPCC, 2006), camels in Western Europe excrete 0.38 kg N/1,000 kg of animal mass per day. In Table 1, this value is compared with other ruminants kept for commercial purposes.

From this data, a camel is found to excrete 0.22 kg N/day, which is in between the typical N excretion from dairy cows and horses. The animal N excretion by camels kept in Western Europe, based on IPCC data, is 80 kg/year. This is substantially higher than the N excretion estimated by Bouwman *et al* (1997), who reported 55 kg/year. Camels have a significantly lower N retention when compared to dairy cows, meaning

Table 1. Nitrogen excretion of commercially kept selected livestock in Western Europe (IPCC, 2006).

Animal species	N excretion (kg N/1,000 kg of animal mass per day)	Typical animal mass (kg/animal)	N excretion (kg N/animal day)	N retention (N fixed in animal products and body mass in % of N intake)
Dairy cow	0.48	600	0.29	20
Horse	0.26	550	0.14	7
Camel	0.38	570	0.22	7

that less of the N intake with feed is converted to animal products (e.g. milk) and reproduction, although also higher values (15-22%) are reported in literature where animals were kept on low quality diets based on desert by-products (Gihad *et al,* 1989).

The NH_3 emission from camels is 20% of the N excreted according to Bouwman (1997). Based on an N excretion of 55 kg/year, the NH_3 emission would be 11 kg/year per camel. This figure represents the NH_3 emission from all sources: housing, grazing, manure storages, and manure spreading.

In table 2, more recent data on the NH_3 emission from various types of commercially kept domestic livestock are presented (Bouwman, 1997; Klimont, 2001).

From this data it can be concluded that the NH_3 emission from camels (all emission sources included) is around 50% of the NH_3 emission from dairy cows, and similar to the NH_3 emission from other cattle and horses.

Table 2. Ammonia emission from various commercially kept large livestock animals according to 2 literature sources.

Animal species	Ammonia emission (kg/head/year)	
	Bouwman *et al*, 1997	Klimont, 2001
Dairy cow	17.4	19.4 – 24.8
Other cattle	10.0	9.5 – 9.9
Horse	10.6	10.6
Camel	12.9	12.9

Most NH_3 emission in cattle husbandry originates from application of animal manure, whereas also storage and the animal barn are important sources. In the Netherlands, the NH_3 emission from dairy cow houses is 9.5 kg/animal/year, being 40-50% of the total. Applying this percentage to the overall emission factor for camel would result in an NH_3 emission from the camel barn of 5-6 kg/animal/year, with the remainder being emitted during grazing (exercise), manure storage (mainly solid manure) and manure application. In the Dutch camel barn, the animals are kept inside most of the time in a barn on sand. Faeces (high dry matter content) are frequently collected, whereas the urine percolates through the sand bed, towards a collection unit below the sand. This means that faeces and urine are directly separated. The sand bed will contain bacteria that produce enzymes that convert N compounds in the urine. However, the management of the sand (frequent removal of faeces; drainage of urine) and the separation of faeces and urine will not likely result in a significant NH_3 emission. Evidence can be obtained from experiments with direct separation of faeces and urine in a commercial pig barn, where a sub-floor inclined belt was used to separately remove faeces and urine (Aarnink *et al,* 2007). Direct separation and separate removal of faeces and urine showed to reduce the pig barn emission of NH_3 with 60-70% compared to a pig barn with slurry, resulting for the camel barn an emission factor of 1.5 – 2 kg NH_3/head/year.

Discussion

The ammonia emission of dairy dromedary camels can be considered to be about 50% of that of dairy cows. When faeces and urine are separated directly ammonia emission can be lowered until 10-20% of that of diary cows.

As far as we know no other studies on the ammonia emission of camels have been published. This is probably due to the fact that in countries with camel husbandries it is not necessary to obtain these data. In Europe, however, governmental authorities need this information for environmental permits to keep camels commercially. Consequently the results of our study are crucial for the development of a European camel milk industry.

