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RESEARCH ARTICLE

Is Danish Venison Production Environmentally Sustainable?

Henrik Saxe*

Technical University of Denmark, DTU Management, Produktionstorvet, DK-2800 Kgs. Lyngby, Denmark/ Mindful Food Solutions, 2920 Charlottenlund, Denmark

ABSTRACT

The objective of this study is to quantify the climate- and environmental impact of venison production from six wild life species in Denmark: Red deer, roe deer, fallow deer, wild boar, mallard and pheasant, and compare it with the environmental impact of commercially produced beef, pork and chicken in Denmark. The method for quantifying the impact of venison applied original LCI data obtained for the complete life cycle of Danish venison production of all six species, supplemented with data from Ecoinvent® and LCAFOOD on materials and processes involved in production of venison and industrial meat. Fodder, foraging on farmers' fields, infrastructure, hunter/hunting and abattoir processes were analyzed separately using Simapro software applying the Stepwise® method. The results indicate that Danish venison production ranges from being slightly less, over being equally, to most often being far more environmentally harmful than the production of comparable industrial meat types. The main environmental impact originated from feed and foraging on farmer's fields and mileage driven by the hunters was surprisingly high. Danish industrial meat from domestic animals is typically more environmentally friendly than Danish venison.

*Corresponding author

Henrik Saxe, Technical University of Denmark, DTU Management Engineering, Produktionstorvet, DK-2800 Kgs. Lyngby, Denmark/ Mindful Food Solutions, 2920 Charlottenlund, Denmark

E-mail: henriksaxe@gmail.com

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INTRODUCTION

It is a popular notion in Scandinavia that we should increase ingredients in our diets that are gathered, caught or hunted in nature rather than bred, grown and harvested on farmed fields, and in stables and waters. These new ingredients include commodities like seafood, seaweed, mushrooms, herbs and venison, i.e. meat from free-ranging wildlife. In the recommendations for the New Nordic Diet, Danish consumers are advised to consume 35% less meat, with more than 4% of the consumed meat being venison [1,2]. But the present study contradicts that the Danish venison production alone will be able to support that goal. A total of 2.6 million wild animals are reported killed by hunters in Denmark each year, and the possibility for increasing Danish venison production is limited, considering Denmark's sustainable conservation policy and the limited area not already occupied by buildings and roads or exploited by agriculture. Presently Danes consume only 0.8% of their meat as venison, and the consumption is very unevenly distributed; most hunters keep the main portion for themselves. The "wild" ingredients in a modern diet are in general assumed to be both healthy and environmentally sustainable. But is that necessarily true? The present study seeks to answer the question if Danish venison production has less impact on the environment than Danish production of meat from domestic animals. Six types of venison were considered: Red deer, roe deer, fallow deer, wild boar, mallard and pheasant. This is the first scientific study that applies a full Life Cycle Assessment including all aspects of breeding support, hunting, agricultural disturbance, abattoir processes and waste to calculate and compare climate- and environmental impact of meat from wild life (venison) compared to commercial meat products from animal husbandry.

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METHODS AND MATERIALS

The goal of this study is to provide information to hunters, nature managers, distributors, retailers, consumers – and to the project sponsors (15 Juni Fonden, Nordea Fonden) – on the sustainability of Danish venison production at *Klosterhedens Vildt*, one of the two major Danish abattoirs, specialising in venison production, and its contracted suppliers.

A 15-page questionnaire was forwarded to the abattoir, game keepers, huntsmen, traders and a wide range of businesses and experts at relevant private and public institutions ahead of a series of interviews to collect relevant LCI (Life Cycle Inventory) data on game management, infrastructure, hunting, feed and foraging, transport, processing, packaging, materials, energy, waste, distribution, and more. The extensive notes from these interviews were processed and returned for approval to those interviewed. After communication back and forth by email and in person, the results obtained formed the basis of a complete LCI of Danish venison production from six species – red deer, roe deer, fallow deer, wild boar, mallard and pheasant – processed at *Klosterhedens Vildt* abattoir in Jutland (Western Denmark). The study focused on the activities in 2010/11 considered to be representative of the venison production at *Klosterhedens Vildt* abattoir even today. The LCIs were elaborated separately for each of the six investigated species, all including three main stages: (1) from animal birth to the abattoir, (2) slaughter, packaging and waste processes at the abattoir, and (3) from abattoir to retailers. The first step was divided into (a) infrastructure, (b) fodder and foraging on farmers' fields and (c) hunters and hunting.

