

Research Article

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The knowledge that went up in smoke: Reindeer herders' traditional knowledge of smoked reindeer meat in literature

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Abstract

Using a literature review, this paper defines the knowledge status of smoked reindeer meat and investigates to what degree reindeer herders' traditional knowledge has been included in scientific articles and grey literature. We developed a four-level categorisation of the degree of including traditional knowledge, from “non-participation” to “self-determination,” and three levels of focus. Very few scientific articles on smoked or smoking reindeer meat appeared in the review. Not only did reindeer peoples' traditional meat smoking knowledge “went up in smoke”—both literally and metaphorically—but also incorrect conclusions were often drawn as a result of that exclusion. We argue that reindeer herders' traditional knowledges and practices of smoking reindeer meat need examination and inclusion through co-production or self-determination methods across scientific disciplines.

Introduction

In 2018, a book about Arctic indigenous people's food systems won the prestigious main prize—Best Food Book in the World—at the Gourmand World Cookbook Awards, the “Oscars of the cookbook.” This prizewinning food book (*Eallu*), an official Arctic Council report, presenting the first overview of the Arctic culinary world, argues that traditional knowledge of food production remains essential for sustainability in the Arctic regions today. However, the skills and knowledge associated with these Arctic traditional food systems have thus far been poorly documented. The smoking of reindeer meat is one traditional practice presented in *Eallu* (Buljo et al., 2018).

Worldwide smoking of food is one of the oldest food conservation techniques, still performed by Sámi reindeer herders (Riddervold & Ropeid, 1988) (see Fig. 1). Sámi reindeer husbandry takes place in Sápmi, in the northern part of Norway, Sweden, and Finland, and in western Russia. In the Arctic, reindeer herding is a livelihood among more than 24 different indigenous peoples. This form of pastoralism has been practised for 1200 to 2000 years or more (Hansen & Olsen, 2004). Traditional practices lasting for thousands of years are important for maintaining cultural identities and social relationships (Nuttal et al., 2005), and the daily use of meat and other reindeer products is important for the reindeer herding economy (Mathiesen, Gerasimova, Gashillova, & Charnyshiva, 2018).

However, in Norway, for example, current management models and governance of reindeer husbandry have built-in barriers to incorporating traditional knowledge in local-level policy implementation (Eira, Oskal, Hanssen-Bauer, & Mathiesen, 2018; Turi & Keskitalo, 2014). Indeed, the management model for Sámi reindeer herding, implemented by the Norwegian government in the 1970s, is primarily based on scientific, not traditional, knowledge (Johnsen & Benjaminsen, 2017). This model is a direct consequence of a “rationalisation” programme for transforming Sámi reindeer husbandry to an economically efficient and environmentally sustainable industry, through optimised meat production (Paine, 1994). Traditional knowledge has thus been de-prioritised in favour of scientific knowledge in reindeer husbandry policy implementation (Turi & Keskitalo, 2014). Whether this de-prioritisation of traditional knowledge also applies to studies on reindeer herders' and Arctic indigenous peoples' food remains under-investigated.

Using a literature review, we explore the knowledge status of smoked and smoking reindeer meat. We analyse the disciplines, methods, and knowledge used in various types of scientific and grey literature and ask to what degree traditional knowledge is included. Then, we discuss the possible consequences of not including this kind of knowledge. Because important information

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Fig. 1. reindeer herder smoking reindeer meat in a traditional Sámi tent—the lávvu. Photo by Kia Krarup Hansen.

may be lost if essential knowledge is excluded, we finally argue for the necessity of including traditional knowledge in future studies of traditional practices.

Two ways of knowing

Within studies of reindeer husbandry, many researchers have debated about and distinguished between scientific and traditional knowledge (Eira et al., 2013; Johnsen, 2018; Johnsen, Mathiesen, & Eira, 2017; Sara, 2009; Turi & Keskitalo, 2014). The most commonly used definition of *traditional ecological knowledge* is the following (Davis & Ruddle, 2010):

a cumulative body of knowledge, practice, belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one and another and with their environment. (Berkes, Colding, & Folke, 2000, p. 1252)

UNESCO uses this definition when discussing *indigenous knowledge* as local and unique to a given culture or society (Nakashima, Rubis, & Krupnik, 2018). Moreover, the Arctic Council and the Sami Council use the definition of traditional knowledge from the Ottawa Traditional Knowledge Principles (2014): “[A] body of knowledge generated through cultural practices, lived experiences, including extensive and multigenerational observations, lessons and skills.”

Berkes (1999) adds that “traditional ecological knowledge” could pose definitional problems if defined narrowly as a branch of biology within the domain of western science. Instead, Berkes (1999) argues that it should be more widely understood as including all living beings and their environments. We refer to reindeer herders’ practical meat smoking knowledge as *traditional knowledge*, whether it is indigenous, local, ecological, or all three in Berkes’ broad understanding.

A number of scholars working across the natural and social sciences argue that citizen knowledge, local knowledge, practitioner knowledge, indigenous knowledge, or traditional knowledge are complementary to science (Berkes, 1999; Davis & Ruddle, 2010; Riseth et al., 2011; Tengö, Brondizio, Elmqvist, Malmer, & Spierenburg, 2014). Riseth et al. (2011) argue that traditional knowledge could provide a useful guide to science. Collins and Evans (2002) write about the distrust of experts, arguing that those with complementary expertise in the relevant areas (e.g. those with local knowledge) can fill gaps in scientific knowledge. Traditional knowledge could complement science with more valid hypotheses for problem-solving. In turn, science and scientific methods have proved to be powerful tools for testing the “why”—a question that traditional knowledge usually does not address. In that way, research can take advantage of the relative strengths of both scientific and traditional knowledge (Moller, Berkes, Lyver, & Kislalioglu, 2004).

Tengö et al. (2014) illustrate a diverse knowledge system in which local knowledge, indigenous practitioners’ knowledge, and traditional knowledge constitute one branch, while the social sciences, the natural sciences, and transdisciplinary and technical knowledge constitute the other. Diverse knowledge systems contribute to an enriched picture of a selected problem or issue, a picture that can serve as a legitimate starting point for integrating knowledge, developing synergies across knowledge systems, and co-producing knowledge (Tengö et al., 2014). Studies for co-producing knowledge are also called “bi-cultural partnership” (Smith, 1999) or “participatory research” (Cornwall & Jewkes, 1995).

In the mid-20th century, Arnstein (1969) wrote about a heated controversy over what she calls “citizen participation,” offering a ladder of participation in policies ranging from “manipulation” to “citizen control.” Discussing user involvement within health, Tritter and McCallum (2006) argue that research should also involve participation. Given the importance of traditional

