Think Tank on Prevention
of Food Loss and Food Waste

ONE\THIRD

UPCYCLING SIDE-STREAMS IN THE DANISH FOOD INDUSTRY – INSPIRATION CATALOGUE

Produced by
koststudio
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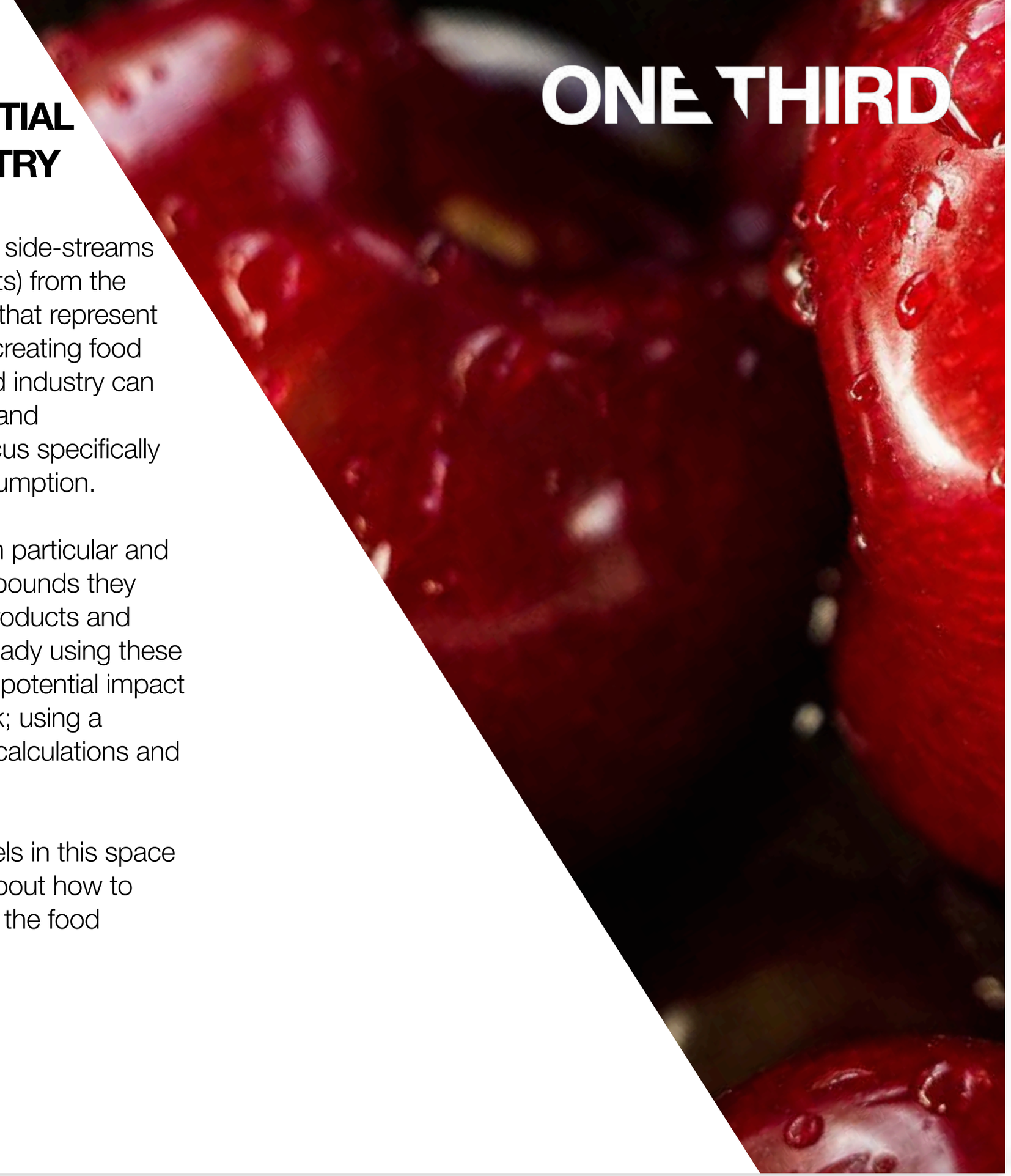
CONTENT

SIDE-STREAMS WITH POTENTIAL IN THE DANISH FOOD INDUSTRY

This project sets out to identify high volume side-streams (also known as waste streams or byproducts) from the Danish food industry and production stage that represent high potential for upcycling into new value-creating food products. Whilst side-streams from the food industry can also be upcycled into materials, cosmetics and pharmaceutical products, this report will focus specifically on upcycling into products for human consumption.

We have focused on 13 key side-streams in particular and provide information on which valuable compounds they contain, the potential for use in new food products and examples of successful business cases already using these side- streams. We have also calculated the potential impact of upcycling these side-streams in Denmark; using a mixture of nutritional values, environmental calculations and economic forecasts.

Finally, we show examples of different models in this space which are providing new ways of thinking about how to upcycle food and keep as much nutrition in the food system as possible available to humans.



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IF FOOD WASTE WAS A COUNTRY, IT WOULD BE THE

WORLD'S 3RD LARGEST EMITTER OF CO_2 BEHIND CHINA AND THE USA

(WRI Indonesia, 2018)

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REDUCING FOOD WASTE BY HALF BY 2030 IN LINE WITH SDG 12.3 IS

ESSENTIAL TO KEEP THE GLOBAL FOOD SYSTEM OPERATING

WITHIN PLANETARY BOUNDARIES

(EAT, 2019)

FOOD WASTE AND SIDE-STREAMS – A WASTE OF VALUABLE RESOURCES

The European Union defines food waste as discarded food and its associated inedible parts, such as bones or fruit cores. (1)

Statistics around food waste are staggering today. Every year, approximately 1.3 billion tonnes of food—one-third of all food produced for human consumption—is lost or wasted worldwide, whilst over 42 million people can't afford a proper meal every other day. (2) This food waste and waste accounts for around 8–10% of total human-caused GHG emissions. (3) Denmark alone produces around 1.2 million tonnes of food waste annually. (4)

This report focuses on food waste from the food processing and manufacturing stage of the value chain, which produces 19% of food wasted in the EU. (5) These waste streams are also known as by-products or side-streams, which are defined as:

"co- or by-products that are potentially edible, but presently not sold as final products on the market due to low demand and...the presence of critical substances such as biological and chemical contaminants, as well as a lack of knowledge regarding their technological processing. These side-streams, if not properly managed, can pose significant challenges in terms of waste disposal, environmental impact, and resource inefficiency." (6)

By reinventing side-streams into resources, upcycling can provide a solution to major food and sustainability issues.

WHAT IS UPCYCLING?

Upcycling combines the concepts of ‘upgrading’ (adding value) and ‘recycling’ (reusing) (7) into a practice of rethinking waste by converting it into something valuable without destroying and reinventing the material. (8)

Applying a circular concept to the food system, upcycled foods are made from ingredients that would not otherwise have been used for human consumption, but might have been sent to landfill, for biogas production or to feed animals. (9)

Innovative solutions such as turning surplus bread into pasta and vodka, making potato peels into breadcrumbs, and even incorporating chicken bones into chicken burgers demonstrate the limitless potential for reimagining side-streams into new food products. (10)(11) (12) (13)

WHY UPCYCLE?

People
Resource efficiency and rethinking waste is vital for a sustainable future and feeding a growing population. When waste is sent to landfill, or even to biogas or animal feed, valuable nutrients are lost that could otherwise remain in the food system for human consumption. By upcycling as much food loss and waste as possible into human food products, we keep as many nutrients in the food system as possible, helping us feed a population of 10 billion people by 2050. (14)

IMAGE SOURCE: WRAP, 2016 (17)

Planet
Upcycling food can create environmental benefits: lowering emissions and pollution by reducing waste sent to landfill; reducing consumption of natural resources and raw materials; and recovering protein that can help reduce reliance on more environmentally-taxing animal protein sources. (15)

Opportunity
Food side-streams are typically discarded, but often highly nutritious and remain vastly underutilised with high business potential. Upcycling can bring economic advantages, transforming existing food into new value-adding products whilst saving money on disposal costs.