Production data for industrially produced meat from domesticated animals were taken from the Ecoinvent® and LCAFOOD databases. The environmental impact of venison production was analysed by Consequential Life Cycle Assessment (cLCA) using Simapro® 8.04. The consequences considered were the substitution of industrial meat types with venison. The Stepwise® 1.05 method [3], analysing 16 environmental impact categories associated with all activities, energy- and resource consumption from soil-to-supermarket or restaurant, was chosen as the most appropriate LCA method with the option of monetizing. Monetizing summarises 15 impact categories in a common expression, thus revealing the socioeconomic cost associated with the environmental impact of Danish venison production within the scope of this study. Monetizing makes it possible to compare the environmental impact of widely different products and services. The monetised environmental impact of venison production from red deer, roe deer, and fallow deer was compared to the monetised environmental impact of beef production, wild boar production with pork production, and mallard and pheasant was compared with chicken production.

The Functional Unit (FU) was 1 kg of meat as there was not enough data on venison's nutritional content to select e.g. protein content as the FU. The geographical scope included venison from Jutland (the Western Danish 29,652 km² peninsula + the island of Samsø 114 km²), and only meat produced at *Klosterhedens Vildt* abattoir during the complete hunting season 2010/11. It is assumed that the studied venison production is a fair estimate of the overall Danish commercial venison production.

Red deer were supplied to *Klosterhedens Vildt* abattoir from three locations: Oksbøl and Ulfborg-Klosterhede plantations managed by the Danish Nature Agency in Western Jutland, and Aage V. Jensen Naturfond's nature conservation and wild life protection area Lille Vildmose in North Eastern Jutland. Each of these data suppliers provided distinctive LCI data. The three areas represent different types of nature management. In the first two, the red deer were free ranging. At Oksbøl they had access to a foraging field planted inside the forest to keep them from foraging neighbouring farmer's fields. At Ulfborg-Klosterhede the deer foraged to a certain extent on neighbouring farmer's fields, and in Lille Vildmose the red deer (and wild boar) were fenced inside a large area where they roam freely but have to be fed to maintain the stock.

LCI data on roe deer came from Brattingsborg estate on the Southern tip of the Island of Samsø where a 2,367 ha fenced area was used for combined agriculture, forestry, pork production and hunting. The roe deer browsed in the forest and fed on the crops. The hunted area was populated with roe deer, fallow deer and pheasants. In this study we only include data on the roe deer from Brattingsborg. Seventy four roe deer were shot during the hunting season of 2010/11, of which 37 were sold to *Klosterhedens Vildt* abattoir.

LCI data on fallow deer were obtained from a deer park run by Ørumgård estate near Vejle. This is the only supplier of fallow deer to *Klosterhedens Vildt* abattoir included in this study, although they only delivered nine of the 140 fallow deer processed at *Klosterhedens Vildt* abattoir in 2010/11. The results are thus less representative than for red deer, and possibly representing high-end impact values for fallow deer since they were fenced in with free access to agricultural fields. However, many fallow deer were delivered from the Central Danish island of Funen and other long-distance locations to the abattoir where environmental impact of transport had higher impact.

LCI data on wild boar came from Lille Vildmose where an electric fence kept them at a safe feeding distance from tourists and thus away from the risk of swine fever. The wild boars were fed, and 165 sold to *Klosterhedens Vildt* abattoir.

Data on mallards were based on 4,000 mallards raised at Bakkegårdens Vildtopdræt and put out in constructed lakes at Frijsenborg who supplied them to the abattoir after

hunting. Data on pheasants were based on 8,000 pheasants raised by Frijsenborg estate. Only 40% of the pheasants at Frijsenborg estate were shot during the estate hunts during 2010/11, while 30% were estimated taken by neighbours and predators, and 30% survived until the following seasons and thus tended to migrate.

