DANISH TECHNOLOGICAL INSTITUTE

Note

Overview of project results from 2021
Bacon fat – from biofuel to food

Louise Hofer

25 July 2022
Project No. 2009653
Version 1
Init. LHHR/mt

Background

This document provides an overview of the results obtained in the first year of the project, when relevant chemical compounds for investigation were identified, the business case was evaluated, and a sensory characterisation of rendered fat was conducted.

Relevant chemical compounds for investigation

The use of rendered bacon fat for frying or as an ingredient in food products can theoretically lead to an increase of unwanted chemical compounds, such as thermic mutagens, N-nitrosamines, and smoke mutagens in the diet.

To evaluate the chemical food safety of the rendered fat and the need for process adjustments along with a possible need for adding additional antioxidant to the bacon, it is of interest to investigate the content of these compounds in the rendered bacon fat.

In the following sections, a short description is given of the relevant compound along with the reason of why it is relevant.

Thermic mutagens

Thermic mutagens are a common name for a variety of heterocyclic aromatic amines (HCAs) some of which are mutagenic and carcinogenic. The compounds are formed at temperatures above 150°C. Natural or synthetic antioxidants can decrease the mutagenic activity and inhibit the formation of HCA. The cooking temperature is the most important parameter for the formation of HCA.

N-nitrosamines

N-nitrosamines, which are classified as carcinogenic, are formed as reaction products between nitric oxide and secondary amines in proteins. The nitrite added acts as a source of NOx, and the amount formed is related to the nitrite level added; a higher initial concentration leads to increased formation of nitrosamines. Meat products on the Danish market have a lower limited value of 60 ppm for the nitrite content compared to the remaining EU countries where the max value is 150 ppm.

Nitrite is in equilibrium with nitric acid, which is formed in small amounts in the slightly acidic meat. Nitric acid is readily soluble in lipophilic solvents and can therefore migrate into adipose tissue. This may explain why nitrosamines are preferentially formed in adipose tissue during frying, and it is one of the reasons why it is found relevant to investigate the content in the rendered bacon fat.

Smoke mutagens

Smoke mutagens are polycyclic aromatic hydrocarbon (PAH) compounds. PAHs are carcinogenic and mutagenic, which is why there is a general agreement on their contribution to cancer diseases among humans. They are on the top of the list, when speaking of dangerous chemical compounds in food items.

More than hundreds of individual PAHs exist that are formed and released by incomplete combustion or thermic decomposition (pyrolysis) of organic material. The EU recommends that member states analyse the content of 15 PAHs.

Rendered bacon fat has previously been analysed for PAH without finding a problematic level. However, it is still found relevant to include the analysis of these compounds in the project.

Reaction products from rancidity

Formation of reaction products due to rancidity has been investigated in fermented sausages with various additions of nitrite and ascorbate. Bacon is similar to the fermented products in that it is not heat-treated and has almost the same composition and addition of salt, nitrite, and ascorbate.

It is interesting to investigate the level of rancidity products, in the form of TBARS and PO levels, to uncover the significance in relation to off-flavour, and the need for the addition of additional antioxidants.

Nitrite/Nitrate

The content of nitrite and nitrate in the rendered fat should be analysed as it has an impact on the potential use of the fat and how it should be declared.