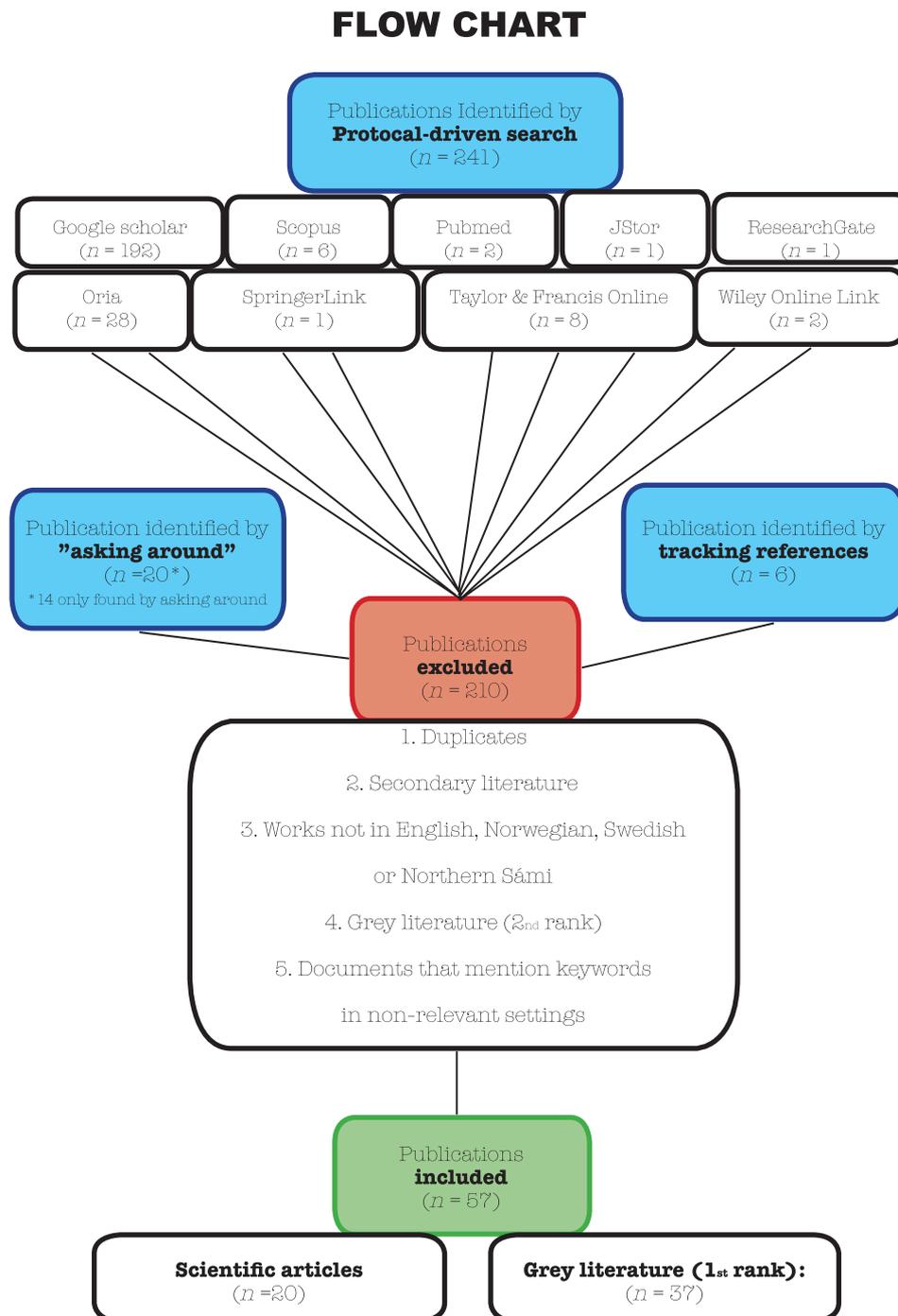


Fig. 2. Flow chart of a literature search on smoked and smoking reindeer meat.

knowledge particularly for reindeer herders but also for scientists and policymakers, we have adapted Arnstein's ladder of participation to examine to what degree traditional knowledge is included in research on smoking reindeer meat.

Methodology

Literature review strategy

Our literature-searching methods were inspired by Cooper (2010), Ritz, Brewer, and Neumann (2016), Parris and Peachy (2013), and

Davis and Ruddle (2010). However, a systematic review of complex evidence (such as reindeer herding) cannot rely solely on formal protocol-driven search strategies because one may fail to identify important evidence (Greenhalgh & Peacock, 2005). Therefore, we searched for literature in the following three ways: (1) by "asking around", (2) through a systematic protocol-driven search, and (3) by looking up references in the literature we found. A flow chart of the search is shown in Figure 2.

We conducted the "asking around" procedure by targeting colleagues, personal contacts, and well-known scientists in our network working with traditional food and indigenous people in the

Table 1. Keywords used in a protocol-driven literature search on Google Scholar: “the product of smoking reindeer meat” and “the practice of smoking reindeer meat” in four languages—English, North Sámi, Norwegian, and Swedish.

Language	North Sámi	Norwegian	Swedish	English	Total
The product of smoking	“suovasbiergu” (2) “suovastun biergu” 1 (1) “suovas” (38)	“røkt reinkjøtt” (2)	“rökt renkött” (16)	“smoked reindeer meat” 12 (52)	(111)
The practices of smoking	“suovasstuhttit” (1) “riibat” (0)	“konservering”+“reinkjøtt” (6) “røyking av reinkjøtt” (0)	“renkött rökning” (69)	“smoking reindeer meat” 1 (4) “smoking of reindeer meat” (1)	(81)
Total	1 (42)	(8)	(85)	13 (57)	14 (192)

The number of documents found before exclusion is given in parenthesis, while the number of peer-reviewed articles included is in boldface.

Arctic. We asked for literature on reindeer herders’ traditional smoking practices. The literature found by “asking around” yielded important keywords for use in the protocol-driven search.

The online databases for the systematic protocol-driven literature search were Google Scholar, Scopus, PubMed, JStor, ResearchGate, SpringerLink, Taylor & Francis Online, Wiley Online Link and Oria (the national database for all Norwegian college and university libraries). We also checked the Polar Record archives ($n=0$). We started with a narrow search on Google scholar, using keywords in local languages (Northern Sámi, Norwegian and Swedish) and then expanded the search to include English keywords (see Table 1). Finnish, Russian, and other Sámi keywords were excluded because of language issues.

This selection strategy allowed us to not only focus on Sámi smoking practices but also on other indigenous and traditional food culture studies. As the English keywords revealed the largest “pool” of relevant literature (Table 1), we used these when searching in the additional online databases. Before introducing the inclusion/exclusion strategy, we found 192 documents by a protocol-driven search on Google Scholar. In contrast, when searching for “smoked meat,” “smoking meat,” and “smoking of meat,” we found a total of 10,686 documents.

Inclusion/exclusion criteria

Initially, we removed all duplicates from the search. We placed no restriction on year of publication and only included primary sources, except for reviews that focused on smoked or smoking reindeer meat. Then, we included only scientific articles and selected grey literature, which comprises documents not published in scientific journals (Rothstein & Hopewell, 2009). The grey literature included, which we call “1st rank grey literature” (Fig. 2), conference reports, project reports, and food authority reports, as well as non-fiction books and book chapters, EU regulations, and Ph.D. monographs. Cookbooks documenting the process of smoking reindeer meat were included, except those containing only recipes.

The grey literature that we excluded, which we call “2nd rank grey literature” (Fig. 2), was bachelor and master theses (none of them focused on smoking or smoked reindeer meat), travelogues, newspaper articles, book reviews, literary fiction, and any analyses of them. Conference abstracts and posters were excluded because we found the same data published in scientific articles. Only works in English, Northern Sámi, Norwegian, and Swedish were included.

We excluded all papers on meat not from reindeer or on reindeer meat that was not smoked. We also excluded documents that mentioned smoked or smoking reindeer meat in non-relevant settings (e.g. in the acknowledgments or an appendix, in a scenario or event, or if “suovas”—smoked reindeer meat—was mentioned

Table 2. The degree of participation or inclusion of traditional knowledge based on criteria inspired by Arnstein’s (1969) ladder of citizen participation.

Degree of participation	Description of criteria
4 Self-determination	Traditional knowledge holders conduct research based on their own knowledge, practices, or experiences.
3 Co-production	Traditional knowledge holders conduct research together with scientists through co-production, including involvement in formulating research questions and analysing and interpreting the data.
2 Consultation	Traditional knowledge and practices are collected, tested, or investigated by scientists. Traditional knowledge holders are not included in formulating the research or interpreting the data.
1 Non-participation	The method design does not entail investigating traditional knowledge or including traditional knowledge holders. Traditional knowledge may be mentioned in theory, or the practices used are described as traditional, but the origin of the data is not given.

only as part of the Slow Food Sápmi project). Some potential documents were excluded because the references to them were incorrect.

