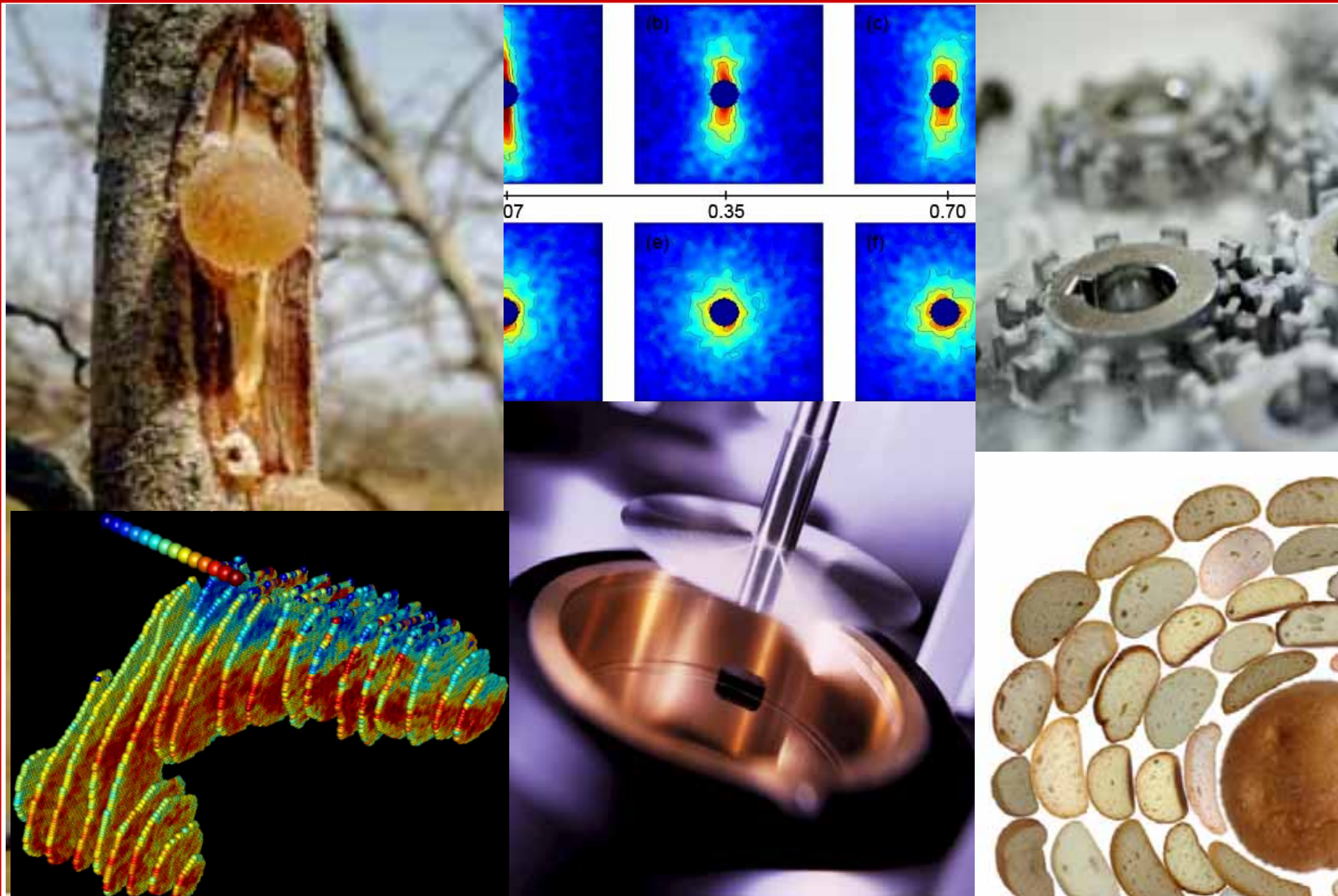


Once upon the time food was simple

Peter Fischer, Institute of food, Nutrition and Health



Once upon the time food was simple



Justus Liebig

12. May 1803 in Darmstadt
18. April 1873 in Munich

Mayor contributions:

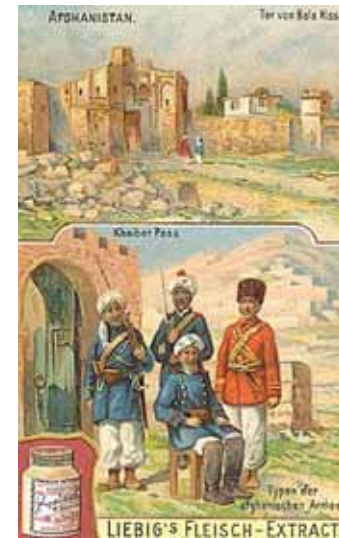
Organic Chemistry
Agricultural Chemistry

Food:

Liebig's Fleischextrakt (Meat extract) invented for the daughter of James Muspratt in 1852. Commercialized by Christian Giebert in Uruguay in 1862.

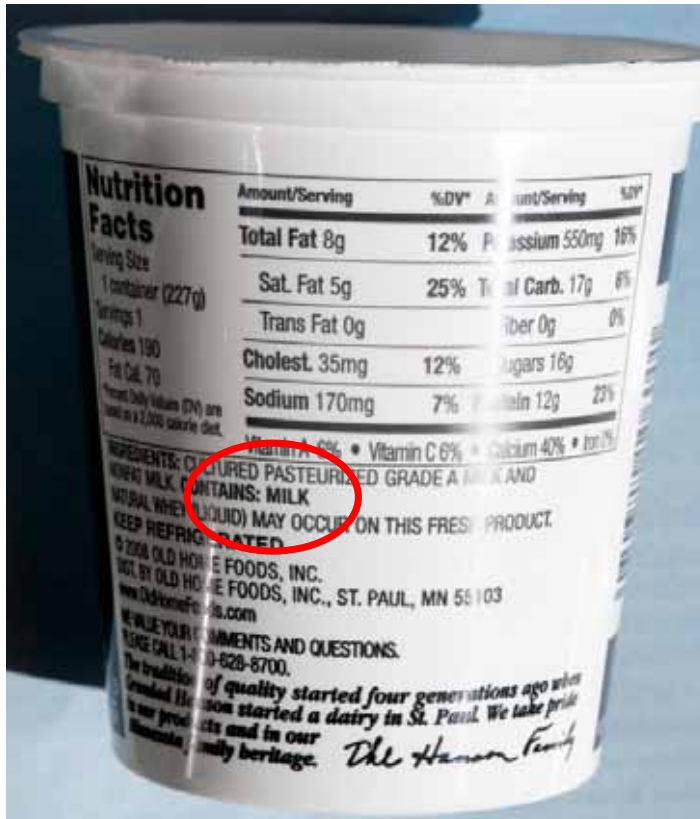
Baking powder (Horsford in the US, Doktor Oetker in Germany)