The LCI of deer foraging on farmers' fields was estimated from expert testimony regarding the species and amount of feed plants consumed and disturbed (trampling and eating reproductive organs) on relevant locations, stomach content of dead deer [4], informal statements by local farmers and Kanstrup, et al. [5]. The LCI of supplied fodder was based on the types and amount of fodder with known compositions targeted at the animals to be fed at each location. The LCI of infrastructure included fences (the share related to wildlife), electricity to supply e.g. cold rooms and electric fences, wood and metal for fences and shooting towers, transport for construction, inspection and replacement of fences and shooting towers, local transport of hunters, and transport of dead animals to the abattoir. The LCI of the hunters and hunting was based on the mileage driven by hunters to the hunting and training sites, and consumed equipment (e.g. bullets and cartridges). The LCI of the abattoir material consumption and processes was allocated to the six species according to weight. It included energy consumption (30,110 KWh), water, people and product transport, cardboard boxes, plastic bags, transport and processing of waste, including gain from incineration at a local plant, and transport of the end products to the retailers. There were no data on enteric emissions and emissions from manure from venison to be included in this study. Saxe [6] gives a detailed and complete description of all calculations for all six species.

Regarding allocation of the environmental impact of venison production there are several options – choices to me made. In this study it was decided that 'the joy of hunting' (1 million hunting licences in Denmark) was counterbalanced by 'the disturbance by hunters' (4.7 million Danes enjoy nature without a hunting licence). Some postulate that hunting equals 'nature management' so that without it, the Danish deer populations would 'run out of control', increasing crop loss from farmed land and ultimately leading to deteriorating health and collapse of starving deer populations. Since population control could be carried out more efficiently than hunting, and may not even be needed, this aspect was not included. Of all mammals and bird species that breed and thrive in Denmark, the 90% not-hunted species manage perfectly well to stay within sustainable population sizes without requiring hunting for regulation. For all six species it was decided to allocate all of the impact to the meat value in this study, and none to the 'joy of hunting', 'disturbance', or 'nature management', since the latter impacts are subjective ('immaterial/intangible goods') compared with the physical and accountable impacts of hunting. The immaterial aspects of Danish nature were discussed by Jacobsen, et al. [7].

There were several sources of uncertainty in the calculations of environmental impact of venison production; the major source being the estimation of foraging, i.e. the feed that deer take from farmers' fields and the impact on plant growth and development by trampling. This is at the same time the largest single source of environmental impact of free ranging deer species.

RESULTS

The total meat production at Klosterheden Vildt abattoir in 2010/11 is given in table 1.

LCI

The hotspots for environmental impact of venison include feed/fodder, infrastructure, and the hunter/hunting. The latter include an unexpected high mileage travelled by the hunters in private cars. The LCI flow chart (Figure 1) for commercial production of red deer venison at Klosterhedens Vildt abattoir is an example of the flow diagrams used as the basis for cLCAs for all six species.

Monetized environmental impact (GWP)

The impact on the GWP of producing 1 kg deer venison (Table 2) was within or below the impact range of producing 1 kg of beef [8]. Dairy cattle emit more methane than deer, both in total and per kg [9]. The GWP associated with meat production was three times larger for wild boar than for industrially produced pork, 11 times larger for mallard, and 47 times larger for pheasant than for industrially produced chicken.

Figure 2 illustrates that the largest overall contribution to the monetized environmental impacts of venison was caused by fodder and foraging on farmers' fields and less on infrastructure and even on the excessive mileage driven by hunters to the selected hunting grounds, though many came from Eastern Denmark in their individual 4WD vehicles to hunt in Western Denmark. The monetized environmental impact of producing 1kg deer venison was – like for the GWP (Table 2) – within or below the monetized impact range of producing 1 kg of beef, and the impact depended, besides on the deer species, on the origin of the venison, as illustrated for red deer. The monetized environmental impact of wild boar was twice that of pork, and for mallard and pheasant it was 19 respectively 61 times more than for chicken. The negative impact values for birds slaughtered at the abattoir were caused by high values of incineration of discarded specimen and waste, generating energy, substituting fuel elsewhere in the system. Of the 15 monetized impact categories, GWP and particulate pollution dominated the monetized impact for all species, with some contributions from non-carcinogenic human toxicity and area use, and little or no contribution from the rest of the impact categories.