After deleting duplicates and applying the exclusion and inclusion criteria, we were left with 57 texts that mention or focus on smoked or smoking reindeer meat. These texts include 20 scientific articles and 37 pieces of grey literature (three Ph.D. monographs, and 34 books, book chapters, and research-based project reports). Most of this literature was located through the protocol-driven search ($n=36$). However, we found 14 texts solely by “asking around”. By tracking the reference lists in the literature, we added six more texts.

Analysis of the literature

Once we had selected the literature, we focused on the context, the results, and the methods used to study smoked and smoking reindeer meat. For each context, we asked: Within what genre, academic discipline, subdiscipline, or theme are smoked or smoking reindeer meat studied? For the results, we asked: What does the literature tell us about smoked or smoking reindeer meat? For the method, we asked: What method is used, and to what degree is traditional knowledge on smoked or smoking reindeer meat included in the study? These questions were developed by following Parris and Peachy (2013). The publications were then grouped according to the following four categories related to the inclusion of traditional knowledge or the practitioners of it: (1) non-

participation, (2) consultation, (3) co-production, and (4) self-determination (see Table 2). These categories were developed by studying Arnstein's (1969) ladder of citizen participation, Bjørkan's (2011) three levels of organisation of knowledge in fishery research, and Huntington's (2005) four methods for collecting traditional (ecological) knowledge.

Level (1), non-participation, covers studies that do not include traditional knowledge. Non-participation is the lowest level of Arnstein's ladder, enabling power holders to "educate" or "cure" the participants. Studies categorised at Level 1 do not specify the origin of the method, nor do they describe the involvement of traditional knowledge holders. For example, non-participation shows up in fishery management, which excludes fishermen's knowledge from research data collections (Bjørkan, 2011).

Level (2), consultation, covers studies in which traditional knowledge is part of the data collection, for example, through being observed, being interviewed, answering questionnaires, or all three. This level corresponds with Arnstein's second level, "tokenism," which allows citizens currently excluded from political and economic processes to listen and "to have a voice."

Level (3), co-production, covers studies in which traditional knowledge holders conduct research together with scientists, by being involved in formulating research questions and analysing and interpreting the data. While many levels of cooperation exist (Bjørkan, 2011), at Level 3, all of them are gathered in one category.

Level (4), self-determination, covers studies in which indigenous or local people and communities study their own environment, communicating their own experiences and using their traditional knowledge. The highest level in Arnstein's (1969) ladder is "citizen control," covering partnerships in which citizens negotiate and engage in trade-offs with the traditional power holders, whereas Bjørkan's (2011) third level includes management, in which fishermen are positioned to take responsibility for knowledge provision. At our Level 4, both the power and the responsibility for providing knowledge lie solely with the traditional knowledge holders. (A description of the criteria used for this four-part-systematic categorisation appears in Table 2.)

Huntington (2000) describes four methods for collecting traditional (ecological) knowledge: semi-directive interview, questionnaire, analytical workshop, and collaborative fieldwork. Studies using the first two methods belong to our Level 2, consultation, whereas studies using the last two methods belong to our Level 3, co-production (Table 2). Studies using several methods to investigate smoked or smoking reindeer meat are categorised according to the method using the highest degree of participation. For example, "co-production" studies, much like "consultation" studies, often use interviews, conversations, and (co-)observations. The difference is that "co-production" studies more widely use collaboration with traditional knowledge holders, from establishing hypotheses to interpreting the data.

We also categorised the reviewed literature according to three focus levels (A, B, and C) on smoked and smoking reindeer meat. The literature in focus level A focused mainly on smoked or smoking reindeer meat, while the literature in focus level B included sections or parts on this subject. Focus level C literature discusses only one single issue of smoked or smoking reindeer meat.

Results

The results are presented according to the main information extracted from the scientific articles and the grey literature: (1) the genres, disciplines, and themes, (2) the knowledge status of

smoked and smoking reindeer meat, and (3) the degree of including traditional knowledge.

Genre, academic disciplines, and themes

Scientific studies of smoked or smoking reindeer meat originate from the natural, health, and social sciences, comprising many sub-disciplines: food science, economics, law, archaeology, education, and geography. The most dominant disciplines are, however, the health and food sciences (Fig. 3). Smoked or smoking reindeer meat was studied according to a wide spectrum of themes: chemical composition, diet, reindeer herders' traditional food culture and sacrifices, cancer, small-scale industry processing, and the Sámi learning environment (Fig. 3). The grey literature covers five additional themes or fields: reindeer management, meat technology/innovation, linguistics, tourism, and history.

The knowledge status of smoked and smoking of reindeer meat

While the scientific articles are presented according to their academic discipline as they appear in Figure 3, the grey literature is presented according to themes associated with academic disciplines. The most comprehensive disciplines/themes are presented initially.

Scientific articles

Within food science, Sampels, Pickova, and Wiklund (2004) studied the content of human nutrition, concluding that smoking reindeer meat, in contrast to drying it, only slightly changed the meat's composition of fatty acids, lipid class, and vitamin content. They injected a salt solution (13% salt, 1.9% sugar, 0.25% ascorbate), and cured (3 days at 4 °C), rinsed, matured (1 hour at 40 °C) and dried (45 min at 45 °C) the meat. The meat was smoked with alder (*Alnus glutinosa*) chips at 80°C (Sampels et al., 2004). Pekkanen and Hänninen (1976) measured the cyanide content of smoked reindeer meat as higher than that of other products but still safe for consumption (Pekkanen & Hänninen, 1976).

In addition, Polder et al. (2010) investigated the levels and patterns of persistent organic pollutants (POPs) that accumulate in the food chain and become a human health hazard (UNEP, 2018). Hexachlorobenzene, used as a solvent in the production of lubricants (UNEP, 2018), was found to be the most abundant POP in smoked reindeer meat, in contrast to meat from domestic animals (Polder et al., 2010). Wretling, Eriksson, Eskhult, and Larsson (2010) analysed different smoked foodstuffs, including reindeer meat, for polycyclic aromatic hydrocarbons (PAH). PAH, formed by the incomplete combustion of organic material, may be toxic, mutagenic, or carcinogenic, causing human health hazards (Ledesma, Rendueles, & Dias, 2016). The Norwegian Food Safety Authority (FSA) requires smoking performed indoors, prohibiting *lavvu* smoking by law unless it can be proved safe (Austdal, 2018, referring to 2007 newspaper article in iFinnmark.no).

Within the health sciences, Hassler, Sjölander, Barnekow-Bergkvist, and Kadesjö (2001) and Wiklund, Holm, and Eklund (1990) studied Sámi cancer data. Smoked reindeer meat was part of the questionnaire in Brustad, Parr, Melhus, and Lund (2008), who showed that three generations of Sámi language speakers ate the most reindeer meat (Brustad et al., 2008). Nilsson et al. (2011) studied the Sámi diet in southern Sápmi in the 1930s, 1950s, and 2000s. Their informants said that meat was dried or smoked in summer for preservation. Smoked meat was more