“Lipids, proteins and sugars”



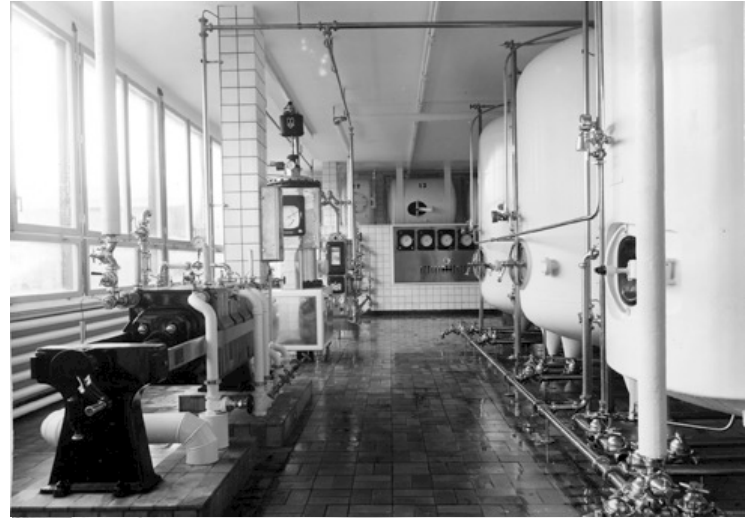
Food Rule I: Eat your grandma's diet

Traditionally food (pure fish in Greenland, seed and nuts in deserts, preserved food in seasonal regions) is surprisingly well balanced and healthy.



We are lucky that the apple was 'invented' before FDA, EFSA, and similar bodies were founded: **Nowadays an apple would be 'Novel Food'.**

Classical food factory



Process operation were more important than designing food

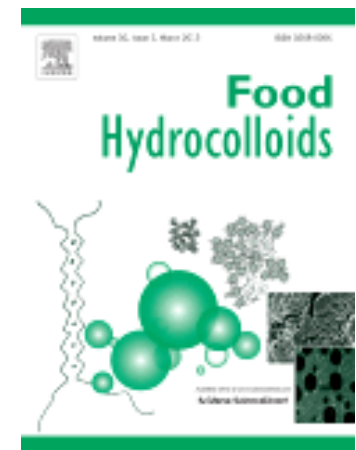
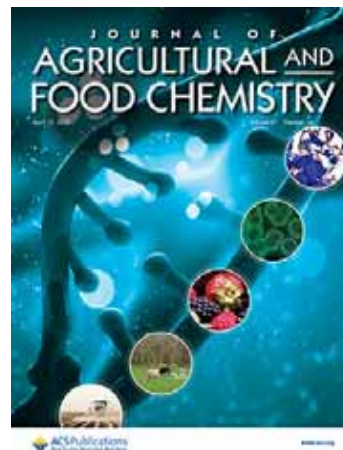
Paradigm change in the 1970s: Food science's golden age

“Shift from eating food to eating nutrients”*

or

“Lipids, proteins and sugars” plus **Micro-Nutrients** and **Additives**

Decomposition and recomposition of food
according to the **Zeitgeist** (flavonoides, omega 3, polyphenols, ...)



Journal foundation end 1960s to mid 1970s
reflects the trend for food additions

* Dietary Goals for the United States, FDA (January 1977), Report on Diet and Cancer, NAS (1982)

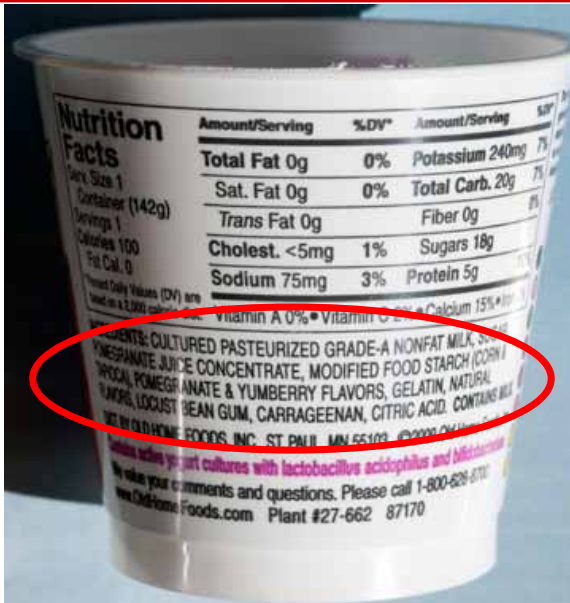
Paradigm change in the 1970s: The ingredients list



Formerly **two-to-three-ingredient** foods (such as bread, mayonnaise, yoghurt) **ballooned epically**

INGREDIENTS: IDAHO® POTATOES, VEGETABLE OIL (CONTAINS ONE OR MORE OF THE FOLLOWING: COCONUT, PALM, SOYBEAN, COTTONSEED, SUNFLOWER, CANOLA), CORN SYRUP SOLIDS, SALT, MALTODEXTRIN, NONFAT DRY MILK, SUGAR, SODIUM CASEINATE, BUTTER POWDER [BUTTER (SWEET CREAM, SALT, ANNATTO COLOR), NONFAT MILK SOLIDS, SODIUM CASEINATE AND DISODIUM PHOSPHATE], MONO AND DIGLYCERIDES, CALCIUM STEAROYL LACTYLATE, NATURAL AND ARTIFICIAL FLAVORS (MILK, SOY), SPICE, SODIUM ACID PHOSPHATE (PRESERVE FRESHNESS), SODIUM BISULFITE (PRESERVE FRESHNESS), DIPOTASSIUM PHOSPHATE, ARTIFICIAL FLAVOR, CITRIC ACID (PRESERVE FRESHNESS), MIXED TOCOPHEROLS (PRESERVE FRESHNESS) AND LESS THAN 2% SILICON DIOXIDE ADDED AS AN ANTI-CAKING AGENT. **CONTAINS:** MILK, SOY.