The market for upcycled food is growing fast and is estimated to reach $97b by 2031.(16)

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CHALLENGES WITH UPCYCLING

While upcycling food offers a promising solution to reducing food loss and waste, several challenges must be addressed to make upcycling scalable and sustainable:

Novel food classification
If a side-stream does not have a significant history of consumption within the EU before May 1997, it is considered a novel food and may require safety testing and approval before it can enter the market for human consumption. (18)

Waste classification
Byproducts can either be legally considered as waste or approved for human consumption according to the EU's byproduct legislation, which can complicate their classification and use in human food products. (19) (20) (21)

Close collaboration
Upcycling requires close collaboration in the food value chain between producers to keep side-streams food grade.

Consistency of supply
Availability of side-streams can fluctuate based on production and demand, and manufacturers may need to adapt recipes to the varying supply of upcycled materials.

Costs
The cost to extract and process these materials can be significant, potentially offsetting some of the economic benefits of upcycling.

Consumer perception
Consumers may find terminology referring to waste or side-streams off-putting when buying upcycled products.

RESEARCH PROCESS: RELIABLE DATA IN THIS AREA IS A CHALLENGE

Gathering reliable data on data on food waste and side-streams from food production that could potentially be upcycled into human food is a significant challenge.

There is a considerable lack of reliable data around food waste, as official figures often do not include material currently sent to animal feed or biogas, (even if it could potentially be used for human food) and many companies don't want to speak openly about producing waste.

We have therefore gathered and triangulated data from a combination of official, industry and academic sources alongside detailed online research, and made qualified estimates to the best of our ability from this information.

In addition to figures from the Food and Agriculture Organization (FAO) and Statistics Denmark, we relied upon data from Professor Jørgen Dejgård Jensen at Copenhagen University's Department of Food and Resource Economics. Professor Jensen has been researching this field extensively and uses a mass balance method to estimate the likely volumes of side-streams by analysing the difference between raw material input and production output in the Danish food industry. (22)

Calculating the potential environmental and economic impact of upcycling individual side-streams is also a challenge, as these forecasts may depend on other variables such as alternative methods of disposal, extraction methods and the environmental footprint of the potential new upcycled product. We have therefore used Chat GPT to give a sense of the potential economic value of upcycling side-streams but acknowledge that accuracy of these claims may be variable. There can also be differences in volume and nutritional content between the dry and wet matter of side-streams that we have done our best to account for.

With so many variables at play, we acknowledge that there may be other ways to calculate these figures, and this report is produced with full transparency in terms of methods, numbers and estimations. We hope for others to build on (and potentially even correct) this data with access to increased knowledge and information; however, we hope that this report provides a general idea of the volumes and opportunities available for food upcycling in Denmark.

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HIGH OPPORTUNITY SIDE-STREAMS IN THE DANISH FOOD INDUSTRY

TOP 13 HIGH OPPORTUNITY DANISH SIDE-STREAMS

This inspiration catalogue has identified 13 side-streams from Danish production which have great potential but are today being overlooked.

These side-streams were identified as generally high volume and high potential value:

- Oilseed Press Cake
- Brewer's Spent Grain (BSG)
- Potato
- Sugarbeet
- Fruit and Vegetables: Apple/Pear
- Grains: Wheat Bran
- Animal Byproducts (ABPs)
- Fish and Seafood
- Eggshells
- Dairy
- Spent Coffee Grounds (SCG)
- Bread
- Wastewater

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UPCYCLING RAPESEED OIL PRESS CAKE IN DENMARK COULD PROVIDE

ENOUGH PROTEIN TO FEED THE ADULT POPULATION FOR ALMOST 2.5 YEARS

(23)

OILSEED PRESS CAKE: RAPESEED

A side-stream from the production of oil, what's known as 'press cake' potentially represents 'the biggest protein source in Europe' and is usually all sent to animal feed. (24) Oilseed proteins are considered a valuable alternative to animal proteins, and Denmark produces a large amount, mainly from rapeseed oil production. (25)

Estimated volume per year in DK:
533,500 tonnes (26)
Valuable compounds:
Protein (30-45%) (27), fibre (30%) (28)

With around 2 kilograms of press cake produced for every kilogram of oil, this is a huge volume of protein and fibre which could be upcycled. Rapeseed oil press cake is currently not certified for human consumption in the EU, but legislation is currently being considered to approve this under the Novel Food Act. (29)

Upcycling just rapeseed oil press cake could provide enough protein to feed 8-13 million adults for a year or meet the fibre needs of approximately 14.5 million people. (30)

30-45%

protein in rapeseed oil press cake, which is higher than the protein content of chicken (31) (32)

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THE CO_2 EMISSIONS FROM DANISH RAPESEED OIL PRESS CAKE WOULD BE EQUIVALENT TO

OVER 4M ✈ FLIGHTS FROM CPH TO PARIS EVERY YEAR*

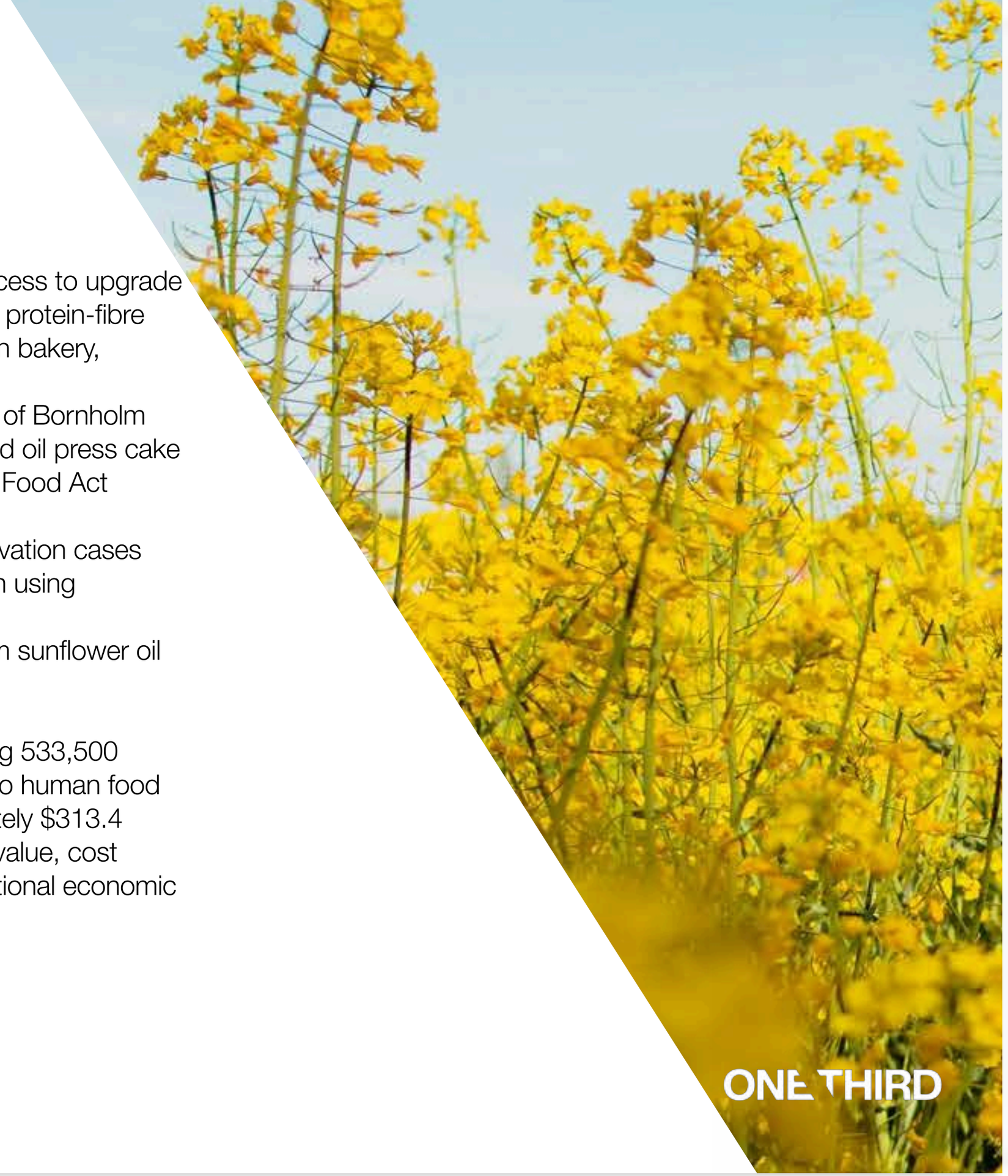
(33)