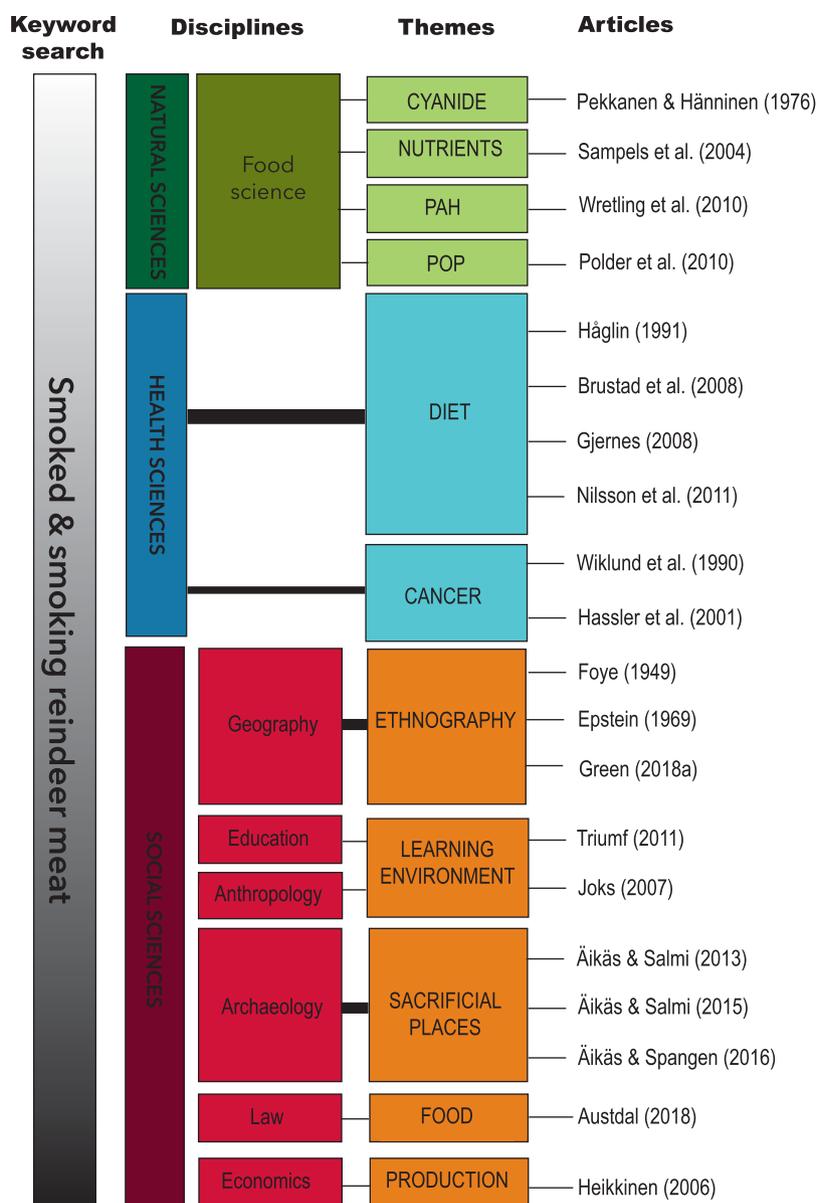


Fig. 3. Scientific disciplines, themes, and peer-reviewed articles that study “smoked reindeer meat” and “smoking reindeer meat” found searching on Google Scholar and other online databases in English, North Sami language, Norwegian, and Swedish. PAH = polycyclic aromatic hydrocarbons, POP = Persistent Organic Pollutants.

common among mountain than forest Sámi, as packed food for travel or snacks between meals (Nilsson et al., 2011).

In line with common Swedish health recommendations, Håglin (1991) found that the Sámi had a poor nutrient intake: “Dried blood, fish and preserved meat were the most important foodstuffs among the West Bothnian Lapps [Sámi] at the summer residences in the mountains” (p. 743). Gjernes (2008) described practical barriers to following health advice, with one informant saying: “Reindeer herders need dry reindeer meat, coffee, and tea for some, rolling tobacco for many, smoked reindeer meat, bread and butter and sugar to create the energy needed and to keep warm” (p. 512).

Anthropologist Green (2018a) studied Sámi food movements, such as the “Slow Food Sweden/Sápmi Presidium Project,” which was aimed at safeguarding unique culinary products. The first unique product promoted by *Slow Food Sweden/Sápmi* is *suovas*—a north Sámi word for smoke that in Sweden is used

for smoked reindeer meat. *Suovas* has been co-opted by non-Sámi and used for other meat products because the word makes them sell better. Therefore, some Sámi have applied for the “Protected Designation of Origin” (PDO) label for the word “*suovas*” (Green, 2018a). This EU designation is the most restrictive, requiring that all stages of production take place in the designated area (Article 5(1) of regulation 115/2012/EC) (Austdal, 2018).

Within geography studies, Foye (1949, pp. 301–302) was served smoked reindeer meat when travelling in “Lapland” (Norway, Finland, Sweden). Epstein (1969) wrote that “[i]n summer the diet of dried and smoked reindeer meat is supplemented by fish from the rivers and lakes” (p. 32).

Archaeological studies in Muonio, Finland, revealed a slice of cold smoked reindeer meat on a *siedi*, a Sámi sacrificial place in north Sápmi (Äikäs & Salmi, 2013, 2015; Äikäs & Spangen, 2016). Today, smoking of reindeer meat is part of the Sámi

educational and learning environment, as Triumf (2011) and Joks (2007) showed how such practical knowledge is passed down from grandparents and parents.

In the field of economics, Heikkinen (2006) focused on how Finnish reindeer herders—both Sámi and non-Sámi—tried to increase their income by enhancing the processing. The highest processing level is smoked reindeer meat, which almost all Finnish small-scale reindeer meat companies produce (p. 202).

Grey literature

Among the grey literature, many geographical and anthropological studies revealed historical knowledge on smoking of reindeer meat from Sápmi and the Circumpolar North. Smoked reindeer meat is documented as early as 1600 (Fjellström, 1985, pp. 262–265, 267). Fjellström (1985) described how the reindeer shoulder was dried and sometimes smoked in the *káta* (Swedish for a *lávvu* or turf hut). Travelling in “Lapland” (Sápmi) in 1732, natural scientist Carl Linnæus wrote that before rut, male reindeer were slaughtered, salted, and stored in storehouses to be eaten in spring, after having been dried by the weather and the sun and by the fire and smoke in the chimney (Linnæus, 1995 [1732], pp. 112–113).

In 1767, Leem wrote that the mountain “Laplanders” (Sámi) smoked reindeer ribs for variety. The meat was pierced with a knife to let the smoke enter more easily (Leem, 1767). After the meat was pierced and salted, the meat was smoked in the tent opening (Vorren, 1951, p. 90). Also, Nergård (2006) described and illustrated how reindeer meat was hung above the fire inside the *lávvu* (see Fig. 1).

Barnes (1975, p. 95) reports the smoking of rib sections, haunches, rumps, and shoulders. Barnes (1975) wrote that the meat is slaughtered in autumn, 40–50% was eaten fresh, and the rest was salted and smoked in smokehouses in spring, for summer eating (pp. 72, 81, 95–96, 123, 148, 169, 202, 273). According to Ruong (1945), the forest Sámi did not smoke their reindeer meat before drying it, as the mountain Sámi did.

From the Norwegian and Swedish part of Sápmi, respectively, Murud (2018, p. 49) and Ryd (2005; 2018, ch. 19) comprehensively document Sámi fire and smoking practices, according to firewood type, smoking seasons, and taste. While Murud (2018, p. 49) is written in North Sámi language, Ryd (2005; 2018, ch. 19) use terms from three Sámi languages. Different smoking practices, use of wood types and smoked reindeer meat recipes from both South and North in Sápmi, Sweden, and Norway, are also given in Sametinget (2010), Harnesk and Brandon-Cox (2014), Jilker and Jáma (2014), Buljo et al. (2018), Huuva (2019), and Asp and Ståhl (2019).

Reindeer meat is also smoked outside Sápmi. Eidlitz’s (1969) Ph.D. thesis showed that many different indigenous peoples of the North—including Alaska, Canada, Eurasia, and Greenland—smoked (reindeer) meat (pp. 106–107). Smoking tents were used by the reindeer Chukchi (in Siberia), the Labrador “Eskimos” [Inuits], and their Canadian neighbours, the “Indians” [First Nations] (Eidlitz, 1969, p. 106). The Evenkies smoke reindeer meat in a *chum*—a Russian word for a reindeer herder’s tent (Vitebsky, 2005, p. 84). The Evenki way of smoking outside above the fire is described by Gerasimova (2017). In Nunavik, Canada, smoked caribou is a specialty among indigenous people, but most processing and marketing occurs in southern Canada, scarcely benefiting the locals (Council of Canadian Academies, 2014). A project report from Alaska refers only to the storage time for smoked meat, the parts smoked, and the length of smoking using indirect heat (Unger et al., 2014).