The ingredients list: Some more examples



Lowers LDL Cholesterol Up To 14%
55% Vegetable Oil

Benecol

Proven to Significantly Reduce Cholesterol

See Nutrition Information For Fat Content

NET WT. 8 OZ. (227g)

No Trans Fatty Acids

Nutrition Facts		Amount/Serving	%DV*	Amount/Serving	%DV*	
Serv. Size	1 Tbsp. (14g)	Total Fat	8g	12%	Cholest. 0mg	0%
Servings	16	Sat. Fat	1g	5%	Sodium 110mg	5%
Calories	70	Polyunsat. Fat	2g		Total Carb. 0g	0%
Fat Cal.	70	Monounsat. Fat	4g		Protein 0g	
* Percent Daily Values (DV) are based on a 2,000 calorie diet.		Vitamin A 10%		Vitamin E 20%		

Ingredients: Liquid Sorbitol Oil, Water, Plant Stanol Ester, Partially Hydrogenated Soybean Oil, Salt, Emulsifiers (Vegetable Mono- and Diglycerides, Soy Lecithin, Polyglycerol Esters of Fatty Acids), Hydrogenated Soybean Oil, Potassium Sorbate, Citric Acid and Calcium Disodium EDTA to Preserve Freshness, Artificial Flavor, dl- α -Tocopheryl Acetate, Vitamin A Palmitate. Colored with Beta Carotene.

Тэжээллэг чанар (100мл)

Илчлэг:	54 ккал	Уураг:	0 гр
Нүүрс-ус:	13.4 гр	Вөх тос:	0 гр
Чихэр:	13.4 гр	Натри:	8 мг

250мл - д

Чихэр	Вөх тос	Натри
33.5гр	0гр	20мг
**	0%	1%

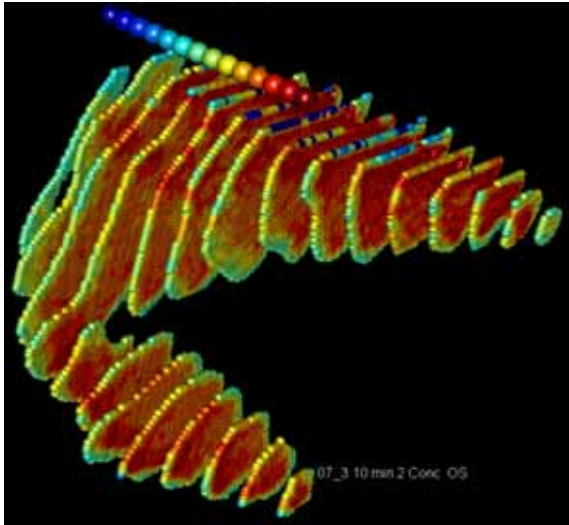
- Илчлэгийн хоногийн хэрэгцээнд эзлэх хувийг 2000ККАЛ - с тооцсон
- Илчлэгийн хоногийн хэрэгцээнд чихрийн эзлэх хувийг тооцдоггүй

Харилцах утас: (976)-7016-5555
Факс: (976)-7016-5500
Web: www.mscocacola.mn

Skyrocketing expectation and some consequences

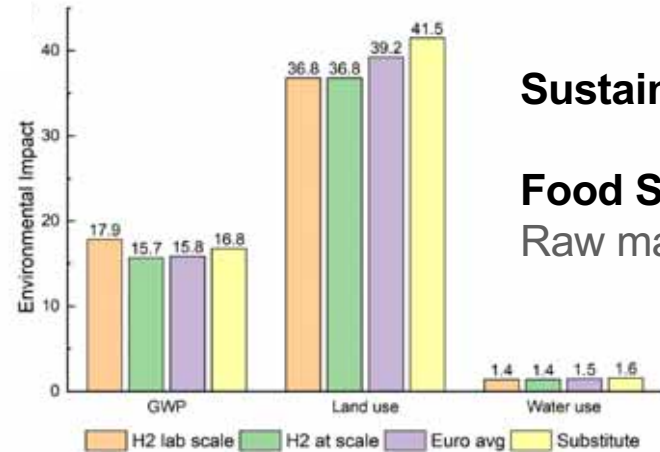
Food and Nutrition

Digestive emulsions



Translation

From animal to plant
Meat analogues



Sustainability

Food Safety

Raw material



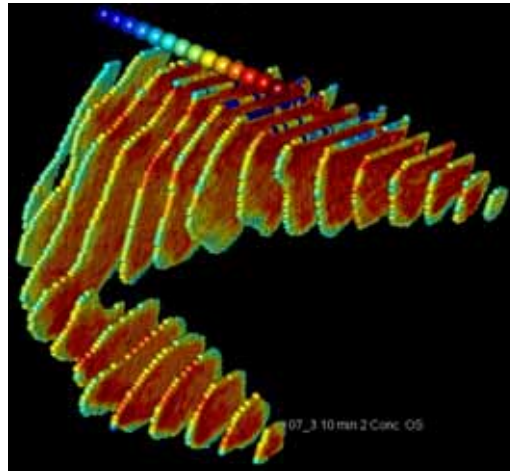
Physiological guided food structures



See milk als **liquid bone**: Casein*, whey, and calcium



shutterstock.com - 316308977



Food structuring before eating,
structure breakdown during **oral processing**,
decomposition and takeup during **digestion**, ...

