



# Protocol for risk assessment of grilled and barbequed food

**from the Panel on Contaminants of the Norwegian Scientific Committee for Food and Environment**

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## **Title**

Protocol for risk assessment of grilled and barbequed food/Risikovurdering av grillet mat

## **Preparation of the protocol**

The Norwegian Scientific Committee for Food and Environment (Vitenskapskomiteen for mat og miljø, VKM) appointed a project group to draft the protocol. The project group consisted of VKM members and VKM staff. The Panel on Contaminants assessed and approved the final protocol.

## **Authors of the protocol**

The authors have contributed to the protocol in a way that fulfils the authorship principles of VKM (VKM, 2019). The principles reflect the collaborative nature of the work, and the authors have contributed as members of the project group and/or the VKM Panel on Contaminants, appointed specifically for the assignment.

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## **Competence of VKM experts**

Persons working for VKM, either as appointed members of the Committee or as external experts, do this by virtue of their scientific expertise, not as representatives for their employers or third-party interests. The Civil Services Act instructions on legal competence apply for all work prepared by VKM.

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# Abbreviations and glossary

## Abbreviations

HAA	Heterocyclic aromatic amines
PAH	Polycyclic aromatic hydrocarbons
PC	Process contaminants
TDI	Tolerable daily intake
TWI	Tolerable weekly intake
TOR	Terms of reference
MOE	Margin of exposure
PICO	Population (patient group), Intervention (the treatment or diagnostic test under investigation), Control (comparison group) and Outcome (variable to be measured).
PEO	Population, Exposure and Outcome
HBGV	Health based guidance values

## Glossary

Barbequing	See grilling
Grilling	The term grilling in Norwegian language encompasses both barbequing and grilling. Both, barbequing and grilling, are denoted grilling in this report. While barbequing is known as a low and slow, indirect heat cooking method, grilling involves high temperature and direct heat. In barbequing the lid is kept closed during cooking allowing a convection process to cook the food, while grilling is without a lid. When barbequing, there is little need to flip the food to prevent burning, while frequent flipping is necessary when grilling.
Process contaminants	Process contaminants are substances that form in food or in food ingredients when they undergo chemical changes during processing
Fried food	In this report fried food includes food prepared with cooking methods involving high temperatures, that are not defined as grilling (grilling and barbequing).
Umbrella review	Systematic reviews of previous systematic reviews.

# 1. Introduction

## 1.1 Background

With the term grilling we include all types of food preparations using grilling devices, commonly used outdoors in Norway, and it includes the term barbeque. Preparation of food using high temperature, such as grilling (grilling and barbequing, from here on denoted grilling), may induce formation of potentially harmful contaminants, heat-induced process contaminants. Examples are polycyclic aromatic hydrocarbons (PAH), heterocyclic aromatic amines (HAA) and acrylamide (AA). Exposure to these compounds may occur through consumption of grilled food. Food can be contaminated with PAH during grilling when fumes form during incomplete combustion of fat dripping on the heat source and stick to the food. HAA is formed in meat and fish both during frying and grilling, while AA occurs in heat-treated carbohydrate-rich food. Several of these substances are both genotoxic and carcinogenic and therefore constitute the greatest health risk compared to non-carcinogenic substances formed during heat treatment.

In a former report from VKM in 2007, it was concluded that there was a lack of knowledge about consumption and composition of grilled food in addition to the concentrations of PAH and HAA as well as other carcinogenic substances in grilled food. These are heat-induced process contaminants, such as oxy-PAHs, nitro-PAHs and nitrosamines that may be formed during grilling. Over the past years consumer habits have changed and a wider range of foods are prepared by grilling. This may lead to changes in composition of process contaminants in grilled food. The grilling methods may also have changed the recent years. The formation of process contaminants may depend on type of grill (charcoal, gas, electricity, campfire), temperature (high or low temperature), cooking time, type of food (fat, protein rich, carbohydrate rich) and types of fuel (charcoal briquettes, charcoal lumps, wood or gas).

The Norwegian Food Safety Authority (NFSA) has asked VKM to compile the recent knowledge on process contaminants formed by different grilling (grilling and barbeque) methods and assess their potential health risks.