*based on CO_2 emissions per kg from Norwegian press cake

INSPIRATIONAL CASES

- NapiFeryn Biotech in Poland have a process to upgrade rapeseed oil press cake into protein and protein-fibre powders as functional food ingredients in bakery, patisserie and meat substitutes
- Lehnsgaard Oil Mill on the Danish island of Bornholm are prepared to start using their rapeseed oil press cake for human consumption once the Novel Food Act permission is granted
- Copenhagen University has several innovation cases that are getting closer to potential launch using rapeseed oil press cake
- Planetarians in the USA made chips from sunflower oil press cake

The estimated economic impact of upcycling 533,500 metric tonnes of rapeseed oil press cake into human food products annually in Denmark is approximately $313.4 million USD. This estimate includes market value, cost savings from waste management, and additional economic contributions. (ChatGPT)



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UPCYCLING BREWER'S SPENT GRAIN EVERY YEAR IN DENMARK COULD PROVIDE

ENOUGH FIBRE FOR ALMOST 1.5X THE ENTIRE ADULT POPULATION (34)

BREWERS' SPENT GRAIN (BSG)

Brewer's Spent Grain is a side-stream (usually barley) from the brewing industry which contains up to 30% protein and 70% fibre. (35) (36) BSG has wide-ranging applications due to its nutritional profile, but is usually used as high-fibre and protein-rich animal feed.

Estimated volume per year in DK:
124,000 tonnes (37)
Valuable compounds:
Protein, Fibre, Bioactive Ingredients, Minerals, Antioxidants

BSG can be upcycled into food products like baked goods, pasta, snacks, functional foods and nutraceuticals, enhancing their fibre and protein content. (38)(39) BSG is being researched for biodegradable biomaterials and packaging, and its bioactive compounds, such as phenolics, have antioxidant and anti-inflammatory benefits. (40) (41)

The potential economic impact of upcycling 124,000 metric tonnes of BSG into human food products annually in Denmark is approximately $50.92 million USD. This estimate includes the market value of the upcycled products, cost savings from waste management, and additional economic contributions. (ChatGPT)

Upcycling Brewer's Spent Grain in Denmark could provide enough protein for over

2M adults

every year (42)

More than 19 companies and 125 products are already on the market containing upcycled BSG, and the demand for dried spent grain is predicted to be worth 24 billion USD by the end of 2033. (43) As a large volume side-stream with high fibre and protein content, BSG has high potential to help prevent food malnutrition globally.

INSPIRATIONAL CASES

- Agrain in DK and Upcycled Foods Inc. in USA turn BSG into nutritional flour
- TetraPak in Sweden have a process to turn BSG into a liquid ingredient for plant-based drinks
- Secontaste in Hungary use BSG to make granola
- Planetarians in USA make a meat alternative from spent yeast from the brewing industry and spent soyabeans

It is estimated that 20% of brewers' spent grain (BSG) in the EU ends up in landfill. (44)

Upcycling just 20% of the BSG in Denmark every year could save CO_2 emissions equivalent to running over

3000 

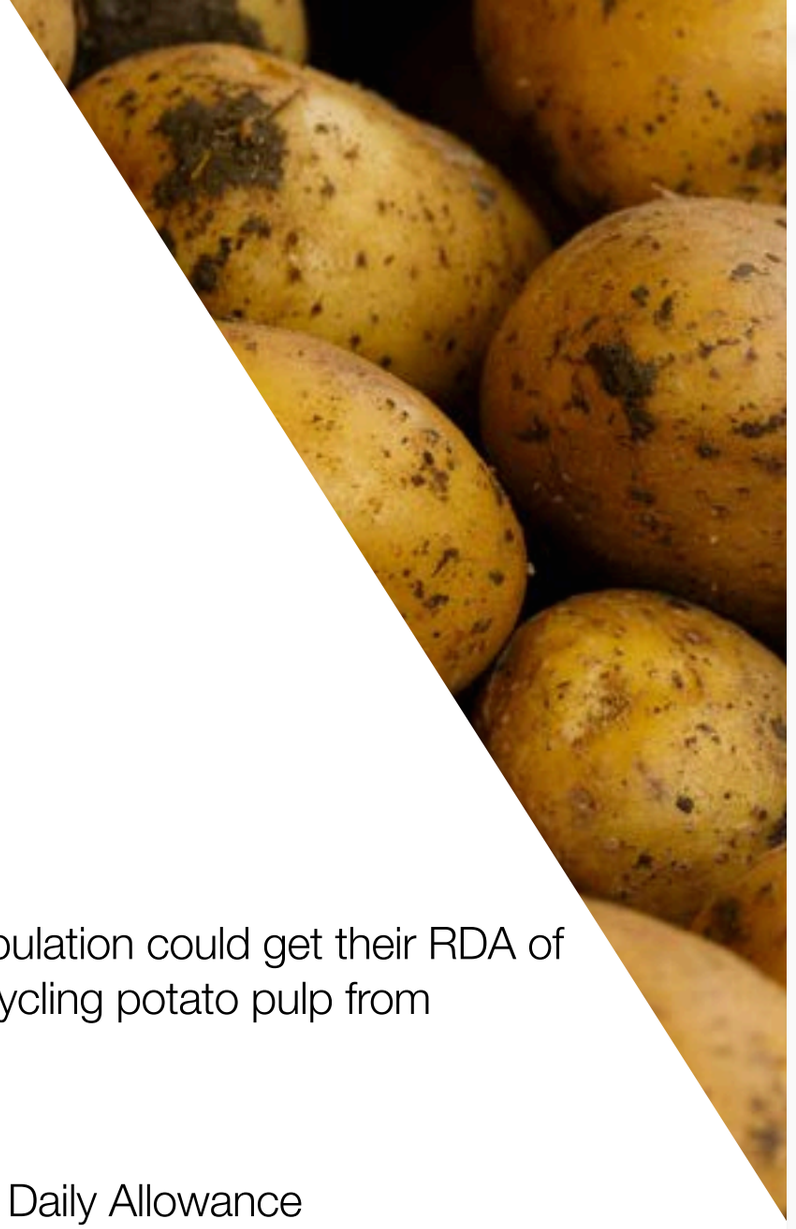
or consuming almost 30k barrels of oil (45)

POTATOES

The potato industry produces one of the highest volumes of side-streams in Denmark, along with sugar beet (46). The vast majority of Danish potatoes (75%-90%) are processed into starch (47).

Side-streams:
Peels, pulp
Estimated total volume per year in DK:
98-125,000 (only pulp from starch production) (48)
Valuable compounds:
Protein, Starch, Dietary Fibre, Pectin, Emulsifiers

Potato side-streams offer valuable benefits and versatile uses. Potato peels are rich in proteins, fibres and phenolic compounds, and can be used in food coatings and in creating biopolymer films and bioethanol. (49)(50) They also have potential health benefits, including anti-inflammatory, antioxidant, antibacterial, antiviral, antidiabetic and anticarcinogenic effects. (51) Potato pulp pectin has a superior emulsifying quality to that of commercial pectin and has applications in food as well as cosmetics and pharmaceuticals. (52)