In **reverse engineering terms**: Food structures should fit our physiology.

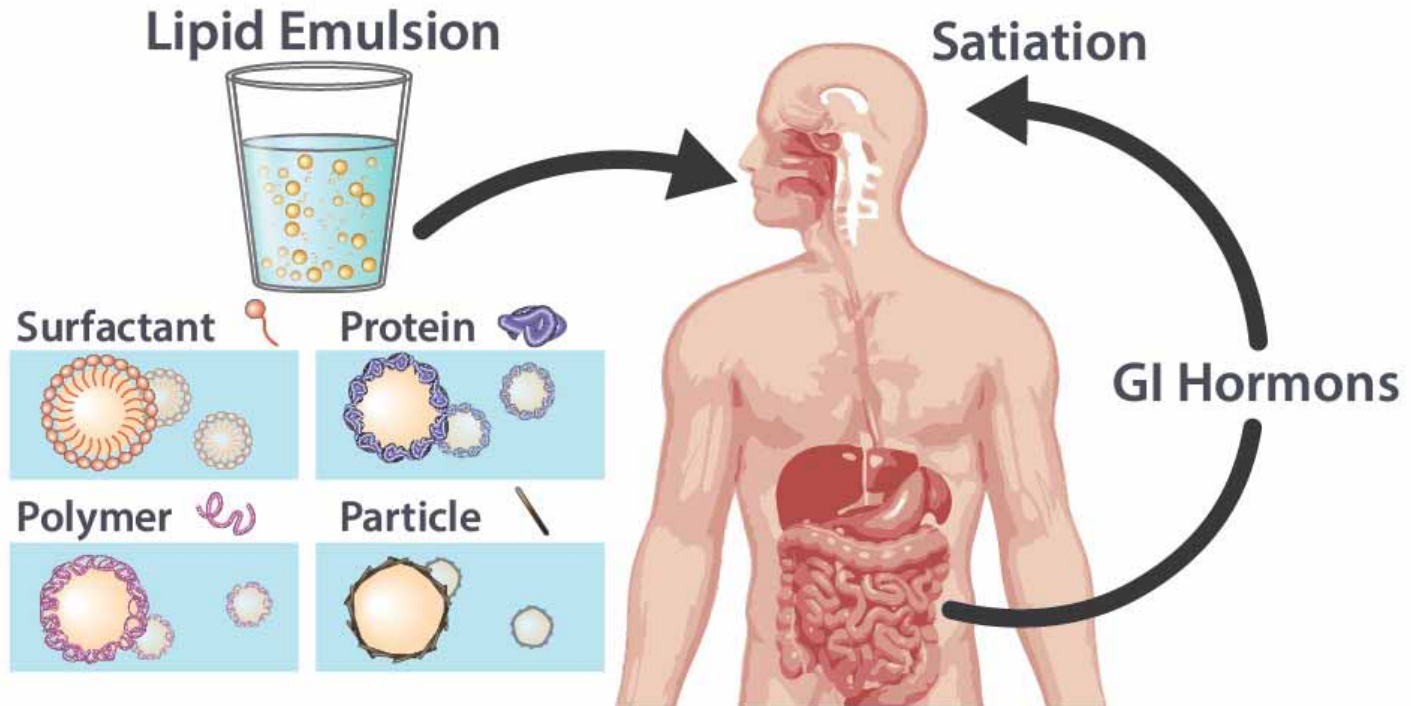


Just try to do that with oat milk!

* For the casein micelle dilemma see Mezzenga & Fischer: Rep. Prog. Phys. 76 (2013) 046601

Reverse engineering: Stimuli-responsive emulsions

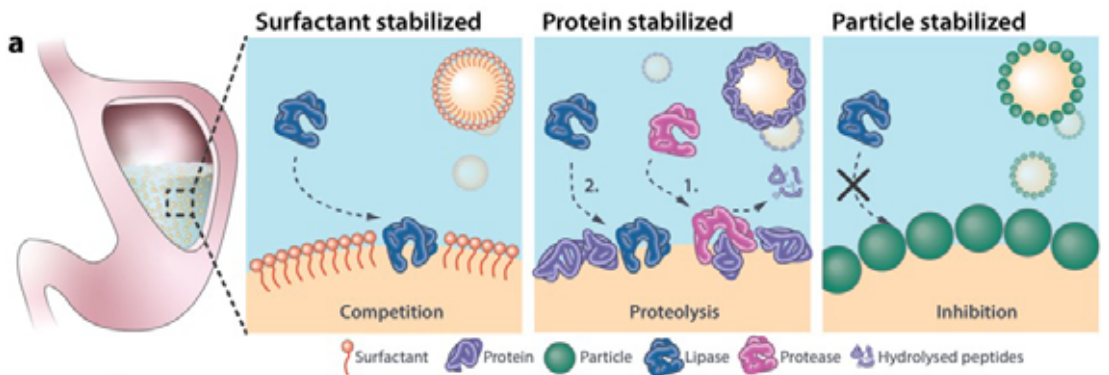
Increasing satiety by defined GI hormone release