## 1.2 Terms of Reference (TOR) from the Norwegian Food Safety Authority

1. TOR 1: Identify process contaminants that are formed to a greater extent by grilling compared with frying and give an overview of reported amount of these substances in different types of grilled food.
2. TOR 2: Highlight conditions (for example grilling devices and methods, and type of food) that are relevant for the formation of the identified food processing substances by grilling.
3. TOR 3: If possible, from available information, evaluate health risks related to consumption of grilled food compared with fried food.

### **1.3 Scope and delimitations to the assessment**

The scope of this project is to provide an overview of process contaminants formed by grilling of food. Furthermore, the assessment will provide an overview of concentrations of process contaminant levels in grilled food and describe factors affecting formation of process contaminants. This will be used to evaluate health risks related to consumption of grilled food compared with similar food that is heat-treated by e.g., frying.

The assessment is delimited to grilled food and the process contaminants formed by grilling of foods like meat, fish, vegetables and other food likely to be grilled in Norway.

When grilling we may use different heat sources like charcoal, wood, gas, bonfire or electricity may be used. In this project we also include grilling devices that intentionally generate smoke (not smoking *per se*) to give flavour to the food, and more traditional grilling devices with and without a lid.

The assessment does not include undesirable substances from incorrect use of food contact materials and incorrect use of the combustion source. The assessment includes oral exposure and excludes inhalation exposure. In the evaluation of potential health risks only human studies will be considered.

### **1.4 From terms of reference to sub-questions**

The overall aim in this project is to identify the compounds formed in grilled foods and assess any impact on health related to eating grilled food. The assessment will be made for the Norwegian population.

For this project we will identify heat-induced process contaminants, the concentrations in which they occur and the factors that determines their concentrations in grilled food by the use of published literature. For hazard characterization existing Health based guidance values (e.g., TDIs) will be used, and if not found it will be identified as knowledge gaps.

The exposure will be estimated through scenarios covering different preferences for types of grilled food and use of different grilling methods and devices.

The risk will be characterized by comparing these exposure scenarios with available health-based guidance values (TDIs/TWIs/BMDL etc.). New knowledge on the consumption of grilled food and health outcomes in humans compared to consumption of fried food will be collected by an umbrella review, i.e., a systematic review of previous systematic reviews.

Main questions to be addressed to answer the terms of reference are divided into the following questions.

The questions a-d) aims to identify and quantify the process contaminants from grilling and will be used for exposure assessment. The question e) aims to identify health effects of eating grilled food compared with eating fried food and will be approached by a systematic literature search on the relation between health and consumption of grilled foods. Questions f) and g) will be approached by risk characterization of the process contaminants identified in b).

Table 1: Interpretation of terms of reference into sub-questions to be targeted in this assessment

Terms of reference		Questions
<b>1</b>	Identify process contaminants that are formed to a greater extent by grilling compared to frying and give an overview of reported amount of these substances in different types of grilled food.	<ul style="list-style-type: none"> <li>a. Which process contaminants are formed by grilling?</li> <li>b. Which process contaminants are found in higher concentrations in grilled than in fried food?</li> <li>c. In what concentrations do we find the process contaminants identified in b) in grilled food?</li> </ul>
<b>2</b>	Highlight conditions (for example grilling devices and methods, and type of food) that are relevant for the formation of the identified food processing substances by grilling.	<ul style="list-style-type: none"> <li>d. Which factors alter the formation of process contaminants identified in b)?                             <ul style="list-style-type: none"> <li>i. the grill itself (e.g., lid)</li> <li>ii. the food itself</li> <li>iii. preparation (e.g., doneness and cooking time, marination)</li> <li>iv. temperature (e.g., heat source)</li> </ul> </li> </ul>
<b>3</b>	If possible, from available information, evaluate health risks related to consumption of grilled food compared with fried food	<ul style="list-style-type: none"> <li>e) Is there new knowledge on health risk related to consumption of grilled food and health (compared with fried food)?</li> <li>f) What are the HBGVs for the process contaminants identified in b)?</li> <li>g) What is the exposure to process contaminants from grilled food in relation to established health-based guidance values or similar?</li> </ul>

## 2. Methods for the assessment

VKM published an extensive report on grilled food in 2007 and most relevant information before 2006 are expected to be covered in that report. We will therefore primarily do searches on literature published in the period from 2006 to today. Two different search strategies will be performed.