Up to

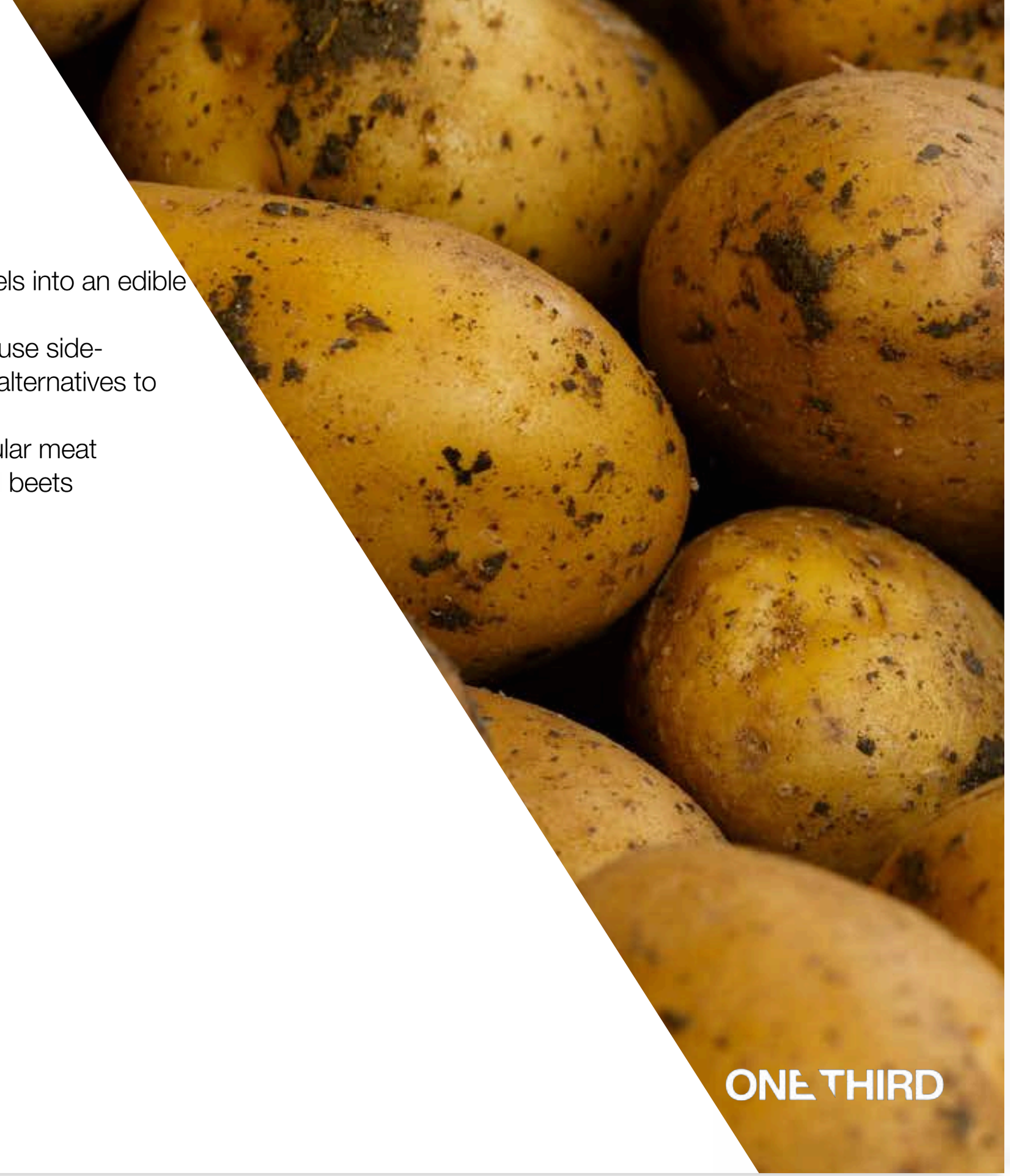
42%

of the Danish adult population could get their RDA of fibre every year by upcycling potato pulp from potato starch*
(53)

*RDA- Recommended Daily Allowance

INSPIRATIONAL CASES

- Sav Food in Belgium upcycle potato peels into an edible coating for food similar to breadcrumbs
- No Palm Ingredients in the Netherlands use side-streams such as potato peels to create alternatives to valuable oils and fats
- Matr Foods in Denmark produce a popular meat alternative from fermented potatoes and beets



SUGARBEET

Sugar beet production has one of the highest volume vegetable side-streams in Europe (54), which is mostly sent to animal feed. (55)

Side-streams:
Pulp, molasses, leaves, tops
Estimated volume per year in DK:
172-381,000 tonnes (56)
Valuable components:
Dietary Fibre, Pectin, Polyphenols

Sugar beet side-streams contain high levels of antioxidants and can offer prebiotic qualities, making them a valuable ingredient for functional foods, nutraceuticals, and fibre supplements which are naturally gluten-free. (57) (58)
Molasses can also be repurposed for producing sweeteners, alcohol, vinegar, and improving the properties of yoghurt. (59) (60) (61)

Up to

4X

the adult population of Denmark could get their RDA of fibre or almost 1.4m adults could get their protein for one year by upcycling sugar beet side-streams*

*excluding molasses. (62)

INSPIRATIONAL CASES

- Sasma in the Netherlands uses sugar beet molasses to make alcohol
- Fibrex is a gluten-free dietary fibre product from Sweden made from sugar beet side-streams

The potential economic impact of upcycling 172,275 to 381,000 metric tonnes of sugar beet side-stream into products for human consumption annually in Denmark is approximately $59.96 million to $125.49 million USD. This estimate includes the market value of the upcycled products, cost savings from waste management, and additional economic contributions. (ChatGPT)

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UPCYCLING APPLE AND PEAR SIDE-STREAMS IN DENMARK COULD PROVIDE

ENOUGH FIBRE FOR OVER 300K DANES EVERY YEAR

FRUIT AND VEGETABLES: APPLE/PEAR

Almost half of all fruit and vegetables produced are wasted (64) and this sector represents a high potential for upcycling. We have focused on apple and pear pomace, but other high opportunity side-streams include cucumber, carrot, tomato, onion, beetroot, citrus fruit, banana and avocado.

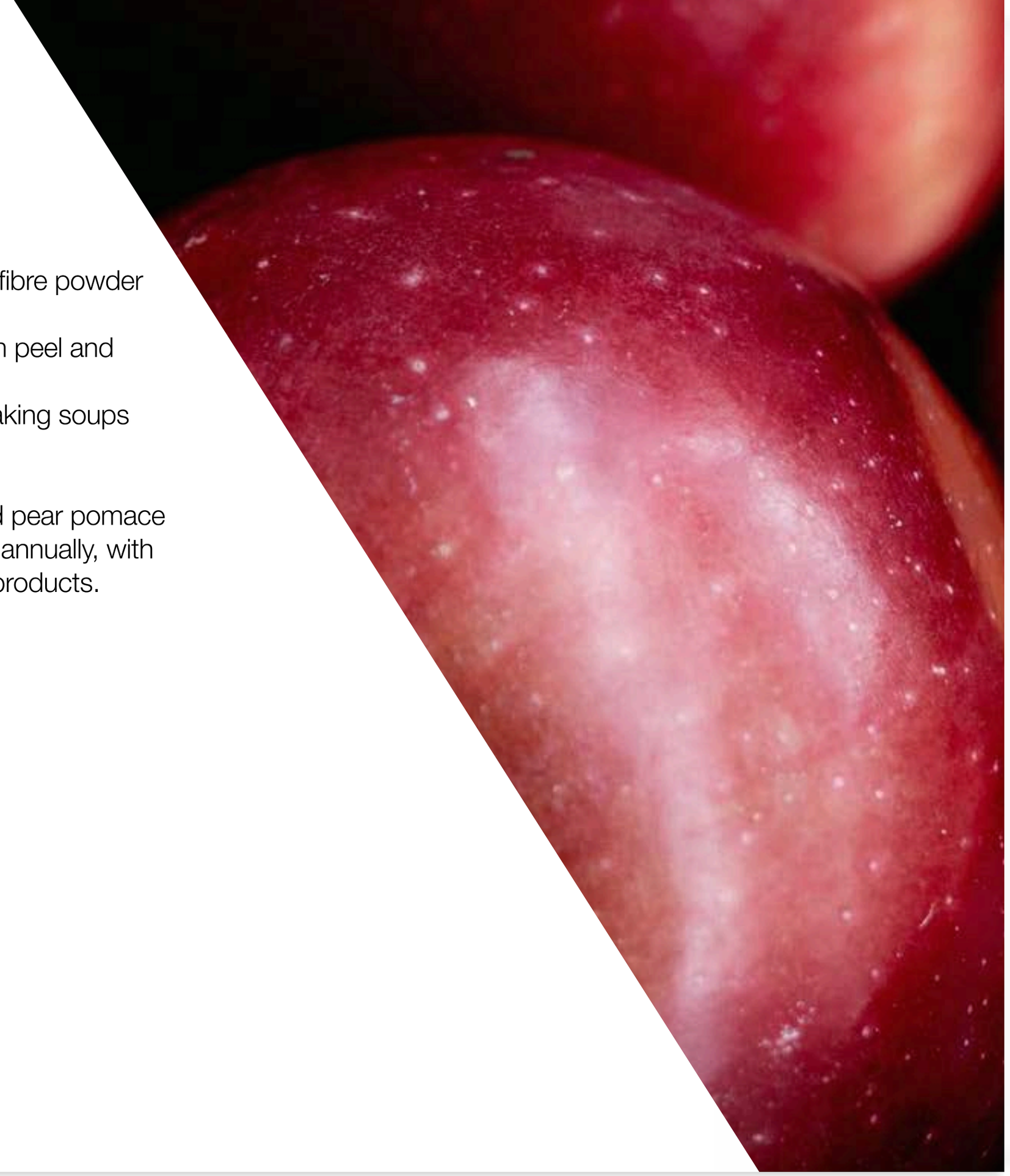
Side-streams:
Pomace from juice production
Estimated volume per year in DK:
4,300 tonnes (just apple and pear pomace) (65)
Valuable compounds:
Dietary Fibre, Polyphenols, Pectin