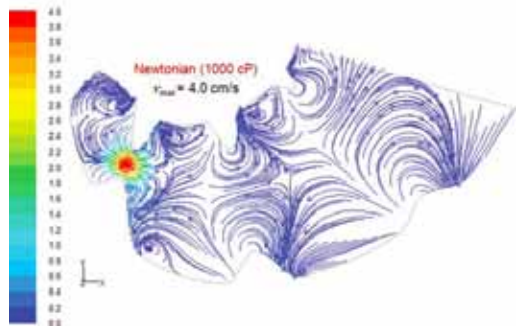
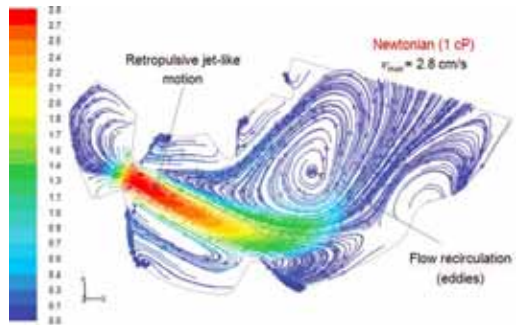
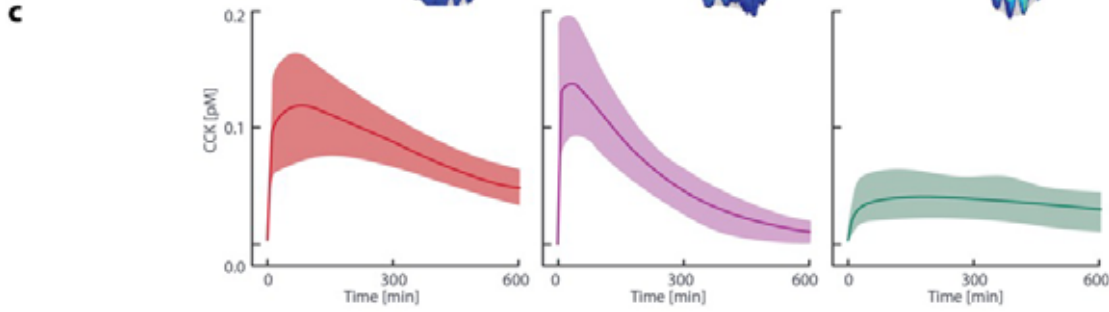
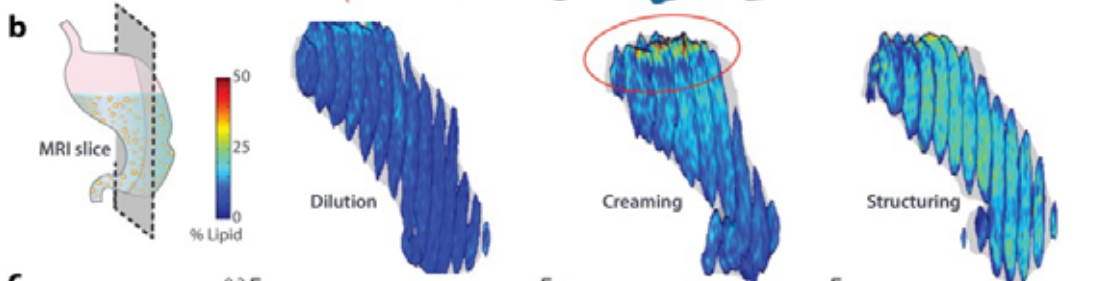
Idea*: Lipids in the small intestine will trigger satiety hormones

Problem: Lipid emulsions have to survive stomach

Stimuli-responsive emulsions: Summary & Tasks



Flow structuring in stomach, intestine, mouth, and esophagus.



Another golden age: From animal to plants

Can we use **plant materials** to make products that are **traditionally made from animal material** – with a desirable level of functionality (e.g. cheese melting), sensory quality, and nutritional value?



Processing Technologies

Added ingredients



Problems:

Which is the **best plant** for what purpose and **how to treat** it?

Animal-based proteins are water-soluble, **plant materials** not necessarily

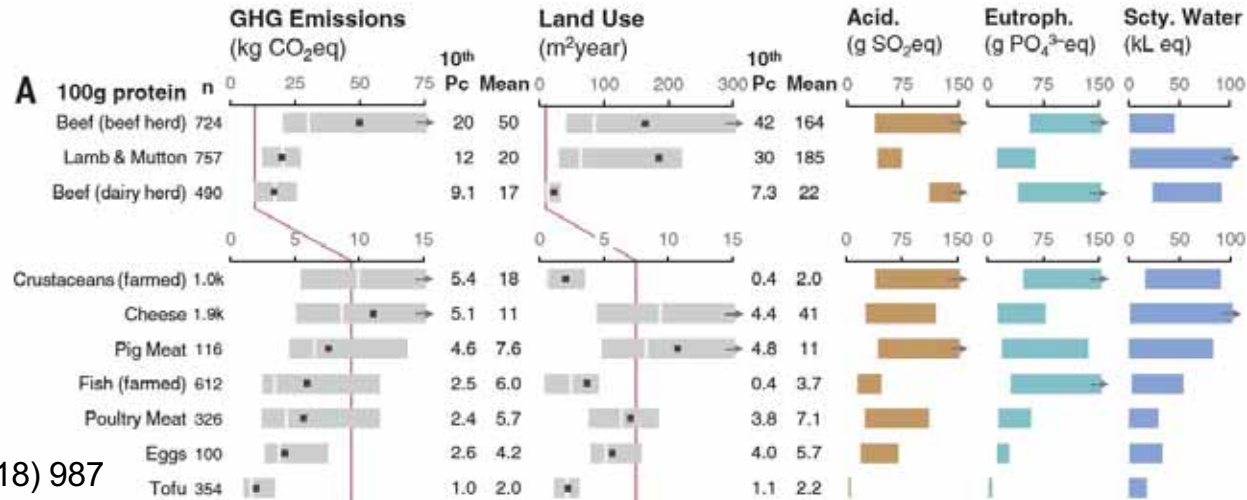
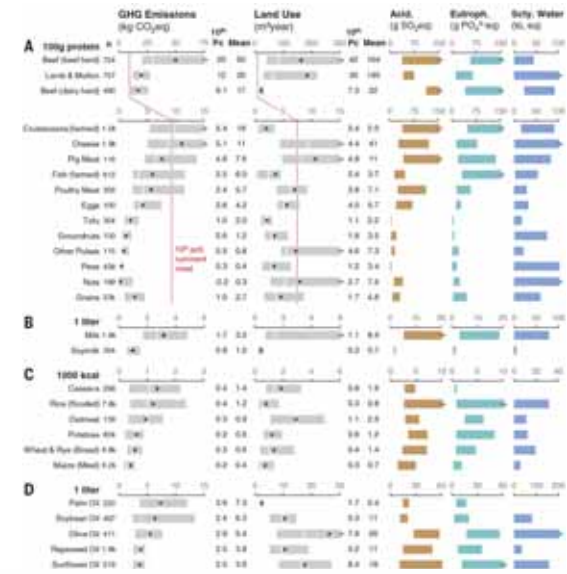
But before we get there: Sustainability