Business case

Background

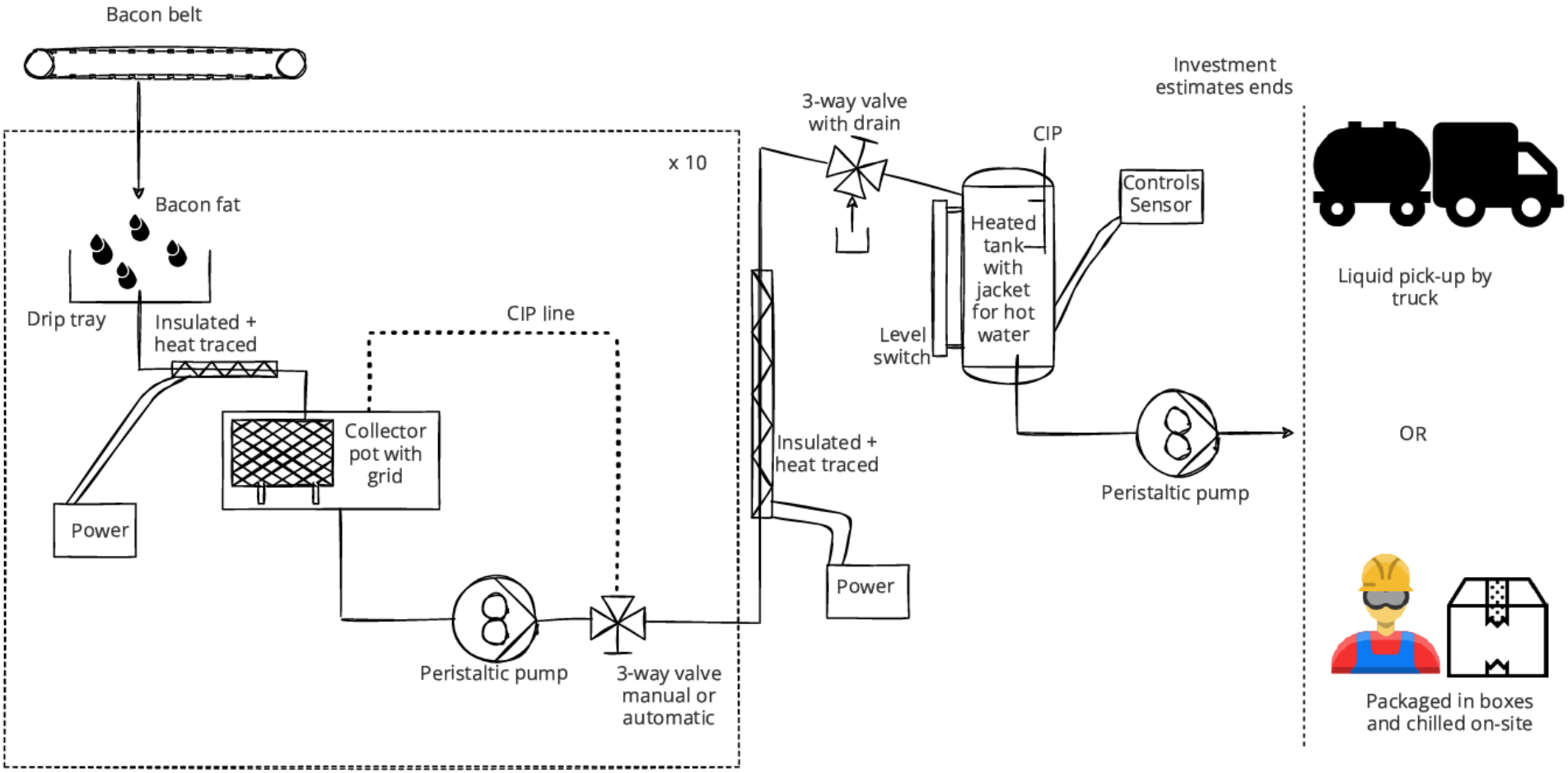
The business case was estimated based on the need of a company to invest in an automatic collection of rendered fat from individual cooking lines. The system considered will be executed in stainless steel, fully heated, and insulated with a pump selection that prevents blockage along with 1 central collection tank located outside the factory for liquid truck pickup.

The example given in this note is estimated based on a fat collection of 25 ton/week or 5 ton/day distributed evenly between 10 cooking lines. The system will be designed to contain 2 days of production (12 m^3 tank).

System design

A principle system design is displayed below and consists of:

- Drip tray for each cooking line
- Collection pot with replaceable mesh during operation (0.5 mm particle size)
- Peristaltic pump for each cooking line
- CIP lines and valves
- Insulated piping with electrical heating
- Central tank of 12 m^3, insulated, jacket for hot water heating, located outside
- Peristaltic pump for liquid transfer to truck pick-up


Bacon belt
x 10
Bacon fat
Drip tray
Insulated + heat traced
CIP line
Collector pot with grid
Power
Peristaltic pump
3-way valve manual or automatic
Insulated + heat traced
Power
3-way valve with drain
CIP
Controls Sensor
Heated tank with jacket for hot water
Level switch
Peristaltic pump
Investment estimates ends
Liquid pick-up by truck
OR
Packaged in boxes and chilled on-site