Apple seed contains bioactive compounds with cardioprotective, antidiabetic, anticancer, antioxidant and antimicrobial properties. It also contains pectin and can be used as a gelling or thickening agent, in the fortification of baked goods, to create flavour and aroma compounds, in teas, to make low-alcohol cider (ciderkin), or as a sweetener. (66)(67)

INSPIRATIONAL CASES

- Greenfield in Poland are making dietary fibre powder from apple pomace
- Rind in the USA are making snacks from peel and wasted fruit and vegetables
- Kromkommer in the Netherlands are making soups from wasted wonky vegetables

Upcycling 4,300 metric tonnes of apple and pear pomace could generate approximately €12.9 million annually, with higher potential if processed into premium products. (ChatGPT)



GRAINS: WHEAT BRAN

Most grains in Denmark are grown to feed animals, and most of the side-streams from the grain industry are also sent to animal feed (68). The largest volume side-stream from the grain industry in Denmark is wheat bran; a valuable and nutritious byproduct. (69)

Side-streams:
Bran, Germ, Straw, Husk
Estimated total volume per year in DK:
104,000 tonnes (wheat bran only) (70)
Valuable compounds:
Protein, Dietary Fibre, Beta-Glucans

Wheat bran has high fibre, protein and mineral content and can be upcycled into several high-value products and applications; including dietary fibre supplements, food fortification, and as an ingredient in baking. Research is also exploring its use in creating biodegradable plastics for eco-friendly packaging. (71)

Upcycling Danish wheat bran could provide up to

93%

of the Danish population with fibre or over 900k adults with protein every year (72)

INSPIRATIONAL CASES

- Swiss start-up Kly uses fermentation to upcycle wheat bran into a plant-based functional flour
- Change ingredients in Italy upcycles wheat side-streams into wheat fibre and wheat germ oil for use in baked goods, pasta, snacks, condiments and beverages

ANIMAL BY-PRODUCTS (ABPs)

Denmark has significant market potential for collecting, handling and utilising its high volume of animal byproducts (ABPs) due to its small size, large volumes and concentrated market (73). It is difficult to establish the current uses of these side-streams, but it is likely there is a high opportunity for upcycling of valuable nutrients.

Side-stream:
Blood, bones, offal, blood, hide, tallow etc
Estimated total volume per year in DK:
500,000 tonnes (74)
Valuable compounds:
Protein, Iron, Gelatin, Collagen

The Danish pork industry produces 60,000 tonnes of pig blood, which is primarily used for animal feed. Pig blood protein offers higher nutritional value than plant or dairy-based protein and this amount could be processed into 5000 tonnes of pure neutral-tasting protein powder for the food industry, (75) (76) providing protein for almost 300k adults every year. (77)

Over 93K

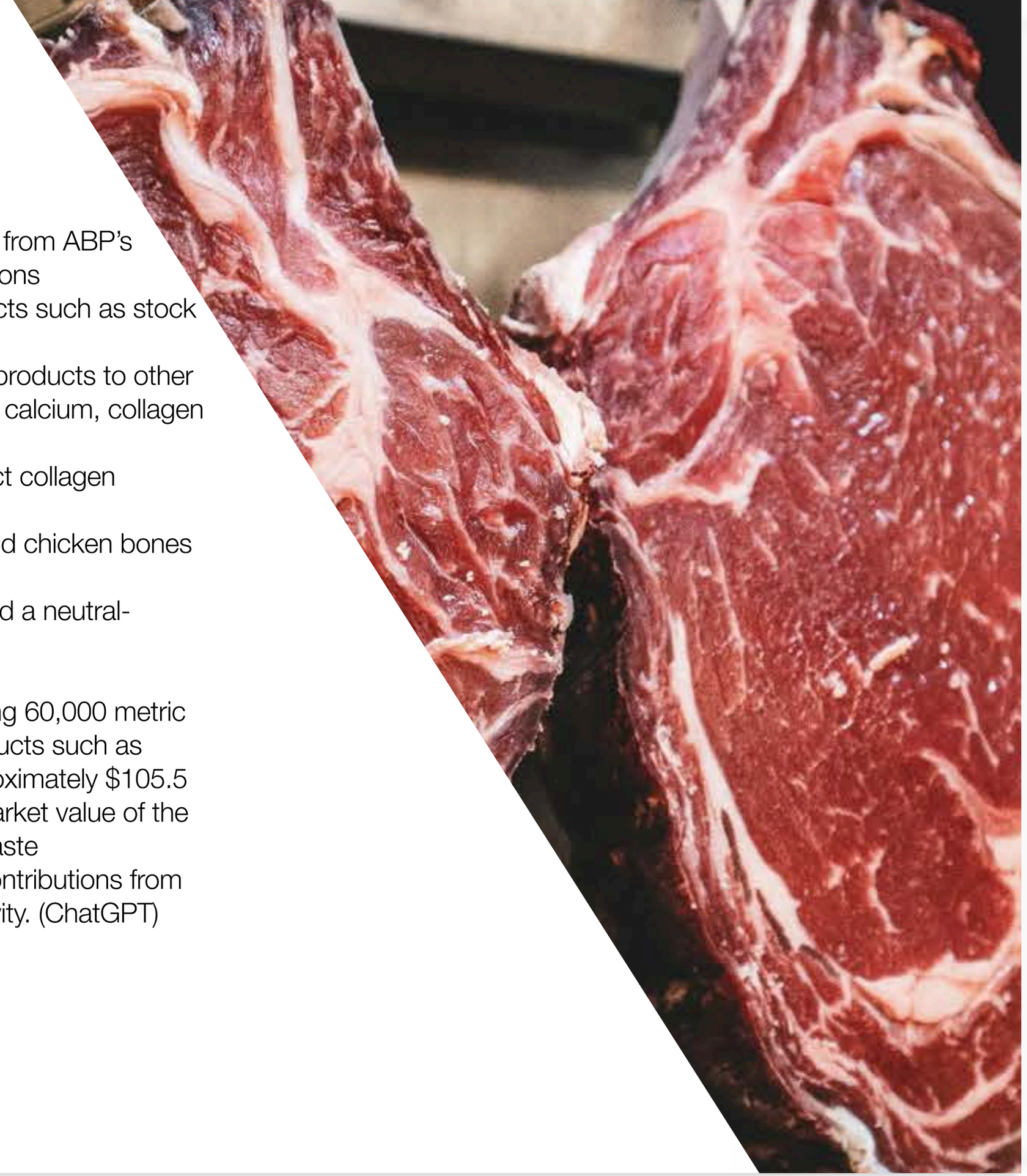
Danish adults could get their RDA of calories for a year from upcycled beef tallow (78)