SUSTAINABILITY

Reducing food's environmental impacts through producers and consumers

J. Poore^{1,2*} and T. Nemecek³

Food's environmental impacts are created by millions of diverse producers. To identify solutions that are effective under this heterogeneity, we consolidated data covering five environmental indicators: 38,700 farms; and 1600 processors, packaging types, and retailers. Impact can vary 50-fold among producers of the same product, creating substantial mitigation opportunities. However, mitigation is complicated by trade-offs, multiple ways for producers to achieve low impacts, and interactions throughout the supply chain. Producers have limits on how far they can reduce impacts. Most strikingly, impacts of the lowest-impact animal products typically exceed those of vegetable substitutes, providing new evidence for the importance of dietary change. Cumulatively, our findings support an approach where producers monitor their own impacts, flexibly meet environmental targets by choosing from multiple practices, and communicate their impacts to consumers.



But before we get there: Sustainability & Health

ARTICLES

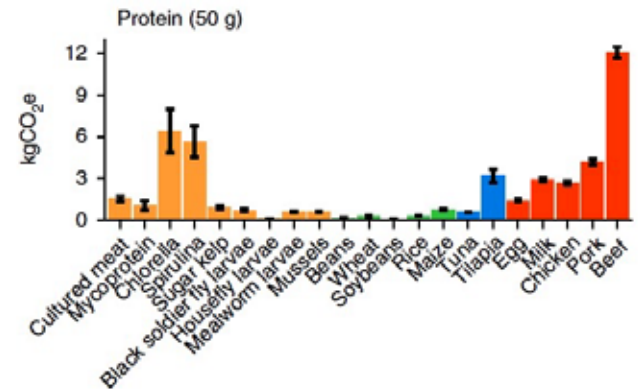
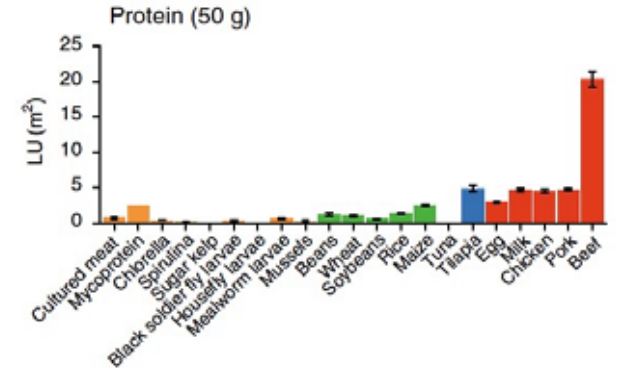
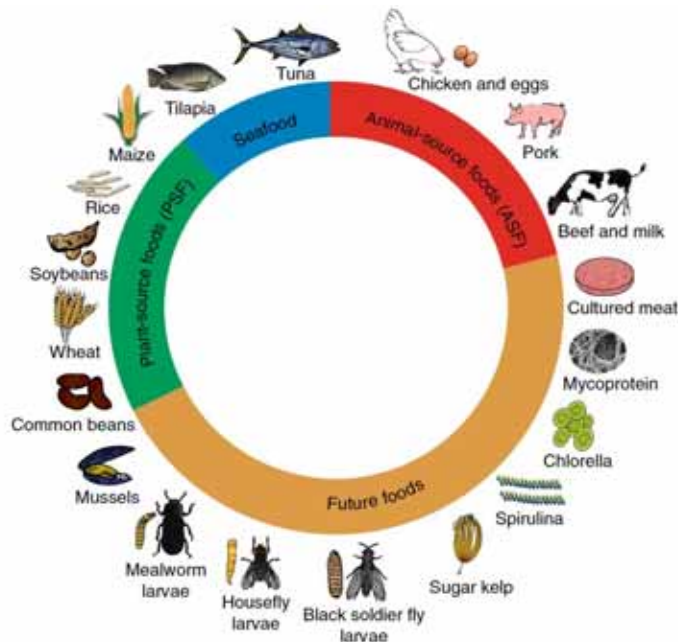
<https://doi.org/10.1038/s41893-018-0189-7>

nature
sustainability

Corrected: Author Correction

The potential of future foods for sustainable and healthy diets

A. Parodi¹, A. Leip², I. J. M. De Boer¹, P. M. Slegers³, F. Ziegler⁴, E. H. M. Temme⁵, M. Herrero⁶,
H. Tuomisto^{7,8,9}, H. Valin¹⁰, C. E. Van Middelaar¹, J. J. A. Van Loon¹¹ and H. H. E. Van Zanten^{1*}



What needs to be done?

Sustainability & Health: Holistic chocolate (side streams)



Mishra et al.: Nature Foods (2024) Holistic chocolate

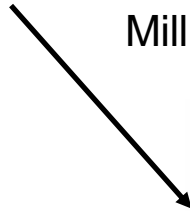
Now, the golden age: Analogues to meat, cheese, ...