No literature could be found to support the NH_3 emission data presented above, e.g. from measurements. Theoretically, NH_3 is mainly produced from N components in the urine, with a small contribution of organic compounds (e.g. undigested protein) in the faeces. For mammals, like humans and dairy cows, urea is the most important source of NH_3 emission. Read (1925) reports that camel urine mainly contains hippuric acids (main constituent of horse urine; chemical formula is presented in Fig 3 and creatinine, and only traces of urea. Since no relationship was reported with the animals diet, it is to be expected that NH_3 is also produced from the decomposition of N compounds other than urea.

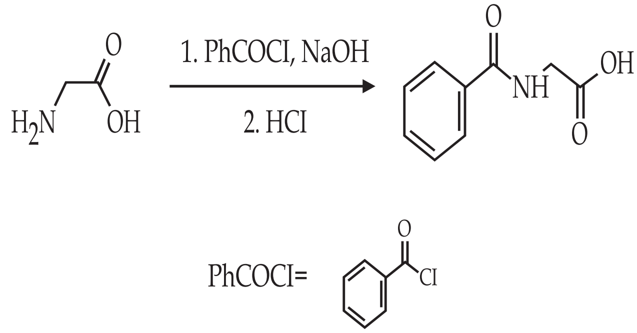

Fig 3. Formation of hippuric acids (right side of the formula).

Since hippuric acid only has one NH group, and urea has two NH groups, it is likely that the potential NH_3 emission from camel urine is smaller than from e.g. dairy cows. Since NH_3 emission (from urine) is not only related to the amount of (urea) N excreted, but also and mostly to the concentration of the N compounds excreted, no literature based conclusion can be drawn about the potential NH_3 emission from camel excreta (mainly urine). Collection, sampling and analysis of urine from commercially kept camels, and laboratory experiments, should be conducted to assess the potential NH_3 emission.

It is most likely that NH_3 from camel urine is produced following the enzymatic conversion of N compounds. This would imply that urine and faeces would have to be in contact, or that urine is deposited on surfaces (e.g. concrete floor) that are fouled with faeces. Considering the management of faeces and urine, including the sand bed, low emissions from the camel barn are to be expected. Full scale measurements are required to confirm this conclusion.

The line of reasoning for the possible NH_3 from grazed camels (limited number of hours per day) is similar to the reasoning for barn related NH_3 emissions. Also outside, the potential NH_3 emission will be low, because the animal only spend limited time outside, and urine and faeces are deposited on different locations in the field. Since also conversion catalyst enzymes are produced in soil bacteria, the outside NH_3 emission will not be negligible, but most likely of limited magnitude. The same hold for NH_3 emissions from stored camel faeces.

Since measuring ammonia emission of camels for only one commercial dromedary farm is too expensive, the Dutch governmental authorities recommended estimating the ammonia emission from a commercial camel barn based on literature. The present study is in accordance with this recommendation. When in Europe more commercial camel farms exist, it will be possible to compare measured ammonia emission with the results of our study.

Some legal authorities forbid camels to be present in or nearby protected natural environments because they are afraid that the ammonia emitted by the camels destroys natural vegetation. Our study shows that this fear is not justified.

The health promoting characteristics of camel milk are another crucial issue for the development of the European camel milk industry. In Europe health claims of food have to be proven scientifically. Subsequently the ECRS stimulated clinical studies, performed by Wageningen University and Research and the Gelderse Vallei Hospital Ede in the Netherlands. These studies are aimed to confirm the positive effects of camel milk for patients with diabetes (Agrawal *et al,* 2005 and Shabo *et al,* 2005) and in patients with Crohn's Disease (Shabo *et al,* 2008) and cow's milk allergy (Shabo *et al,* 2005). For these European multicentered studies a lot of fresh raw camel milk has to be available. Camel milk cannot be imported into Europe from countries outside Europe.

Consequently the results of the present study are crucial for the development of a European camel milk industry in Europe and other countries. To conclude, camels are not only friendly (i.e. healthy) for humans, but also for the environment.

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