Animal byproducts are high in protein and valuable for many food and pharmaceutical applications. ABPs could be used to produce bioactive peptides for functional foods, which are in high demand and can provide health benefits like antihypertensive, antioxidant, and antimicrobial effects. ABPs also have technological uses, such as foaming and emulsifying, making them suitable as food ingredients. Trimmings can also be used in processed meats. (79) (80)

INSPIRATIONAL CASES

- Essentia in Denmark produces protein from ABP's such as blood for use in food applications
- Reduced in Denmark produces products such as stock from laying hens and veal
- Norilia in Norway exports edible meat products to other cultures as well as producing proteins, calcium, collagen and oils from ABPs and eggshells
- Gelita in Germany uses ABPs to extract collagen peptides, collagen and gelatin
- Superground in Finland includes ground chicken bones to enhance their chicken products
- Copenhagen University have developed a neutral-tasting protein powder from pig blood

The potential economic impact of upcycling 60,000 metric tonnes of pig's blood into high-value products such as supplements annually in Denmark is approximately $105.5 million USD. This estimate includes the market value of the high-value products, cost savings from waste management, and additional economic contributions from job creation and increased economic activity. (ChatGPT)



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UPCYCLING FISH SIDE-STREAMS IN DENMARK* COULD PROVIDE

ENOUGH PROTEIN FOR OVER 2.8M ADULTS EVERY YEAR (81)

*from Danish industry currently sent to fish feed

FISH AND SEAFOOD

Only 30-60% of a fish is generally used, with the remainder discarded or used as fishmeal. (82) This means that highly valuable compounds are currently being severely underutilised and could be recovered for human consumption.

Side-streams:
Skin, bones, trimmings, scales, entrails, oils, blood, roe, shell
Estimated total volume per year in DK:
150,000 tonnes (83)
Valuable compounds:
Gelatin, Collagen, Protein, Omega 3, Minerals, Enzymes, Oil, Fatty Acids, Chitin

Fish side-streams offer many valuable applications across multiple industries including food supplements and cosmetics. Marine side-streams can create edible coatings to extend food shelf life; fish bones can be ground into seafood products; residual meat can be recovered from bones to make mince, while fish collagen can be utilised for food and pharmaceutical purposes. Marine proteins and peptides have bioactive functions, as well as antimicrobial, antioxidative, antihypertensive, and antihyperglycemic properties. (84)(85)

48%

of the Danish population could get their RDA of protein by upcycling fish side-streams* (86)

*RDA- Recommended Daily Allowance, for a year

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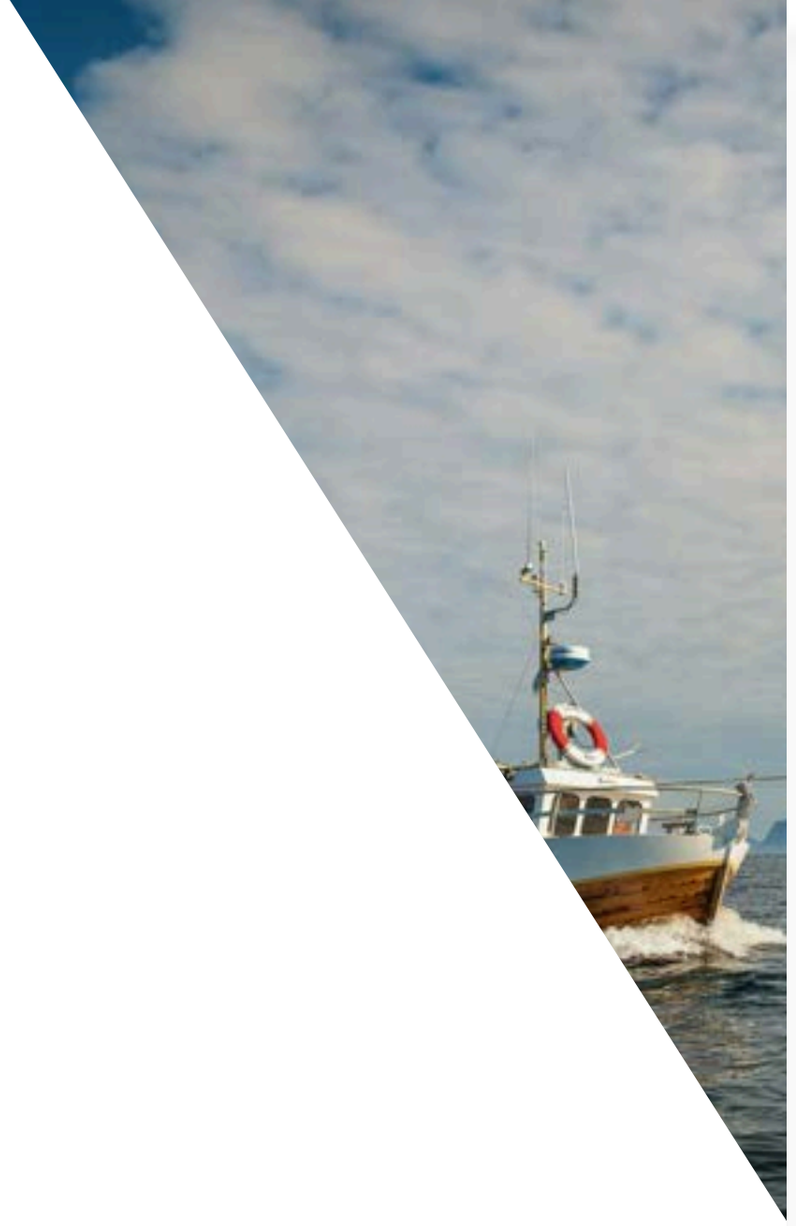
THE MARKET FOR COLLAGEN AND GELATIN IS EXPANDING, WITH AN

ESTIMATED VALUE OF $1.6B USD BY 2028. (87)

INSPIRATIONAL CASES

- Superground in Finland uses fish side-streams such as bones to enhance their fish products
- Hailia in Finland upcycles low-value fish side-streams into seafood products
- Fisk Seafood in Iceland produces proteins and food supplements from fish side-streams as well as leather from fish skin
- Axfoundation in Sweden makes fish burgers from herring backbone meat
- Collab in Iceland produces an energy drink from fish collagen
- Polar Seafood in Greenland uses 90% of its Halibut through selling parts to Asian markets whilst Codland in Iceland aims to use 100% of the Cod through extraction of oil, collagen and minerals
- Biomega in Norway produces salmon peptides and oil from salmon side-streams

The potential economic impact of upcycling 150,000 metric tonnes of fish side-streams into high-value protein products annually in Denmark is approximately $331.5 million USD. This estimate includes the market value of the high-value protein products, cost savings from waste management, and additional economic contributions from job creation and increased economic activity. (ChatGPT)



EGGSHELLS

Eggshells are currently used as fertiliser, but contain valuable compounds that could be extracted and reused in food products. (88) (89)

Side-streams:
Eggshell, Eggshell Membrane
Estimated total volume per year in DK:
c. 2100 tonnes (90)
Valuable compounds:
Collagen, Calcium, Peptides

Eggshells can be utilised as a valuable ingredient for nutraceuticals, supplements and food fortification, providing a source of calcium or vegetarian collagen. (91) (92) Eggshell membrane has a rich composition of nutrients, and research shows it can also benefit joints, muscles, and even wound healing. (93)