A non-systematic literature search will be used to answer research questions a-d (Table 1).

Information from the literature search will be included in the assessment based on expert judgement.

An umbrella review (a systematic review over systematic reviews) using a defined systematic literature search process to answer research question e) in Table 1.

EFSA, JECFA and WHO or other trusted authorities will be used as sources for health-based guidance values needed for questions f) and g) in Table 1.

## **2.1 Non-systematic literature search: process contaminants from grilled food**

The first step covers the questions a), b) and c), to identify process contaminants in grilled food and give an overview of these substances in different types of grilled food. The second step is to highlight conditions related to the formation of process contaminants, e.g., factors related to the grill, the food and the temperature.

The data on contaminants and formation will be collected from previous risk assessments from recognized national and international organizations e.g., VKM and EFSA, and from published reviews from scientific journals. The literature search(es) will be performed by the project group on at least two of the major recognized search engines for scientific literature, such as Medline (OVID), Scopus (Elsevier) and Web of Science. Some reports may only be available in the grey literature, so additional searches will be performed in Google Scholar. Types of publications will include risk assessments, book chapters, monographs, original scientific publications, review publications (systematic or non-systematic) in the English, German and Scandinavian languages

Occurrence data of process contaminants in grilled food, and the factors that alter the formation will be presented in the final report. The type and amount of process contaminants in food will be compiled from data from Norway (data from e.g. The Norwegian food safety authority) and EU (e.g., EFSA Open food tox) and will be summarised in tables and figures.

## **2.2 Systematic literature search: health effects of consumption of grilled food**

The systematic literature review may give insight on what we know about the relation between consumption of grilled food and health. VKM performed a risk assessment of grilled food in 2007 indicating small to moderate increased risk of cancer after high consumption of well-done fried and grilled meat.

For this report, a systematic literature search of systematic reviews, covering the period from 2006 until the search date, will be performed. This umbrella review will be based on systematic reviews on the relation between intake of grilled food and health. The plan for the search, inclusion, exclusion criteria and assessment of risk of bias is outlined in figure 1. An experienced research librarian will perform the literature searches in cooperation with the project group. The search result will be screened based on predefined inclusion and exclusion criteria (Table 2) by the members of the project group.

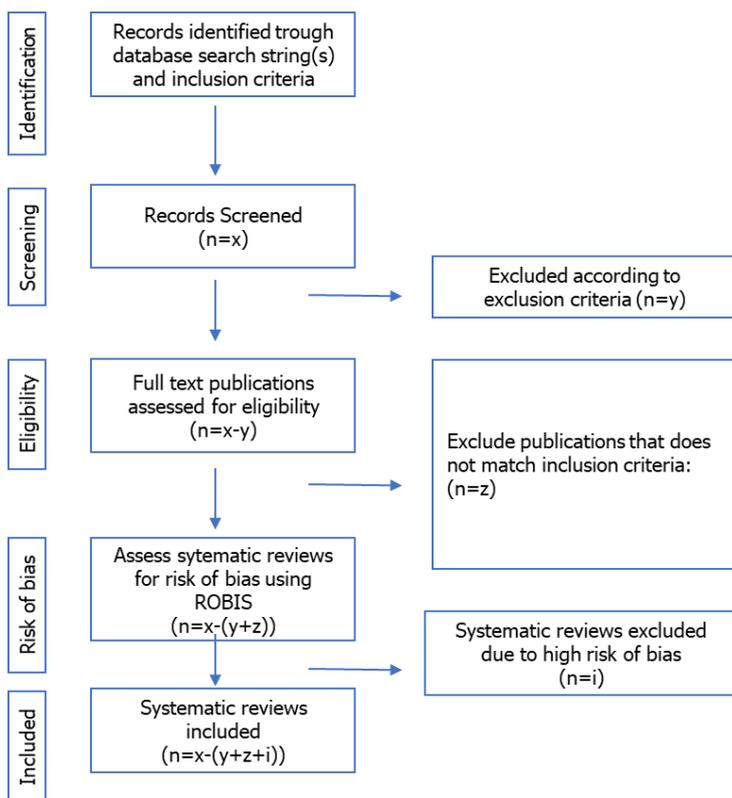


Figure 1 Flowchart systematic literature search and how we will include and exclude the results from the search string(s)

If no or few results on systematic reviews are found – this is a finding and a checkpoint. In dialogue with the Norwegian Food Safety Authority and VKM we will decide if we stop here and recognize this as a knowledge gap or proceed with a review on original research. If the Norwegian Food Safety Authority requires a systematic review on original literature this should be sent as a new request so that VKM may allocate the necessary resources.