Structuring of plant protein melts



Milling and milk making



Cheese analogues:

Coagulation of the protein milk and 'whey' removal (like tofu making)

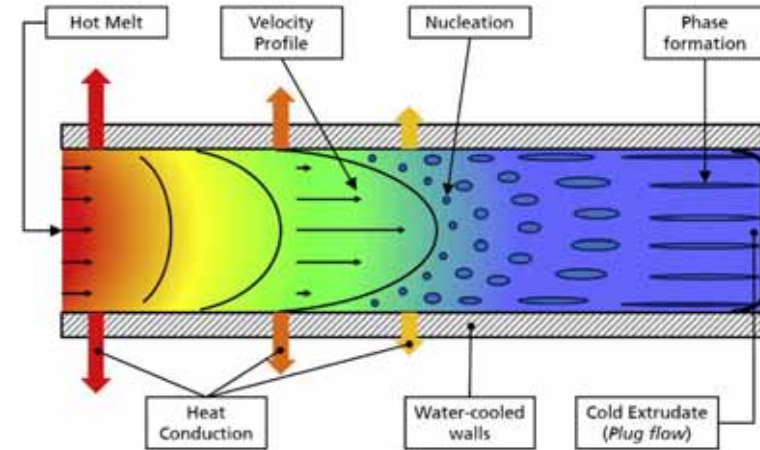
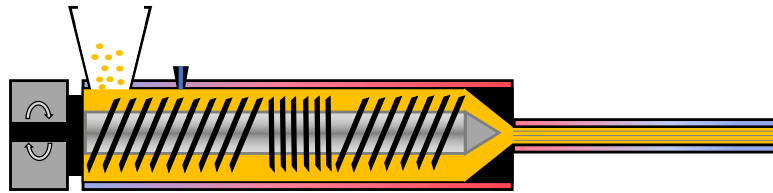


Meat analogues:

Extrusion of protein melts to mimic the structure of meat

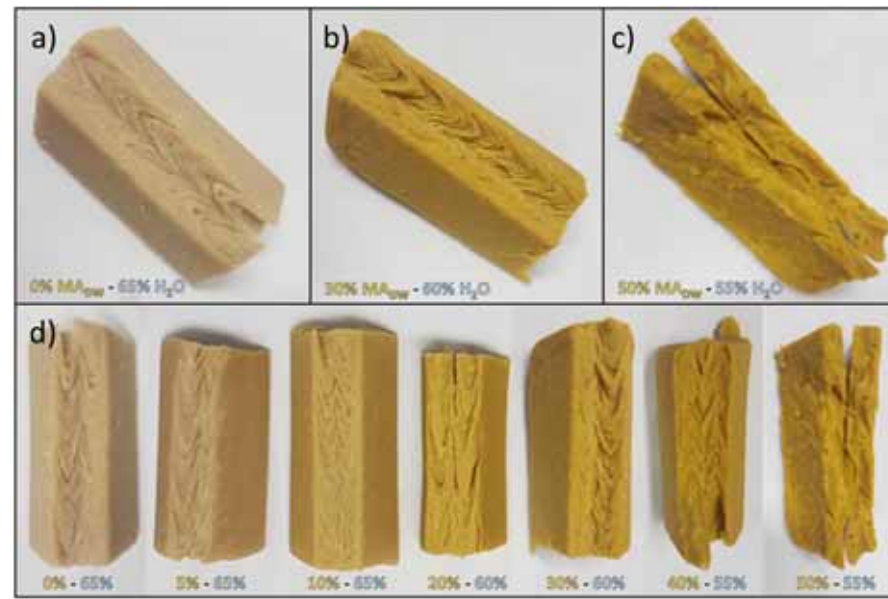
How plant proteins are structured in extrusion?

High moisture extrusion: Melt & Flow leads to Structure

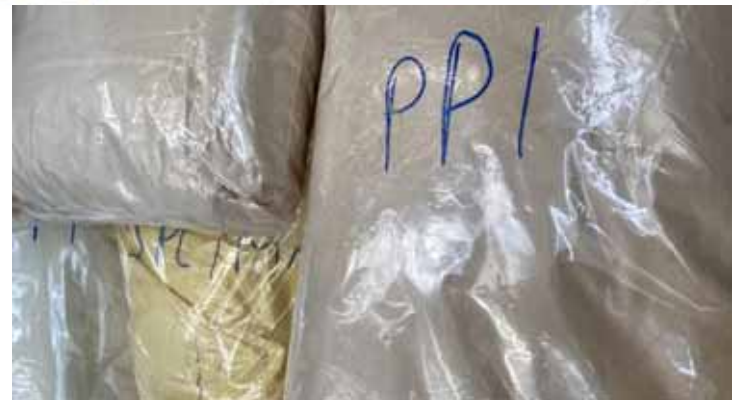
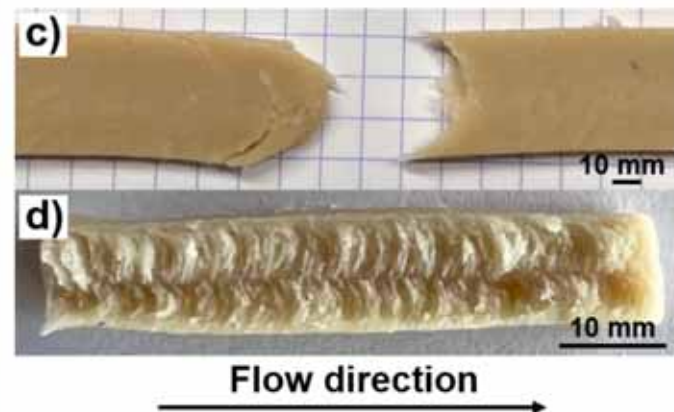
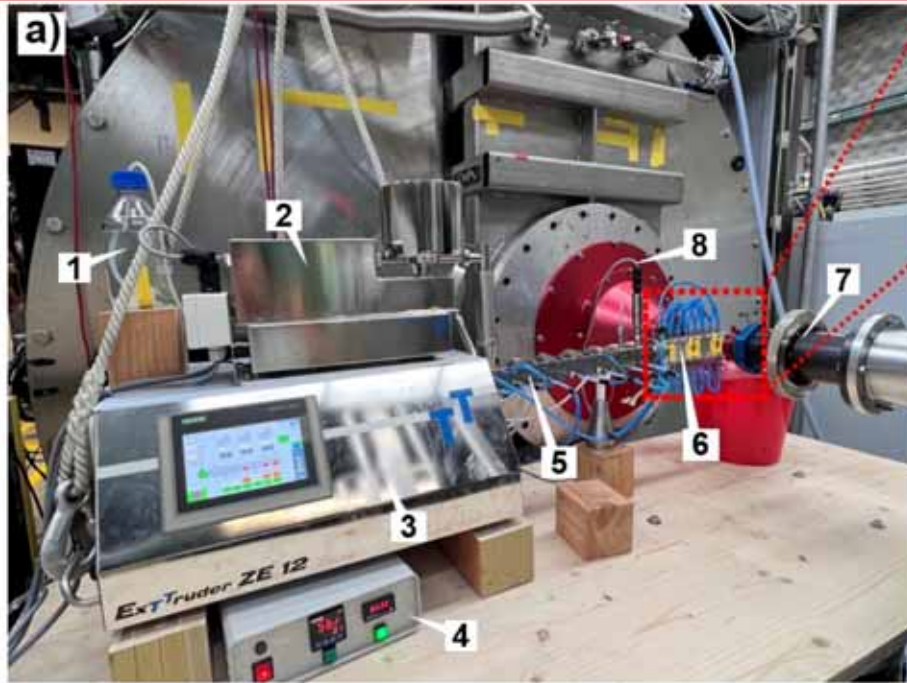