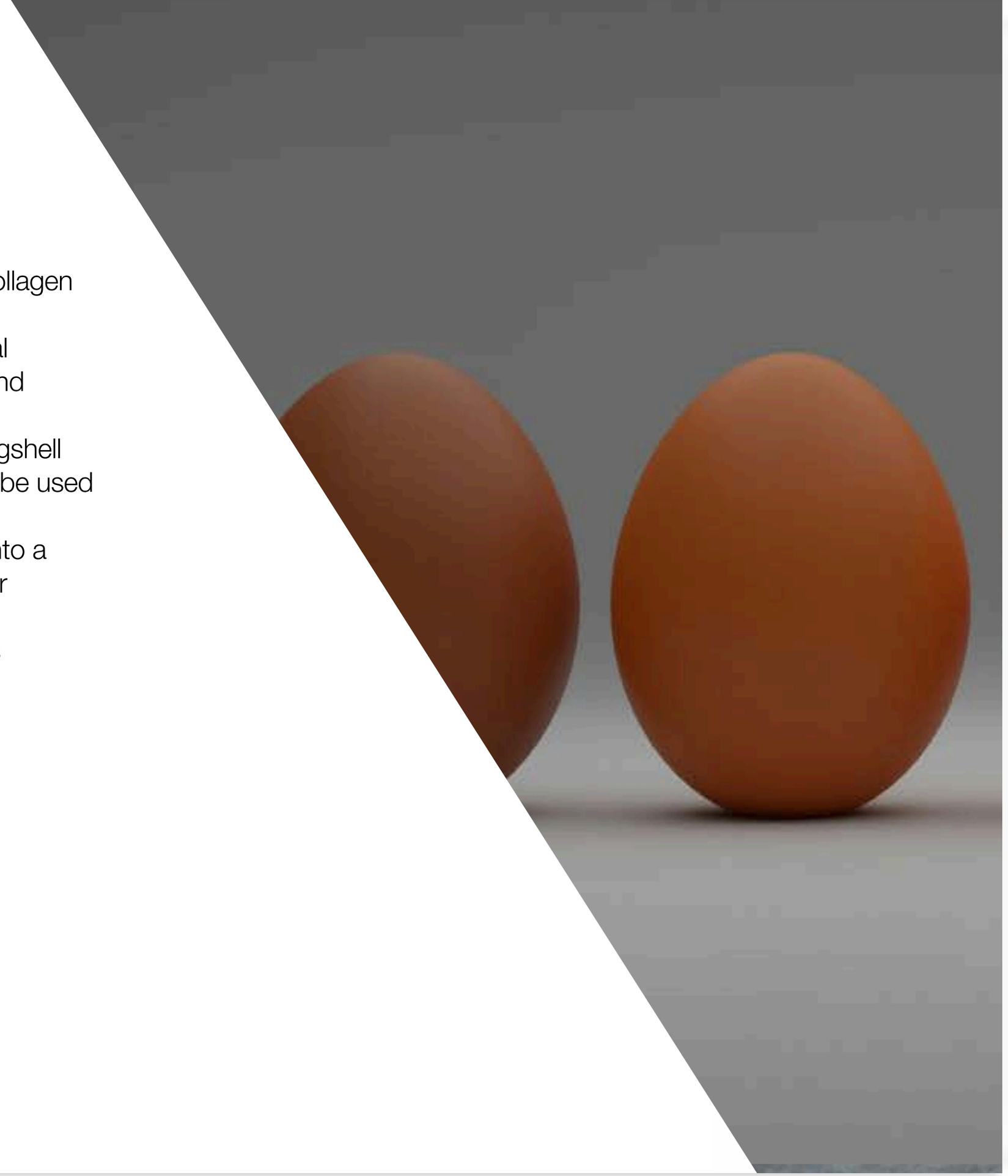
Upcycling eggshells every year in Denmark could provide enough calcium for

over 2M

people (94)

INSPIRATIONAL CASES

- Netzro in the USA upycles calcium and collagen from eggshells for human consumption
- Eggnovo in Spain produces neutraceutical ingredients such as vegetarian collagen and calcium from eggshells
- Eggbrane in the Netherlands upcycles eggshell membranes into protein powder that can be used in food, beverages and supplements
- EggTech in the USA upcycles eggshells into a more easily absorbed calcium with greater bioavailability for food, drinks, dietary supplements, and natural health products



DAIRY

Whey was previously considered a side-stream, but has now evolved into its own high value market of protein shakes and supplements. Whey is therefore a prime example of a side-stream being transformed into a value-added product with a rapidly growing market, sometimes surpassing the value of the original product. As a result, whey is no longer viewed as an underutilised side-stream but as a success story in upcycling. (95) However, the dairy industry still has high quantities of unused leftovers that could potentially contain valuable compounds and be used for food products and would merit investigation. (96)

Up to

250K

tonnes of dairy side-streams are still potentially underutilised in Denmark (99)

Side-streams:
Whey, Buttermilk, Sludge
Estimated total volume per year in DK:
249,000 tonnes (residuals excluding whey) (97)
Valuable compounds:
Proteins, Carbohydrates, Peptides, Amino Acids

Dairy side-streams contain high nutritional value, and can be used for development of dairy and other food products. (98)

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UPCYCLING SPENT COFFEE GROUNDS*
COULD SAVE

THE EQUIVALENT OF ALMOST 15K IN CO_2 EMISSIONS

EVERY YEAR (100)

*based on the spent grounds being sent to landfill.

SPENT COFFEE GROUNDS (SCGs)

We only get 1% of the coffee bean's nutrients from making a cup of coffee, meaning that 99% of the nutritional value is left in the spent grounds and goes to waste. (101) The average Dane drinks about 8.7 kg of coffee per year (102), which makes SCGs a high-volume and high opportunity sidestream in Denmark.

Estimated total volume per year in DK:
100,920 tonnes (103)
Valuable compounds:
Protein, Fibre, Antioxidants, Polyphenols, Fatty Acids

SCGs contain important bioactive compounds including antioxidant and anti-inflammatory properties. SCGs have diverse applications, including use as ingredients in flour, nutraceuticals, baked goods, functional foods and beverages and cosmetics. (104)(105)

By upcycling spent coffee grounds in Denmark every year, more than the entire adult population could get their recommended daily allowance of fibre. (106)

99%

of coffee's nutritional content is generally wasted (107)

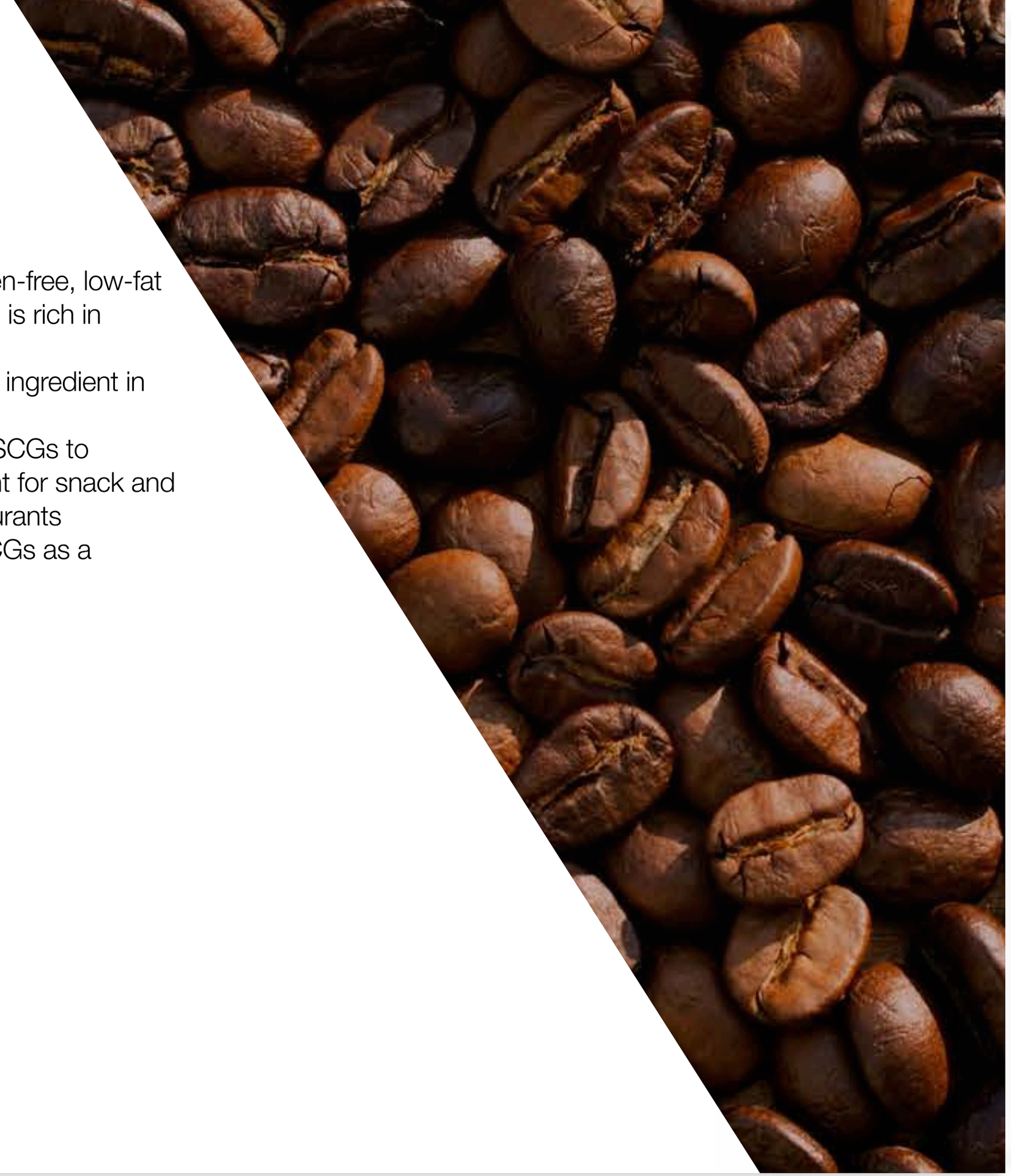
By upcycling spent coffee grounds in Denmark every year, we could save the equivalent CO_2 emissions of almost