### 2.2.1 The search process

The search will be formed by using a PEO approach, which is derived from PICO (Participants, Interventions, Comparisons and Outcomes) (Higgins et al. 2013) We use Exposure (not intervention) as we expect find publications on consumption of grilled food from observations studies, not clinical or randomized controlled studies (Morgan et al., 2018). Inclusion and exclusion criteria listed in 2.2.2 and 2.2.3 will be used when the records are screened using the Rayyan software. The literature search will be performed on the databases recommended by the experienced librarian in dialogue with the project group.

### 2.2.2 Inclusion and exclusion criteria

Table 2 Inclusion and exclusion criteria for the systematic literature search on systematic reviews on consumption of grilled food and health

	Inclusion	Exclusion
Population	Humans, all age groups, males and females	Animal studies, in vitro studies
Exposure	Oral intake of grilled food e.g., fish, meat, cheese, vegetarian/vegan products, vegetables and fruits. Food prepared on grilling devices, mainly outdoors. The assessment includes oral exposure.	Food that are boiled, steamed or raw. Do not include studies on compounds alone but include studies with compounds as they occur in grilled food. Do not include undesirable substances from incorrect use of food contact materials and incorrect use of the combustion source. The assessment excludes inhalation exposure.
Outcomes	Any adverse health outcomes, health effect related to intake of grilled food	Health effects that are not considered adverse
Design	Systematic reviews 2006 until today	All papers that are not systematic reviews
Language	English, Norwegian, Swedish, Danish and German	All other languages

### 2.2.3 Assessing bias in systematic reviews

The full text systematic reviews assessed for eligibility will be further assessed for the risk of bias using ROBIS (see links below). Two members of the project group will independently assess the quality of each of the included systematic reviews. Any disagreements will be resolved through discussion or contact with another researcher in the project group.

About ROBIS: <https://www.bristol.ac.uk/population-health-sciences/projects/robis/robis-tool/>

The ROBIS tool is found here: <https://www.bristol.ac.uk/media-library/sites/social-community-medicine/robis/ROBIS%201.2%20Clean.pdf>

### 2.2.4 Confidence in evidence

We plan on using a weight of evidence approach e.g., GRADE (Grading of Recommendations, Assessment, Development and Evaluations) or similar to rate the quality of evidence. GRADE is a transparent framework for developing and presenting summaries of evidence and provides a systematic approach for making clinical practice recommendations, that has been applied for environmental and occupational health (Morgan et al., 2016).

GRADE has four levels of evidence – also known as certainty in evidence or quality of evidence: very low, low, moderate, and high. Evidence from randomized controlled trials starts at high quality and, because of residual confounding, evidence that includes observational data starts at low quality. A very low rating

indicates that the true effect is probably markedly different from the estimated effect. A low rating indicates that the true effect might be markedly different from the estimated effect. A moderate rating indicates that the true effect is probably close to the estimated effect. And a high rating indicates a high degree of confidence that the true effect is similar to the estimated effect.

<https://bestpractice.bmj.com/info/toolkit/learn-ebm/what-is-grade/>

## **2.3 Identify health-based guidance values - HBGVs**

Sources like EFSA, JECFA, WHO, RIVM, BFR, google scholar, ANSES will be used as sources for health-based guidance values HBGVs needed for the process contaminants identified in research question b).

Research question b) is: Which process contaminants are found in higher concentrations in grilled than in fried food?

## **2.4 Exposure assessment**

The exposure assessment will be conducted using relevant scenarios, as we do not have adequate consumption data on grilled foods. The concentration data extracted from research questions a-c) and consumption (exposure) scenarios will be combined.

The consumption scenarios will be based on information on grilling habits, consumption data and expert opinion, to best reflect the consumption of grilled food by the Norwegian population. The Norwegian Food Safety Authority may provide information about surveillance data on sales figures of relevant food items and types of grills, and if available reports on consumer behavior.