Some grey literature is situated between social ethnography, natural science, and health science. Veterinaries and reindeer scientists Skjenneberg and Slagsvold (1979) write about the Sámi meat smoking for summer food conservation. But, they also reveal levels of C- & B-vitamin in smoked meat, compared to meat that have only been frozen (Skjenneberg & Slagsvold, 1979). Chemist and ethnologist Riddervold (2002) and reindeer herder Smuk (2003) write about both the Sámi way of smoking meat in the *lávvu* using willow and discuss the PAH levels of the *lávvu*-smoked reindeer meat.

Additional health and food science studies accounts, a Norwegian FSA report on PAH levels of reindeer meat (Frantzen, Sanden, & Måge, 2017), and a Swedish FSA book on pathogenic bacteria in food and water (Lindberg, Stenström, & Ternström, 2012). According to Lindberg et al. (2012) may Brucella, a bacterium resistant to smoking, be found in reindeer meat from Russia, Alaska, and Canada but not in meat from Scandinavia.

Meat technology and innovation in relation to smoked meat are emphasised in several grey literature. A conference paper by Niinivaara and Petäjä (1985) focused on improving smoked reindeer meat production. Suggested improvements included “speed[ing] up production, improv[ing] the homogeneity of products, reduc[ing] salt concentrations and rais[ing] profitability” (Niinivaara & Petäjä, 1985, p. 115). Finnish smoked reindeer meat (*Lapin Porin kylmäsavuliha*) is smoked in temperature-controlled cabinets and described by, for example, water, protein and fat content in Håseth, Thorkelsson, Puolanne, and Sidhu (2014),

Suovas (smoked reindeer meat in Sweden) is the first product promoted by the “Slow food Sápmi” project. The second is *gurpi*, a smoked reindeer sausage of coarsely chopped meat wrapped in a stomach fat caul (Green, 2018b; Harnesk & Brandon-Cox, 2014). These products are both traditional and innovative. In Sametinget (2010), modernised products of *suovas* are described. Also Eikjok (2007) exemplified how smoked reindeer meat undergoes transformation when mixed with Indian Lentils and Thai coconut milk.

From conceptual analysis, Korhonen (1997) has argued that the Sámi word *suovas* is used by the general public in North Sweden. However, Swedish Sámi applied for EU PDO for *suovas* (Green, 2017, 2018b; Nygård, 2012). Likewise, *Lapin Porin kylmäsavuliha*, traditional cold-smoked reindeer meat from Finland, has EU PDO and Protected Geographical Indication status (EC 2010; EU 2011b).

In relation to economics, slow food books—Petrini (2007, p. 197) and Petrini (2006, pp. 189–190)—briefly mention that *suovas* from southern Swedish Sápmi have great commercial potential. Smoked reindeer meat is also highly prized in Alaska (Palmer, 1934) and interesting to tourism in Sweden (Danius, 2003).

Last, the grey literature has revealed that children learn traditional smoking of reindeer meat in a Swedish Sámi elementary school (Green, 2017) or from elders (Liliequist, 2016).

Degree of traditional knowledge included

The literature is categorised according to the degree of participation in Table 3 (peer reviewed scientific articles in Table 3a and grey literature in Table 3b). Initially, the literature at the highest focus level A is presented, then literature at focus levels B and C.

Scientific articles

The study methods and the main disciplines of the scientific articles (natural, health, and social sciences) are specified in Table 3. All scientific articles are categorised at Level 1, non-participation or Level 2, consultation, except one scientific article at Level 4, self-determination. All the natural science articles are

categorised at Level 1, non-participation. This also applies to the only two articles that focused on smoked or smoking reindeer meat (focus level A).

1. Non-participation

The only peer-reviewed articles that specifically focused on smoked reindeer meat were Sampels et al. (2004) and Pekkanen and Hänninen (1976). Sampels et al.'s (2004) study was categorised as non-participation because the only method used was chemical analysis, and the origin of the smoking practices was not presented. In Pekkanen and Hänninen (1976) and Polder et al. (2010), the meat analysis was performed on local supermarket products; moreover, as nothing was mentioned about the production process, there was no participation. The cancer data studies by Wiklund et al. (1990) and Hassler et al. (2001) and the excavation studies by Äikäs and Salmi (2013, 2015) and Äikäs and Spangen (2016) are likewise non-participation studies, as no traditional knowledge appeared in either the collection or the interpretation of the data.

2. Consultation

Most social science articles are categorised at Level 2, consultation (Table 3a). However, all these articles are at focus level C, except for

one at focus level B—Green (2018a), using ethnographic fieldwork studying Sámi food activism. Brustad et al. (2008) used food-frequency questionnaires, while Nilsson et al. (2011), Håglin (1991) and Gjernes (2008) interviewed Sami people about their diet. Only Heikkinen (2006) combined all these methods, including a relative high degree of traditional knowledge. Nonetheless, study by Heikkinen (2006) is categorised as consultation because herders are not included in data interpretation. Moreover, even though Joks (2007) is Sámi, she is not from the local reindeer-herding society she studied, and she included interviews with herders only in the data collection, not in data interpretation. Foye (1949) and Epstein (1969) simply observed Sámi reindeer herders serving and eating smoked reindeer meat.

3. Co-production

No scientific article on smoked or smoking reindeer meat is using co-production methods.

4. Self-determination

The only peer-reviewed article at Level 4, self-determination, is Triumpf (2011). However, this article is categorised at focus level C because Triumpf (2011) only briefly wrote about her own experiences with meat smoking.

Table 3. Degree of participation in the literature via a systematic literature search on smoked and smoking reindeer meat.

Degree of participation	Focus level	Author (year)	Method
3a. Scientific articles			
4 Self-determination	A		
	B		
	C	Triumpf (2011)	(S) Personal experiences
3 Co-production	A		
	B		
	C		
2 Consultation	A		
	B	Green (2018a)	(S) Ethnographic fieldwork
	C	Brustad et al. (2008) Nilsson et al. (2011) Gjernes (2008) Håglin (1991) Foye (1949) Epstein (1969) Heikkinen (2006) Joks (2007)	(H) Questionnaires, health data analysis (H) Interviews (H) Interviews (H) Interviews, food consumption data analysis (S) Travelogue (S) Ethnographic fieldwork (S) Participatory observation, posted inquiries, interviews, newspaper articles studies (S) Interviews, filming
1 Non-participation	A	Sampels et al. (2004) Pekkanen and Hänninen (1976)	(N) Meat chemical analysis (N) Meat chemical analysis
	B	Wretling et al. (2010)	(N) Meat chemical analysis
	C	Hassler et al. (2001) Wiklund et al. (1990) Polder et al. (2010) Äikäs and Salmi (2013) Äikäs and Salmi (2015) Äikäs and Spangen (2016) Austdal (2018)	(H) Cancer data analysis (H) Cancer data analysis (N) Meat chemical analysis (S) Excavations (S) Excavations (S) Excavations (S) Food law review

(Continued)

Table 3. (Continued)