650K flights

from Copenhagen to Paris (based on the spent grounds being sent to landfill). (106)

INSPIRATIONAL CASES

- Kaffe Bueno in Denmark produces gluten-free, low-fat and caffeine-free fibre from SCGs which is rich in proteins
- Secontaste in Hungary use SCGs as an ingredient in granola alongside BSG
- Connecting Grounds in Denmark uses SCGs to produce a multifunctional food ingredient for snack and confectionery products as well as restaurants
- Rotterzwam in the Netherlands uses SCGs as a substrate for growing mushrooms



ONE THIRD

UPCYCLING WASTED BREAD AT PRODUCTION STAGE COULD PROVIDE

THE RDA OF FIBRE FOR ALMOST 13K ADULTS

(114)

BREAD

Almost 700g bread per person is consumed daily in Denmark. (108) 40-50% of bread is wasted at retail and consumer stage, but there are also substantial side-streams available to upcycle from the production stage. (109)

Side-streams:
Wasted bread, trimming, over-processing waste, defects
Estimated total volume per year in DK:
2,880-5,820 tonnes (just production stage) (110)
Valuable compounds:
Dietary Fibre

Bread waste is a good source of fermentable sugars and can be used to produce beer, spirits, and other fermented products such as garum. It can be used as a flavour enhancer, to produce glucose syrup and bioethanol. (111) It's even possible to create a circular system where surplus bread is transformed into beer and spirits, then fermented and potentially returned again to the bread production cycle. (112)

Up to

50%

of bread is wasted at retail and consumer stage. (113)

The 1-2% of wasted bread at production stage could still save the equivalent of CO_2 emissions of up to 2,770 cars for a whole year. (114)

INSPIRATIONAL CASES

- Wasted in Denmark is making pasta from wasted bread
- Toast in the UK and Brøl in Denmark are using surplus bread to make beer
- Misadventure in the USA is using surplus baked goods to make vodka
- Food Remade in Denmark upcycle leftover bread into to customised crumb and flour mixes and food ingredients
- No Waste Republic in Belgium is upcycling surplus bread into beer and breadcrumbs

ONE THIRD

EVERY YEAR, AN ESTIMATED

8M TONS OF OLIVE OIL MILL WASTEWATER IS GENERATED WORLD WIDE (119)

WASTEWATER

The food processing sector is one of the top consumers of drinking water globally. (115) Wastewater is an overlooked sidestream with a high volume: 2500 litres are needed to produce just one person's daily food consumption. (116) These high volumes of wastewater from food processing can cause severe environmental issues if not treated properly, which is often a costly and complicated process. (117) The Danish food industry has reduced its water consumption as a result of high water and disposal costs (118); but more could be done to recover and reuse valuable nutrients found in food processing wastewater.

Valuable compounds:
Starch, Protein, Sugars, Pectin, Vitamins, Phenolic and Bioactive Compounds

Some examples of industries where wastewater could be utilised and upcycled are potato, fruit and vegetables, fish, meat, dairy, wine, soy and edible oil.

2500L

amount of water needed to produce one person's daily food intake (123)

For example:

- Potato wastewater can be processed to extract starch and significant levels of potato protein, which has high potential for use in food and healthcare. (120)

- Wastewater from fruit and vegetable processing contains vitamins and valuable carbohydrates including starch, pectin and sugars. (121)

- Wastewater from the edible oil industry can be utilised to recover carbohydrates and phenolic compounds, which can have antimicrobial, antioxidant, anti-cancer, anti-allergic and anti-hypertension effects. Polyphenols can be used as natural preservatives and added to food products such as baked goods and meat. (122)

ONE THIRD

THE FUTURE OF UPCYCLING

– NEW MODELS ARE APPEARING TO FACILITATE INCREASED UPCYCLING OF SIDE-STREAMS

NEW MODELS ARE APPEARING

Upcycling certification in the USA
The existence of a standard for upcycled products in the USA provides a stamp of reliability, supply-chain sustainability and quality as well as increasing consumer awareness: we need something similar in the EU but nothing has been approved yet.

Financial models
To avoid the difficulties of being reliant upon the side-stream of another company, it's possible to create models of mutual interest between the supplier and side-stream user. For example, in the case of upcycled beverage Lillow, the side-stream producer became a part owner of the upcycled product, and so are unlikely to change their recipe or interrupt the supply.

Communities working to overcome barriers
Food Valley in the Netherlands is working on breaking down barriers to widespread adoption of upcycled products in the EU

Side-stream subsidiaries
Big companies are making new departments or subsidiaries with the purpose of upcycling existing side-streams into new value-added products: businesses are seeing that upcycling and waste reduction is in their interest. Examples include Arla food ingredients, Farmfood A/S, Essentia (a subsidiary of BHJ) and business areas within DAKA. (124)

Services matching side-streams with potential producers
Models are appearing to facilitate the matching of available sidestreams with interested parties or start-ups to minimise food loss and waste. Examples include Sidestream in Copenhagen and EIT Food Digital Marketplace for Side-streams. De Clique in the Netherlands also collects and distributes spent coffee grounds and orange peels to third parties for extraction of valuable compounds.

CONSTRUCTING CIRCULAR SYSTEMS

Regional circular systems based around the bioeconomy are being created; where sidestreams can become primary materials for other companies and food loss and waste is dramatically reduced.

Iceland is generally far ahead, and is getting over 30% more value from each cod than average and using about 90% of the fish. Despite annual catch being down by 45% since 1981 due to quotas, their total export value has increased more than 100%. (125) (126)

1. Iceland Ocean Cluster is a community of more than 90 companies which supports and invests in startups working with under-utilised marine resources. It includes companies in aquaculture, fish sales, marine technology, software, design, biotechnology and cosmetics, and uses up to 90% of its fish side-streams but is aiming for 100% utilisation.

2. Codland is a part of this cluster; founded fishing companies, it is engaged in interdisciplinary collaboration between academia and research institutions to maximise utilisation. Codland was a driving force in setting up Marine Collagen Ltd.; the first Nordic producer of gelatine made from cod skin. By extracting gelatine and collagen, they predict the value of cod skin will increase by 300% from the current low value. Their facilities are close to an existing fish drying plant, enabling almost all fishery side-streams to be processed at one location and creating a closed-loop system. (127) (128)

3. Big and small companies in Iceland are working together to process side-streams more efficiently and create economy of scale, with high potential for mergers. (129)

Digipolis in Finland is a Geothermal Resource Park with circular resources such as ingredients, side-streams and energy. (130)

“The Fish Value Machine” (Iceland Ocean Cluster)

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