High moisture extrusion:

- Aqueous **protein flours**
- Heating to **130-150° C**
- **Denaturation** and shearing
- Cross-linking of **protein-melt**
- **Alignment** of protein
- **Fiber** formation
- Cooling and **solidification** of melt flow



SANS: Placing an extruder in the beamline



Food Rule II: Do not eat anything with health claims

HEALTHY • CONSCIOUS • COFFEE



BEAN & BODY

coffee
anti-ox

Rainforest Alliance Certified Coffee
with Superfruit Flavors and Herbs

BEAN OF IMMORTALITY
ALL NATURAL
BOUTIQUE BREWED FOR WELLNESS
8 FL OZ (240mL)

PUT DOWN FREE RADICALS WITH A MOVE TO HIGHER GROUNDS
BEAN & BODY anti-ox is a harmonious blend of artisan organic coffee and the powerful health promoting antioxidant flavors of pomegranate, açai berries and blueberries. Antioxidants help protect your body's cells from damage caused by harmful free radicals. Savor your youth with the great taste of coffee anti-ox. Bon Cofféit!

SIP HEALTHY, LIVE HAPPY
BEAN & BODY Ultra Premium Organic Coffee
with a Tease of Sweetness and a Splash of Milk

Nutrition Facts
Serving Size: 1 can (8 fl oz)
Amount Per Serving
Calories 100 Calories from Fat 15
% Daily Value*

Total Fat	1.5g	2%
Saturated Fat	1g	5%
Trans Fat	0g	
Cholesterol	5mg	2%
Sodium	65mg	3%
Total Carbohydrate	17g	6%
Dietary Fiber	0g	0%
Sugars	17g	
Protein	4g	
Vitamin A	4%	Vitamin C 2%
Calcium	15%	Iron 0%

*Percent Daily Values are based on a 2,000 calorie diet.

CONTAINS 39mg CAFFEINE

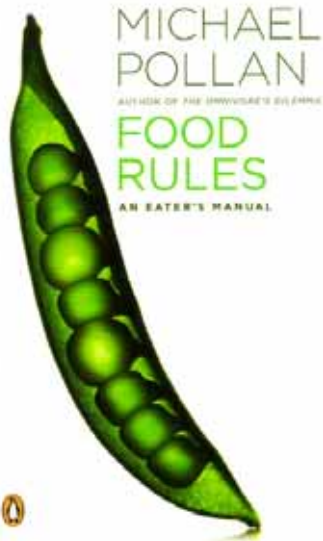
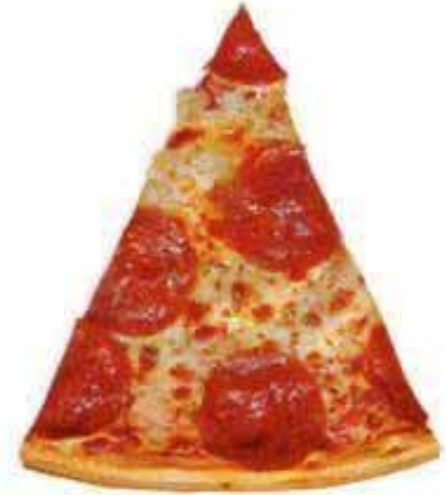
healthier human BEAN
average. Tested and Certified by Brunswick Labs.
filled or over ice. Refrigerate after opening.

INGREDIENTS: BREWED COFFEE (FILTERED WATER, ORGANIC AND RAINFOREST ALLIANCE CERTIFIED COFFEE), ORGANIC DRIED CANE SYRUP, WHOLE MILK SOLIDS, NON-FAT DRY MILK, PECTIN, BAKING SODA, NATURAL FLAVORS (INCLUDING EXTRACTS OF POMEGRANATE, AÇAÍ AND BLUEBERRY), CARRAGEENAN, ASHWAGANDHA ROOT.

CONTAINS MILK.

Mini problem: The anti oxidant is a natural ingredient of the coffee bean!

Food Rule III: Eat food, not too much, mostly plants



CLOSE ENOUGH.

Thanks for listening

REVIEWS OF MODERN PHYSICS, VOLUME 95, APRIL–JUNE 2023

Featured in *Physics*

Culinary fluid mechanics and other currents in food science

Arnold J. T. M. Mathijssen 

*Department of Physics and Astronomy, University of Pennsylvania,
209 South 33rd Street, Philadelphia, Pennsylvania 19104, USA*

Maciej Lisicki 

*Institute of Theoretical Physics, Faculty of Physics, University of Warsaw,
Pasteura 5, 02-093 Warsaw, Poland*

Vivek N. Prakash 

*Departments of Physics, Biology, and Marine Biology and Ecology, University of Miami,
1320 Campo Sano Avenue, Coral Gables, Florida 33146, USA*

Endre J. L. Mossige 

*RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion, University of Oslo (UiO),
Forskningsveien 3A, 0373 Oslo, Norway*