Degree of participation	Focus level	Author (year)	Method
3b. Grey literature			
4 Self-determination	A		
	B	Sametinget (2010) Gerasimova (2017) Murud (2018) Huuva (2019)	Provision of indigenous government Personal experiences Personal experiences Personal experiences
	C		
3 Co-production	A	Riddervold (2002) Smuk (2003)	Collaborative fieldwork Collaborative fieldwork
	B	Jillker and Jäma (2014) Harnesk and Brandon-Cox (2014) Buljo et al. (2018) Asp and Ståhl (2019)	Analytical food workshops Analytical food workshops Analytical food workshops Interpretation from co-production
	C	Council of Canadian Academies (2014) Petrini (2006) Petrini (2007)	Panel discussions Food activism narrative Food activism diary
2 Consultation	A		
	B	Eidlitz (1969) Fjellström (1985) Ryd (2005); (Ryd, 2018) Nergård (2006) Green (2017) Green (2018b) Barnes (1975)	Literature review Ethnographic fieldwork Participatory observations, Interviews Ethnographic fieldwork Ethnographic fieldwork Ethnographic fieldwork, literature review Ethnographic fieldwork
	C	Linnæus (1995 [1732]) Leem (1767) Ruong (1945) Korhonen (1997) Danis (2003) Eikjok (2007) Vitebsky (2005) Liliequist (2016)	Ethnographic fieldwork Ethnographic fieldwork Ethnographic fieldwork Conceptual analysis Inspiration-seminars, food workshops Personal communication Ethnographic fieldwork Narrative analysis
1 Non-participation	A	Niinivaara and Petäjä (1985) Håseth et al. (2014)	Chemical analysis Literature review
	B	Vorren (1951) Skjenneberg and Slagsvold (1979) Unger et al. (2014) Frantzen et al. (2017)	n.d. n.d. Literature review Chemical analysis
	C	Palmer (1934) Lindberg et al. (2012) Nygård (2012)	Presentation of scientific studies n.d. Literature review

Literature in focus level A is specifically on smoked or smoking reindeer meat; in focus level B, only in part; and in focus level C, only brief mention. The methods used at the different levels of participation are listed. In studies marked “n.d.,” the method was not detected. Table 3a shows peer-reviewed articles. Their affiliation with the natural, health and social sciences is given by (N), (H) and (S), respectively. Table 3b shows grey literature (books, book chapters, and reports).

Grey literature

Most of the grey literature is also categorised at Level 2. However, a higher amount of the grey literature used methods of co-production and self-determination (9 and 4 literature, respectively), than the scientific articles (0 and 1 literature, respectively). In general, compared to the scientific articles, the grey literature focused more on smoked or smoking reindeer meat (4 grey literature at Focus Levels A and 19 grey literature at focus level B, compared to 2 A-literature and 2 B-literature for the scientific articles, Table 3).

1. Non-participation

A quarter of the grey literature was categorised in the non-participation category (Table 3b), at all focus levels. This literature

builds on methods that were not described, literature reviews, or chemical analysis. Even though Unger et al.’s (2014) study is co-produced with indigenous people, we list it as non-participation because recommendations on smoking reindeer meat are given by references to the U.S. Department of Agriculture Food Safety.

2. Consultation

The grey literature mainly builds on consultation, using ethnographic fieldwork. Ryd (2005, 2018 in Norwegian) included a great amount of traditional knowledge of smoking, interviewing elder Sámi traditional knowledge holders on the “art” of Sámi bonfires (2B, Table 3b). Nergård (2006) performed long-term fieldwork observing Sámi reindeer herders in northern Norway, and Ruong (1945) in Sweden. Green’s (2017) and Barnes’s (1975)

Ph.D. theses also included ethnographic fieldwork in Swedish Sápmi, and Fjellström (1985) combined fieldwork with archive material from the 17th, 18th, and 19th centuries. Because Eidlitz (1969, pp. 106–107) reviewed older ethnological literature on the smoking reindeer meat, ranging from 1789 through 1958, her work is categorised as consultation. Linnæus (1995 [1732]), Leem (1767), and other authors in the literature at focus Level C just simply observed smoked reindeer meat.

3. Co-production

The only documents focusing on meat smoking that met the co-production criteria were by scientist Riddervold (2002) and reindeer herder Smuk (2003), who smoked meat in the *lavvu* (Sámi tent) with representatives of the Norwegian FSA. Other collaboration studies between scientists and indigenous people in the Arctic North examined various aspects of smoking (Asp & Ståhl, 2019; Buljo et al., 2018; Jillker & Jåma, 2014). These studies used conversations and workshops to collect, discuss, and present information on traditional food. Participants sought co-production in the “Slow Food Sweden/Sápmi” project (Harnesk & Brandon-Cox, 2014; Petrini, 2006, 2007) and in the panel discussions by multidisciplinary scholars’ working with and within aboriginal communities (Council of Canadian Academies, 2014).

4. Self-determination

In the self-determination category are books by Murud (2018) and Gerasimova (2017), two reindeer-herding women documenting various aspects of their traditional smoking practices, the Sámi and Evenki way, respectively. Huuva (2019) documented his own smoking recipes and practices, building on knowledge from reindeer herding and local Swedish traditions. A project report by the Sámi parliament in Sweden (Sametinget, 2010) is categorised as Level 4, self-determination, even though the data source is unknown.

Discussion

Our review reflects an incomplete understanding of smoked and smoking reindeer meat because research methods did not include traditional knowledge. This exclusion of traditional knowledge in science may be problematic if used as a basis for management of reindeer and reindeer husbandry. Therefore, firstly, we present the general lack of traditional knowledge in reindeer management and science. Secondly, we discuss the consequences of these “white spots” in the literature by using examples from the scientific and grey literature on smoked and smoking reindeer meat. Thirdly, we examine the knowledge status of smoked and smoking reindeer meat. Last, we discuss how to ensure the inclusion of traditional knowledge in future scientific studies.

Traditional knowledge in reindeer management and science

In literature on reindeer husbandry, the scientific way and the traditional way of knowing have been viewed not only as both competing (Johnsen et al., 2017) and conflicting (Johnsen, 2018) but also as complementary in terms of developing adaptation strategies for climate change (Eira et al., 2013).

In Norway, reindeer herders and state policies compete to define sustainable, “rational” and “proper” reindeer husbandry. While reindeer herders see a human–animal–nature relationship, state policies see reindeer as an object that can be manipulated to

produce maximum amount of meat through streamlined herding practices (Johnsen et al., 2017). Today, governmental reindeer herding management is based on scholarly experts’ notions of how to optimise reindeer meat production, not on herders’ complex traditional knowledges and practices. The government, for example, implements what they perceive as “proper” reindeer husbandry by providing economic rewards for calf production. This management technique remains in conflict with—and undermine—herders’ knowledge of profitability, herding vulnerability, animal welfare, and work efficiency (Johnsen & Benjaminsen, 2017).

Conflicts arise, when those who govern do not acknowledge, or are not even aware of, the different sets of knowledge or worldviews of those being governed (Blaser, 2009a). An example of such a conflict is the destocking of herds in parts of northern Norway, where management-based and traditional Sámi reindeer herding compete to define “proper” reindeer management and herding practices (Johnsen et al., 2017). Turi and Keskitalo (2014) have criticised Norwegian reindeer husbandry policy for its lack of local participation and autonomy, its over-regulation, and its top-down management.

Indeed, as given in the Introduction, some scholars suggest valuing traditional knowledge as complementary to science (Berkes, 1999; Collins & Evans, 2002; Davis & Ruddle, 2010; Eira et al., 2013; Riseth et al., 2011; Tengö et al., 2014). In the following, we exemplify that traditional knowledge has, so far, not been valued in studies of smoked and smoking reindeer meat. This exclusion might have huge consequences.

Traditional knowledge in studies of smoked reindeer meat

Both in the scientific articles and in the grey literature, we found examples of erroneous conclusions because reindeer herders’ traditional knowledge and practices were excluded from investigations on smoked reindeer meat. We will illustrate this consequence with one example from the scientific articles (Sampels et al., 2004) and one from the grey literature (Niinivaara & Petäjä, 1985).