Table 1: Venison from six species processed at *Klosterhedens vildt* abattoir.

Species	Number of animals	Tot kg meat weight	Ave kg per animal	Net kg produced
Red deer	774	36.378	47.0	25.465
Fallow deer	140	4.340	31.0	3.038
Roe deer	252	2.873	11.4	2.011
Wild boar	174	4.727	27.2	3.545
Mallard	3,082	2.620	0.85	1.965
Pheasant	12,721	8.269	0.65	1.819
Total	-	-	-	37.843

Figure 1 LCI of red deer venison production during 2010/11 involved 3 main suppliers (green boxes) that covered 78% of the red deer venison produced by *Klosterhedens Vildt* abattoir. The environmental impact associated with minor suppliers (blue box) was estimated as an average of the main suppliers. For all suppliers, a share of the abattoir impact (yellow box), waste and transport to the consumer was added to arrive at the overall environmental impact.

DISCUSSION

The environmental impact of commercially available venison produced in Denmark has not previously been studied. The findings in this paper offered several new insights discussed below.

Transport

There was surprisingly much transport involved in the production of venison: Hunters driving to hunts, hunters driving to buy equipment and acquire their licence, and test-shooting their weapons every season; there was

transport of fodder, transport of carcasses, transport of produce and transport of waste; transport of materials for the infrastructure, e.g. fences and shooting towers; and driving to check and repair fences after storms, and after hunting that could have caused e.g. red deer to run into and damage fences. For the 180 red deer originating from Oksbøl there was about 240,000 km of transport involved (Figure 1). But in terms of environmental impact, transport only made up a minor part of the overall impact associated with the commercial production of venison. Transport was mostly associated with the hunter/hunting including helpers and retrievers (brown colour in figure 2).

Table 2: The GWP associated with Danish venison production.

Species and hunting grounds	Red deer, Lille Vildmose	Red deer, Øksbøl	Red deer, NST Vestjylland	Red deer, weighted average	Roe deer, Samsø	Fallow deer, Ørumgaard	Wild boar, Lille Vildmose	Mallard, Frijsenborg	Pheasant, Frijsenborg	Beef, shop	Pork, shop	Chicken, shop
GWP, kg CO _{2eq} /kg venison	11.3	24.4	44.8	28.6	10.5	9.8	10.2	34.9	145.2	20 - 46	3.3	3.1

Figure 2 Monetized environmental impacts of red deer (from three locations), roe deer, fallow deer, wild boar, mallard, pheasant and commercially produced beef, pork and chicken. The individual impact contributions of fodder, feeding on farmers' fields, infrastructure, hunter and hunting and abattoir are distinguished by individual colour codes.

Fodder and feeding/trampling on farmers' fields

The main environmental impact of commercially produced venison at Klosterhedens Vildt abattoir was what the animals consume, either when fed (as e.g. red deer and wild boar at Lille Vildmose or pheasant at Frijsenborg estate – dark green colour in figure 2) and/or when trampling and foraging on farmers' fields (light green colour in figure 2). The environmental impact of fodder and/or foraging on farmers' fields was from 1.3 (roe deer) to 20 (pheasant) times larger than the sum of all other impacts associated with venison production (green colours in figure 2). For wild boar it was 1.4 times, for fallow deer 4.9 times, for red deer 6.7 times and for mallard 12.3 times larger.

The foraging and trampling on farmers' fields is a difficult component to estimate, and at the same time in this

study it was found to be the most important component in the environmental impact of commercially produced deer venison. For free ranging red deer it averaged more than 90% of what the deer consumed, and for fallow deer it was about 50%, while for confined animals, wild boars and red deer at Lille Vildmose, and mallards and pheasants at Frijsenborg estate it was zero. Farmers, hunters and nature managers often have opposing interests in the magnitude of wild life populations, though farmers, even when loosing crops may also enjoy hunting.

One conclusion from the above is that wild game and raised game most likely have very similar environmental footprints because they need equal amounts of feed/foraging. The distinction between the two in this respect is difficult to make; the transition between wild and raised

game is gradual. In fact very few wild game individuals are truly wild in the Danish landscape – they are most likely living off a significant amount of agricultural crops one way or another. This may be different in e.g. Sweden where there are much larger natural fields and forested areas [10].