The scenarios will be outlined for population groups based on age and gender, but also for consumption groups e.g., high/low intake of meat, fish, vegetables. As three factors, type of grill, type of food and temperature all influence the amount of process contaminants from grilling food, we will attempt to consider all three dimensions when we create the scenarios.

## **2.5 Risk characterization**

The risk characterization (for single compounds) will be based on exposure characterization of process contaminants from b) and relevant hazard characterizations from previous risk assessments by recognized authorities, such as EFSA, in which there may be established health-based guidance values, such as TDI and TWI. In addition, there may be reference values (e.g., BMDL) for specific adverse effects which enables estimation of margins of exposure (MOEs).

To answer the question on possible health risk related to consumption of grilled food, we will use the exposure assessment described in 2.4. The exposure to process contaminants in consumption scenarios will be compared to health-based guidance values or BMDLs to assess health risks.

Results from the systematic literature search may bring new insight on the risk characterization.

## 3. Uncertainties

VKM will describe the uncertainties in a narrative way.

## 4. References

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# Appendix

## Systematic literature search

Example. Literature search per 31.01.2023 in Medline. Similar searches are performed in Embase, Web of science, Cochrane Database of Systematic Reviews and Epistemonikos

**Search results 31.01.2023 in Ovid MEDLINE: n = 312**

1	Hot temperature/ or Maillard reaction/ or (((hot or high) adj temperature?) or "cooking method?" or "thermal process*" or "heat process*" or Maillard or glycation or "food browning?" or "browning reaction?" or doneness or "meat dripping?" or barbecu* or barbequ* or BBQ or grill* or bonfire or charcoal? or charred or (open adj (flame? or pit?)) or burn* or sear or searing or broil or broiling or fry or frying or fried or "air fryer" or airfryer or rotisserie).tw,kf.	340902
2	Amines/ or Heterocyclic compounds/ or Polycyclic Aromatic Hydrocarbons/ or exp Acrylamides/ or exp Furans/ or exp Nitrosamines/ or ("process* induced contaminant?" or "process* contaminant?" or "Polycyclic Aromatic Hydrocarbon?" or "polyaromatic hydrocarbon?" or PAH? or "Heterocyclic amine?" or "aminoheterocyclic compound?" or Acrylamide? or Furan? or furfuran? or Nitrosamine? or (("n nitrosoalkylamine" or nitrosamino) adj derivative?) or nitrosamide or nitrosamin or nitrosoamine or "Glycerol derived process contaminant?" or "cooking related mutagen?" or "mutagen index").tw,kf.	173072
3	1 or 2	507844
4	exp Fishes/ or Seafood/ or Shellfish/ or exp Meat/ or Cheese/ or Bread/ or exp Vegetables/ or Salads/ or Diet, Vegan/ or Diet, Vegetarian/ or Fruit/ or (food? or dish* or seafood or shellfish* or prawn? or shrimp? or scallop? or lobster? or crab? or crayfish* or fish* or cod or salmon or trout or mackerel or tuna or halibut or flounder or haddock or saithe or herring or sardine? or anchov* or fishproduct? or fishburger? or fishcake? or (fish adj (product? or burger? or cake?)) or meat? or pork? or veal or beef or lamb or mutton or chicken or turkey or poultry or venison or burger? or sausage? or hotdog? or "hot dog?" or cheese? or bread? or vegetable? or fruit? or jackfruit? or tofu or seitan or ((vegan or vegetarian or plantbased or "plant based" or beyond) adj (burger? or patty or patties or meat? or sausage? or hotdog? or "hot dog?" or product?))).tw,kf.	1386466
5	3 and 4	43860

6	limit 5 to "reviews (maximizes specificity)"	254
7	Meta-Analysis/ or Network Meta-Analysis/ or ((systematic* adj2 review*) or metaanal* or "meta anal*" or (review and ((structured or database* or systematic*) adj2 search*)) or "integrative review*" or (evidence adj2 review*)).tw,kf,bt.	487959
8	6 or (5 and 7)	345
9	limit 8 to (danish or english or german or interlingua or multilingual or norwegian or swedish)	342
10	limit 9 to yr="2006 -Current"	312