The scientific article, Sampels et al. (2004), for example, pioneered the study of the effect of smoking and drying on the fat content of reindeer meat, but did not describe the origin of the smoking practice used. Instead of using Sámi reindeer herders’ traditional knowledge, they performed a standardised biological experiment described only by temperature and hours of smoking. Furthermore, Sampels et al. (2004) smoked meat from 16 ten-month-old reindeer calves, “slaughtered and processed following the usual practice at the abattoir” (Arctic Deli AB, Harads, Sweden) (p. 524). In contrast, the Sámi people traditionally only smoke two-to-three-month-old reindeer calves for preservation in summer, when they are slaughtering for traditional reindeer skin processing for making clothing (reindeer herder Inger Anita Smuk, personal communication, 2 September 2017). As given in some of the grey literature, Sámi reindeer herders traditionally slaughter and smoke meat from adult male reindeer before the autumn-rut, castrated males, or over-aged females (Barnes, 1975, p. 80; Linnæus, 1995 [1732], p. 112). Therefore, as this example illustrate, by not including traditional knowledge in planning an experiment, scientists may fail to achieve their goal of investigating traditional products.

In addition, Sampels et al. (2004) used standardised wood chips, instead of the wood traditionally used in the Circumpolar North, as described in the grey literature (Asp & Ståhl, 2019, p. 51; Buljo et al. 2018, p. 49; Frantzen et al., 2017; Harnesk & Brandon-Cox, 2014;

Ryd, 2005, ch. 19; Sametinget, 2010, p. 10; Skjenneberg & Slagsvold, 1979, p. 238). Yet, the type of wood used for smoking affects the temperature (Murud, 2018): The higher the temperature, the more fat drips from the meat, igniting the fire and making the temperature rise (Ryd, 2005, 2018). The inclusion of traditional knowledge about wood and smoking practices presented in the grey literature would likely have generated valuable results in this otherwise interesting scientific article on the fat content of smoked reindeer meat. Now, however, the conclusions are misleading.

Yet another example from the grey literature that might promote “rational” reindeer husbandry management of reindeer meat products appears in this review: a conference report entitled “Problems in the production and processing of reindeer meat” by Niinivaara and Petäjä (1985). This study undermines reindeer herders’ traditional knowledge by, for example, suggesting that less expensive parts of the carcass (e.g. the shoulder) could obtain a better price if it were smoked. Yet, Niinivaara and Petäjä (1985) do not explain how they came to this conclusion or whether they consulted traditional knowledge holders. However, as Sámi reindeer herders have traditionally smoked the shoulder (Barnes, 1975; Fjellström, 1985), smoked shoulder in no way represents the new product that Niinivaara and Petäjä (1985) suggest. By suggesting new products that are not new to traditional knowledge holders, scientists have drawn erroneous conclusions. The unknown empirical material and analysis used in Niinivaara and Petäjä (1985) conflict with traditional knowledge, and the findings are irrelevant to reindeer herders.

The consequence of not including traditional knowledge in scientific planning, methods and analyses may as the above examples show, leads to erroneous conclusions that are irrelevant for reindeer herders and misleading for reindeer herding management. Yet, the study of Arctic indigenous food systems offers an additional arena of conflict between science and traditional knowledge.

Knowledge about smoked reindeer meat

Despite the limited literature, we will discuss the knowledge status of smoked reindeer meat and the practice of smoking it. The scientific articles mainly focused on health issues related to food smoking. This is possible because biomass fuel smoke can constitute a major health concern in the developing world (Fullerton, Bruce, & Gordon, 2008; Pratali *et al.*, 2018). For example, the PAH derived from incomplete combustion of wood may cause cancer in humans (Ledesma *et al.*, 2016). Indeed, the EU Scientific Committee on Food has established maximum levels of PAH in food (EC 2006; EU 2011a). Chemical analysis of carcinogenic PAH levels in traditionally smoked reindeer meat is therefore important. Such scientific studies are critical, especially among the Sámi, because reindeer herding Sámi—despite their lower cancer risk in general—have a higher risk of stomach cancer than non-Sámi (Hassler *et al.*, 2001; Wiklund *et al.*, 1990).

In the literature reviewed, only one scientific article, Wretling *et al.* (2010), publishes data of PAH levels of smoked reindeer meat. This scientific study does not use reindeer herders’ traditional smoking methods. Three grey literatures investigated PAH levels of smoked reindeer meat. Of these, the traditional smoking method of the meat analysed is only described in Riddervold (2002) and Smuk (2003), not in Frantzen *et al.* (2017). Nonetheless, all the PAH levels of smoked reindeer meat in the scientific articles and grey literature fall below the EU maximum levels. But none of

the literature reveals PAH levels of meat smoked with birch—the most commonly used wood among the Sámi—according to the grey literature Ryd (2005). This omission of scientific documentation of PAH from traditionally smoked reindeer meat is problematic. Using input from traditional knowledge in designing these experiments might have eliminated this problem. Because food safety legislation impacts traditional food by, for example, requiring indoor smoking (Austdal, 2018), including traditional knowledge in the investigation is critical. Therefore—and also because knowing whether one’s products are health hazards is important—we recommend additional research on PAH levels of traditional smoked reindeer meat in future research studies.

Apart from chemical investigations of smoked reindeer meat, no scientific studies focus on traditional smoking practices. Yet, the grey literature shows that traditional knowledge of smoking reindeer meat is rich, diverse, and still in use (e.g. Asp & Ståhl, 2019; Buljo *et al.*, 2018; Ryd, 2005). For example, a common practice among many Arctic reindeer people is smoking reindeer meat in their traditional tents (Fig. 4). However, even among the Sámi, local differences in smoking techniques appear, as illustrated by the following examples.

While on the Norwegian side of Sápmi, the meat is smoked in summer and autumn (Nergård, 2006; Riddervold, 2002; Smuk, 2003), on the Swedish side it is smoked in spring and dried thereafter (Asp & Ståhl, 2019; Barnes, 1975; Harnesk & Brandon-Cox, 2014; Huuva, 2019; Petrini, 2006; Ryd, 2005, 2018). Drying smoked meat is performed only by the mountain reindeer Sámi, not the forest Sámi (Huuva, 2019; Ruong, 1945). In Petrini (2006, p. 190), a herder from southern Sweden explained that the meat was coated with salt for three months before being smoked in the spring, while in northern Sweden, the meat was salted for 1–3 days (Huuva, 2019, p. 47) or 3–4 days (Barnes, 1975, p. 95) before being smoked.

Salt was once little used in Sámi preservation (Harnesk & Brandon-Cox, 2014; Sametinget, 2010) because transporting it was impractical (Ryd, 2018) and the poorest Sami could not afford it (Fjellström, 1985, p. 262). Therefore, drying and smoking were used for preserving the meat for both storage and transport (Fjellström, 1985, pp. 264–265). Many types of wood are used for smoking (Harnesk & Brandon-Cox, 2014; Murud, 2018; Ryd, 2005, ch. 19), resulting in different colours and tastes (Murud, 2018). A herder from southern Sweden uses fresh birch, while Huuva (2019) from northern Sweden uses dry birch without the bark, but willow and alder with the bark. In contrast, another southern Sweden herder uses willow and alder without bark (Asp & Ståhl, 2019), and northern Norway herders use willow with leaves (Riddervold, 2002; Smuk, 2003).

Ryd (2005) argued that a dry wood fire needs continuous control, while green firewood, such as willow (Murud, 2018), allows one to leave the fireplaces. But, green wood should not be used when the smoked meat is to be dried (Murud, 2018). As juniper and dry pine preserve the meat very well, they were in use when salt was less available (Ryd, 2005). Some smoke the meat 7–10 h (Asp & Ståhl, 2019), whereas others for 2–3 days (Ryd, 2005).