Commercial vs. privately taken venison

This study investigated only commercially produced Danish venison in order to compare the environmental impact hereof with commercially produced meat from cattle, pig and chicken. Some may assume that private hunting by individuals has a far smaller environmental footprint than the commercially produced venison from organized hunts described in this paper. However, in line with the above, since intentional feeding and arbitrary foraging on farmers' fields is the rule rather than the exception for the studied Danish game, even for raised fowl that escape their owners after months living under well-fed conditions, the sum of this feed typically constitutes the major part of the environmental impact of the venison, even the venison taken privately by individual hunters. Thus both commercial and privately taken venison must have a similar large environmental footprint. Furthermore, private hunting often results in a lower yield than organised hunting for commercial venison where 3–4 large animals may be bagged in a single two-man rifle hunt, or 30–40 birds in a single battue, while many hunters return empty handed from private hunts, thus driving many kilometres in vain.

Representativeness

How well do the results in this study represent all the commercial venison produced in Denmark? Klosterhedens Vildt abattoir produces the majority of Danish venison sold to consumers from Danish shops and restaurants, and by weight this is mostly red deer and wild boar. Kivan Food Ltd., the other major Danish venison supplier produces similar amounts, but mostly as fowl. The rest comes from minor suppliers.

In Denmark, there are 50 species of mammals and 300 bird species that are in principle protected. But for 10 mammal species and 33 bird species hunting is permitted for some months every year. Annual statistics are prepared for all wildlife hunted and killed [11]. In recent years the annual hunting yield has been around 2.6 million 'wild' animals. Roe deer, hare, fox, pheasant, wood pigeon and mallard are the most frequently hunted. In 2010/11 128,200 roe deer, 7,400 red deer, 6,000 fallow deer, 61,300 hares and wild rabbits, 39,300 foxes, 721,400 pheasants, 299,500 wood pigeons and 485,400 mallards were shot in Denmark [11].

According to the above numbers and to table 1, Klosterhedens Vildt abattoir produced 10% of all red deer shot in Denmark during the 2010/11 hunting season, 2% of the fallow deer, 0.002% of the roe deer (nearly all roe deer were taken privately, i.e. not sent to the abattoir), nearly all

wild boar, 0.06 % of the mallards (nearly all taken privately) and 0.2% of the pheasants (nearly all taken privately). Even though Kivan Ltd. produced most of the Danish bird venison, breeding and feeding of mallards and pheasants would be more or less the same as for birds delivered to Klosterhedens Vildt abattoir.

In conclusion, the environmental impact numbers in this study are reasonable representative for all commercial Danish venison, but less representative of the overall hunting yield in Denmark, where most is taken by the hunters themselves. But according to the section above, the environmental impact may not be much smaller for game taken by the private hunters compared to game sold for commercial production. Venison sold by private hunters directly to consumers is legally a grey zone.

Positive and negative impacts of game and hunting - perspectives

The largest environmental impact of commercially produced venison is caused by feed consumption (Figure 2). The environmental benefits envisioned for venison from wild animals in terms of them being sustained by wild flora, i.e. foraging on areas that are not farmed, turned out to be a false pretence – and more so with some species than others. The production of venison from mallard and pheasant were proven to be respectively 19 and 61 times more harmful to the overall environment than chicken meat; production of wild boar venison was 3 times more harmful to the environment than pork, while production of deer meat was equally or less harmful to the environment than production of beef, but far more harmful than pork or chicken.

The bottom line is that there is little or no environmental advantage in choosing any type of venison over industrial meat, mostly because there are little or no savings on feed for wild animals compared with domestic animals, sometimes on the contrary – and extensively so. This is because of the inefficiency of most venison production. Feeding is inefficient because it is not targeted, and from a production point of view it is therefore often 'wasted' when other wild life consumes it, or it is left to decompose in nature. 'Harvesting' the 'wild' animals is also inefficient as many of the well-fed animals happily escape out of the production systems, as most clearly seen with mallards and pheasants, and as hunters compared with industrial butchers transport themselves over long distances, sometimes without taking home any game at all.