Investment cost estimate

Investment estimate				
	qty.	unit	unit price	cost
Stainless collection tray /w heating	10	pcs	DKK 15,000	DKK 150,000
Stainless collection pot(s) with coarse mesh/filter + heating	10	pcs	DKK 10,000	DKK 100,000
Peristaltic pump(s) in production	10	pcs	DKK 8,000	DKK 80,000
Stainless 2" insulated piping /w heat from trays to pots	21	m	DKK 1,000	DKK 21,000
Stainless 2" insulated piping /w heat from pump to central tank	172	m	DKK 1,000	DKK 172,000
Heating cable (10 W/m use 2 m cable per m pipe)	386	m	DKK 150	DKK 57,900
Electrical junctions and supplies for heating	10	pcs	DKK 5,000	DKK 50,000
Stainless fittings/elbows/bends	21	qty	DKK 1,000	DKK 21,000
Valves for CIP (3 way)	9	pcs	DKK 2,000	DKK 18,000
Stainless tank insulated /w CIP /w heating jacket (water) 12 m^3	1	pcs	DKK 150,000	DKK 150,000
Peristaltic pump at central tank	1	pcs	DKK 200,000	DKK 200,000
Sensors, programming, and integration with factory software	1	pcs	DKK 50,000	DKK 50,000
Engineering and design	80	hours	DKK 1,000	DKK 80,000
Installation and welding/insulation/electric	400	hours	DKK 700	DKK 280,000
Contingencies (unforeseen extra works)	15	%		DKK 214,485
Total DKK				**DKK 1,644,385**
Total EUR				**€ 221,000**

The estimate displayed in the table represents the entire supply and installation of the equipment from a contractor supplying the complete project.

Operational cost estimate

Yearly operational cost estimate				
	qty.	unit	unit price	cost
Electrical power heating	20,628	kWh	DKK 0.80	DKK 16,503
Electrical power pumping	4,000	kWh	DKK 0.80	DKK 3,200
Cleaning water heating (natural gas 0.8 efficiency)	362,847	kWh	DKK 0.16	DKK 58,056
Cleaning water	5,000	m^3		
Cleaning manpower 2h/day	500	hour	DKK 500	DKK 250,000
Maintenance materials	24,000	DKK	DKK 1	DKK 24,000
Maintenance manpower 5h/month	60	hour	DKK 500	DKK 30,000
Tank heating water circuit (natural gas 0.8 efficiency)	6,738	kWh	DKK 0.16	DKK 1,078
Total DKK				DKK 383,000
Total EUR				€ 51,000

Return on Investment

It is currently possible to sell the bacon fat for biofuel production for 0.36 EUR/kg, and it is expected that if the bacon fat is sold for human consumption in the future, it will be possible to achieve a sales price of approx. 0.60 EUR/kg. The calculation below is obtained by absorbing the entire investment during year 1 along with the regular operational costs. The subsequent years are based on sales of 1140 ton fat at two different prices.

	Biofuel	Human consumption
Fat price EUR/kg	0.36 EUR/kg	0.60 EUR/kg
Return on investment	0.66 year	0.40 year
Business case:		
Result		
Year 1 (investment)	EUR 138,000	EUR 412,000
Year 2	EUR 359,000	EUR 633,000
Year 3	EUR 359,000	EUR 633,000

The calculation shows substantial business potential with a return on investment of less than 1 year for both sales prices and a subsequent yearly potential of between 359,000 and 633,000 EUR after subtraction of operations costs.

Sensory characterisation

Method

A sensory profile analysis was performed by a professional panel according to DMRI analysis instruction SM 305, based on ASTM-MNL 13:1992, ISO 4121:2003 and ISO 13299:2016. The method was performed according to ISO 17025:2017. The sensory evaluations on bacon fat were conducted on 26th November 2021.

The panel used a 15 cm unstructured line scale to evaluate the intensity of each attribute, and all samples were evaluated with three replicates.

This sensory analysis was not performed accredited as the panel consisted of seven trained panellists, and the standard states that eight panellists are required. The panel was well trained and had years of experience with performing sensory analysis on meat products, therefore the data is valid and can be used for analysis.

Samples

Rendered fat from both sliced bacon and cubed bacon was collected as well as fat from different cooking lines both with identical and different frying conditions.

Results

The results showed that overall variation in the rendered fat is to be expected. Both the bacon type (cubes or slices) and the different cooking lines (both with identical and different frying conditions) resulted in different sensory profiles.

The level of bitter taste and off flavour in the samples was in general low. Smoke and salt taste was not found to variate in the samples, whereas a difference was found between “fresh bacon odour”, “fried bacon odour”, “raw bacon flavour” and “fried bacon flavour” for the different cooking lines and bacon types. The intensity of the sample’s aftertaste was in general found to be high but with no difference between the samples.