A variety of traditional smoking practices clearly exist, as shown by the heterogeneous practices compared in this literature review. However, each of the documents we reviewed gives the impression that smoking of reindeer meat is done by one traditional practice alone. Yet, in line with Davis and Ruddle’s (2010) more general conclusions, we find no consensus on what constitutes traditional knowledge on smoking reindeer meat. This finding corresponds with Krupnik, Nakashima, and Rubis’s (2018) argument that



Fig. 4. Sami traditional meat smoking with birch and juniper in a lavvu (Sámi tent). Photo by Kia Krarup Hansen.

traditional knowledge is local knowledge, unique to its given culture. Traditional knowledge often combines knowledge and practices to give a holistic understanding of human interaction with their surroundings (Nakashima & Roue, 2002). Reindeer herding is a complex human-coupled ecosystem (Magga, Mathiesen, Corell, & Oskal, 2011), and traditional knowledge is embedded in complex networks of social relations, values, and practices (Nadashy, 1999, p. 5).

If these complex social and cultural processes are not factored into systematic research, the consequences may be flawed understanding, misrepresentation (Davis & Ruddle, 2010), and conflicts (Blaser, 2009b; Johnsen et al., 2017). To document the complex

knowledge system and various meat-smoking practices of Arctic reindeer herding peoples, and to avoid future misrepresentation, we recommend studies that are designed to include traditional knowledge in scientific research.

Towards including traditional knowledge in scientific research

As few studies have assessed Arctic reindeer herding peoples' knowledge of reindeer meat smoking, our extensive review provides important insights for future research. The barriers against incorporating traditional knowledge in the governance of reindeer husbandry (Turi & Keskitalo, 2014) could be linked to the methodological barriers we found against including traditional practices in science.

Knowledge holders' self-determination, through conducting their own research, constitutes one way of including traditional knowledge in science. Alternatively, when scientists study traditional practices, co-production with traditional knowledge holders can ensure the inclusion of traditional knowledge, thereby improving and expanding scholars' understanding of the subject under study. According to Cornwall and Jewkes (1995) and Bergold and Thomas (2012), participatory research engages participants in mutual learning, analysis, and co-production of knowledge. For example, co-production is common in climate change research, with community-based workshops forming a good basis for gathering people from different knowledge spheres (Krupnik, Aporta, Gearheard, Laidler, & Holm, 2010; Magga, Mathiesen, Corell, & Oskal, 2013; Pogodaev & Oskal, 2015; Tyler et al., 2007).

Within reindeer herding, access to traditional knowledge depends on both participation and practices (Eira, Magga, & Eira, 2010; Sara, 2009), and the knowledge of smoking practices is transmitted generationally within the family (Green, 2017; Joks, 2007; Triumph, 2011). But, to date, no scientific articles use methods that include participation in the practice of traditional smoking where these generational transmissions take place. However, the grey literature showed the usefulness of co-production of knowledge when it comes to participate in traditional smoking (Asp & Ståhl, 2019; Buljo et al., 2018; Harnesk & Brandon-Cox, 2014; Riddervold, 2002; Smuk, 2003). In this grey literature, scientist participated in the traditional smoking of reindeer meat through analytical workshops and collaboration fieldwork (Table 3). These are co-production methods that future research on traditional food systems should consider. Further recommendations to follow for sustainable research are four general principles for co-production: (1) situate the process within the context in which they are embedded, (2) recognise multiple knowledges, (3) develop shared goals, and (4) meet frequently, as proposed by Norström et al. (2020).

The knowledge of sustainable food systems and traditional food security in Sápmi is likely a key to developing future systems of food security and sovereignty among the Sámi and other peoples in the North (Nilsson, 2018). In a scientific article reviewed, it is argued that local processing might be the key to economically sustaining reindeer husbandry, if, for example, traditional smoked reindeer meat can be utilised as a new gourmet food for the EU market (Heikkinen, 2006). Additionally, the grey literature Petrini (2006) wrote that smoked reindeer meat can sell for 8 to 13 times more than a live animal. But Sámi food activism, which focuses on smoked reindeer meat, achieves limited self-determination (Green, 2018a). Therefore, if indeed a high economic value exists for smoked reindeer meat, we need more

knowledge on how to achieve Sámi self-determination and food sovereignty. Only in that way, taking advantage of traditionally high valued products might help sustain reindeer husbandry.

Nevertheless, that many disciplines study smoked or smoking reindeer meat (Fig. 3) prove that reindeer husbandry is not merely an economic enterprise. Its practices are rooted in historic and cultural values, regulated by law and management, handed down through generations within families and education, dependent on geography and the environment, and disseminated through travelling, grey literature, and scientific articles. Indeed, just as the nature of traditional knowledge is multidisciplinary (Berkes, 1999; Pierotti & Wildcat, 2000), so is that of reindeer husbandry. However, science often works within unconnected disciplines. For example, none of the studies reviewed here are multidisciplinary across the natural and social sciences (Fig. 3).

Sustainable research should include pluralistic co-production bringing together scientist from different disciplines and people from other sectors (Norström et al., 2020). Huntington (2000) suggests that ecologists could engage with social scientists in conducting research that documents traditional knowledge because the methods for collecting that knowledge derive from the social sciences (Huntington, 2000). Likewise, we suggest that scientists within health and chemistry could benefit by involving social scientists in their studies of smoked reindeer meat. At the same time, chemical analyses could provide important information if applied to practices in use. Social science ethnographic studies, long-time observations, interviews, or conversations could reveal what practices actually remain in use. The health sciences often use different methods, seeking to combine practical and evidence-based multidisciplinary knowledge (Bondevik & Engebretsen, 2017). We therefore suggest that the unique position of the health sciences situated between the natural and social sciences (as illustrated in Fig. 3) could act as a multidisciplinary bridge to achieve complementary knowledge systems.

Conclusion

Dividing the literature on smoked or smoking reindeer meat into three focus levels reveals a huge knowledge gap on this subject. Our four-level categorisation of including traditional knowledge, non-participation, consultation, co-production, and self-determination showed the following:

First, this categorisation showed that traditional knowledge is almost never included in scientific papers on smoked and smoking reindeer meat. This is because non-participation methods, such as chemical analyses of the meat, are commonly used. Metaphorically speaking, the traditional knowledge “went up in smoke.” Neglecting or ignoring this important knowledge has led to misleading conclusions, which could have been prevented had traditional knowledge been included. To avoid erroneous conclusions and the conflicts that follow, we recommend that scientific research includes traditional knowledge in all future studies that could and should consider traditional practices and products.

Second, traditional knowledge is sometimes included only through consultation, in social science methods of interviewing and observing. Even though none of the social science studies we reviewed specifically focuses on smoked meat, together they reveal a diverse range of traditional smoking practices among reindeer herders. We argue that reindeer herders’ traditional knowledge and practices of reindeer meat smoking are indeed a complex knowledge system. However, as discussed, today’s reindeer management leaves little room for this complex traditional

knowledge. Yet in line with other scholars, we claim that traditional knowledge comprises important knowledge of traditional practices that could be used to create valid hypotheses. Scientific methods, on the other hand, could be used to study, for example, “why” these traditional practices are sustainable or not, “why” they are healthy or not, and “why” they vary geographically. By including both traditional and scientific knowledge, science could take advantages of their relative strength and promote effective management of reindeer husbandry, including its food system, in a changing Arctic.

Third, smoked or smoking reindeer meat is studied within many different disciplines, mainly the health and food sciences. Yet, no multidisciplinary studies across the natural and social sciences exist, and no study uses co-production methods. In line with other scholars, we argue that multidisciplinary co-production could meet the need for developing methodologies that link different knowledge systems. This includes co-production not only between scientific and traditional knowledge holders but also between the natural and social sciences and the humanities, taking advantages of their respective methods.

Last, this review revealed that further research is needed in order to understand the prevalence and significance of traditional knowledge and practices of meat smoking. In addition, scientific experiments on smoking temperatures and PAH analysis of traditional smoked meat should be conducted. We argue that co-production will result in greater understanding of different knowledge systems, ensure healthy traditional food products that act as an adaptation strategy for changes, and—rather than allowing traditional knowledge to continue to *go up in smoke*—will sustain the knowledgeable and rich Sámi practice of reindeer husbandry.

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