The damage to farmers' fields and foraging on those fields has never been precisely accounted for, and may be underestimated by wildlife managers and hunters who may have an interest in trivialising this subject. Farmers may condone wildlife foraging or may even try to attract wildlife by putting out fodder if they want to hunt wildlife themselves. If farmers could agree that they would prefer to have less wildlife feeding off their fields, the Nature Agency

could possibly (at a cost) supply more feed or plant fields inside forests to keep the deer in the forests and natural areas. Furthermore, the nature agency could put up more fences if they wanted to protect farmers' fields and road traffic against deer collisions, and protect the deer against unwanted hunting, rather than only putting up fences to protect new plantations against deer browsing. These are charged questions as input to a currently ongoing debate on wildlife management and hunting in Denmark for which this study contributes with new knowledge.

Danish venison makes up less than 1 pct. of the recommended meat content in the New Nordic Diet

The existing populations of hunted wildlife in Denmark yielding approximately 1.4 g venison per Dane per day only satisfy a quarter of the recommended venison intake suggested by the New Nordic Diet [1], even if the goods were evenly shared among Danish consumers and all were following the healthy recommendations. If the Danish venison production was to be increased, it would take significantly more feeding and fencing; and in that scenario, it is a big question whether the game could still be considered free ranging wildlife, both in terms of animal welfare, human health, taste and environmental impact.

Animal welfare is also part of the ongoing debate on venison versus industrial meat. Meat from mallard and pheasant is extremely inefficient in environmental terms – they have very high environmental impacts per kg meat compared with chicken meat. However, both mallards and pheasants live at least a few months of their lives in nature, sometimes even years before they are killed. In contrast, commercial chicken meat comes from birds that typically never saw daylight or truly natural living conditions. Deer and wild boar experience superior animal welfare compared with cattle and pigs in conventional Danish animal production.

Is hunting a sport?

Some scientists will make the argument that hunting is a sport, so that the environmental impact of hunting should be compared with other sports – not with commercial meat production. An LCA of weekly playing tennis or football (i.e. transport, facilities and equipment) demonstrated that the monetised environmental impact of these sports respectively cost only 1.60 DKK/year and 1.80 DKK/year – an impact that is between six and 200 times smaller than the monetised environmental impact of hunting for meat, depending on the type of venison.

CONCLUSION

Venison typically has higher environmental impact than comparable industrial meat types. Regarding wild life, the reasons for this is a combination of the following: (1) inefficient feeding, (2) harmful foraging on farmers' fields,

(3) loss of animals to carnivores, disease, or to freedom, (4) hunters' staggering mileage driving to hunting grounds, (5) the small-scale production typical for venison. However, the fact, that deer emit less methane than dairy cattle work against the above.

From table 2 and figure 2 it is concluded that both the GWP and the overall (monetized) environmental impact of 15 impact categories associated with consumed meat may or may not improve if the consumers chose to eat commercially produced Danish deer venison rather than beef; it is less harmful to the environment to consume pork than commercially produced Danish wild boar, and much less harmful to the environment to consume chicken rather than commercially produced Danish mallard or pheasant. All in all, production of venison is much more harmful to the environment than presumed by diet recommendations like e.g. the New Nordic Diet [1]. Furthermore, realistically there can never be produced enough meat to satisfy the recommendations of the New Nordic Diet or the present Danish diet. More than 99% of the meat eaten by Danes comes from animal husbandry, not from wildlife.

Even if we consider hunting to be a sport, its monetised environmental impact is 6–200 times larger than that of playing tennis or football on a weekly basis, i.e. only 1.60–1.80 DKK/year.

The wildlife is not out there just 'for the taking', free of environmental impact. On the other hand, if we did not take advantage of the available wild life for venison production, some may consider it a waste of resources. Others may prefer to enjoy the wild life without killing it – to live and let live.

This study informs the consumers, wildlife managers and scientists that while preferring venison over commercially produced meat may be healthier, it results in a much higher climate- and environmental impacts in a Danish perspective. In other countries where the landscape and ecosystems are richer in natural forest and there is relatively less agriculture, the conclusions may differ – venison may be more sustainable.

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