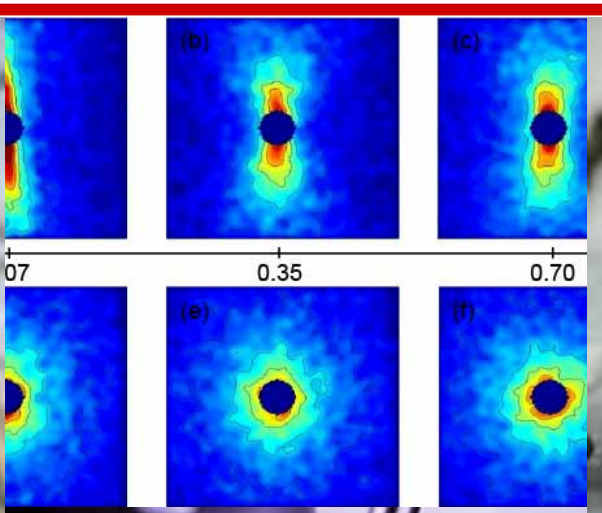
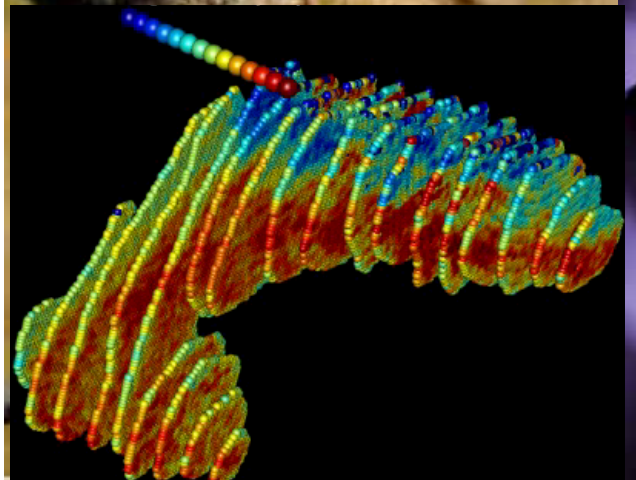
Once upon the time food was simple

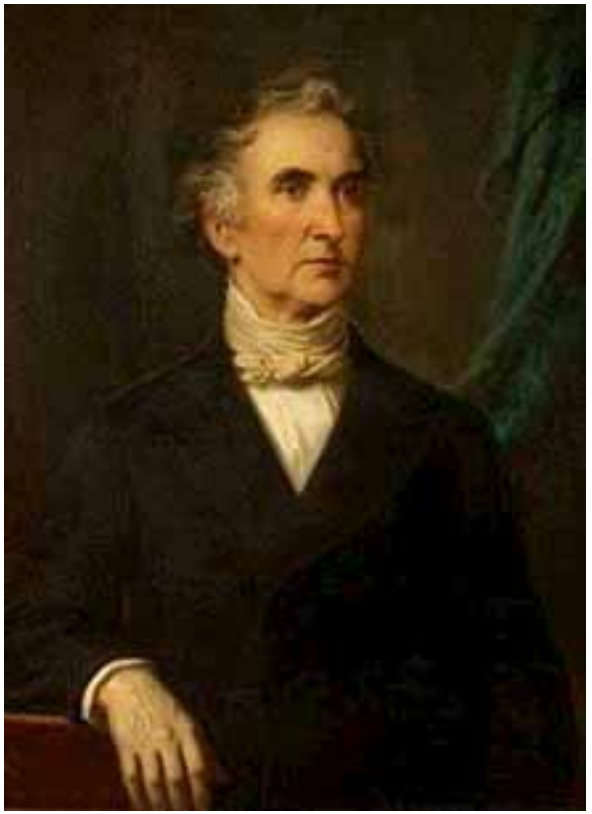
Peter Fischer, Institute of food, Nutrition and Health

ETH zürich





Once upon the time food was simple



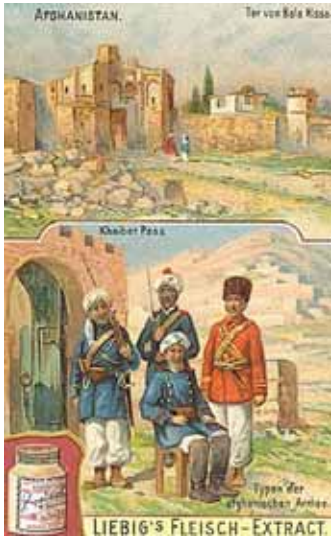
Justus Liebig
12. May 1803 in Darmstadt
18. April 1873 in Munich

Mayor contributions:
Organic Chemistry
Agricultural Chemistry

Food:
Liebigs Fleischextrakt (Meat extract) invested for the daughter of James Muspratt in 1852. Commercialized by Christian Giebert in Uruguay in 1862.

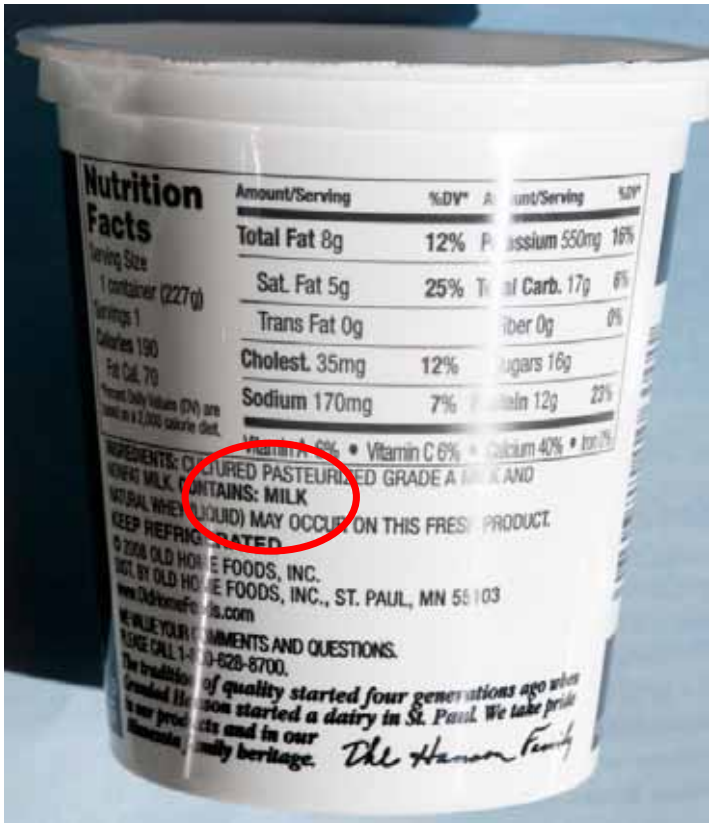
Baking powder (Horsford in the US, Doktor Oetker in Germany)

“Lipids, proteins and sugars”



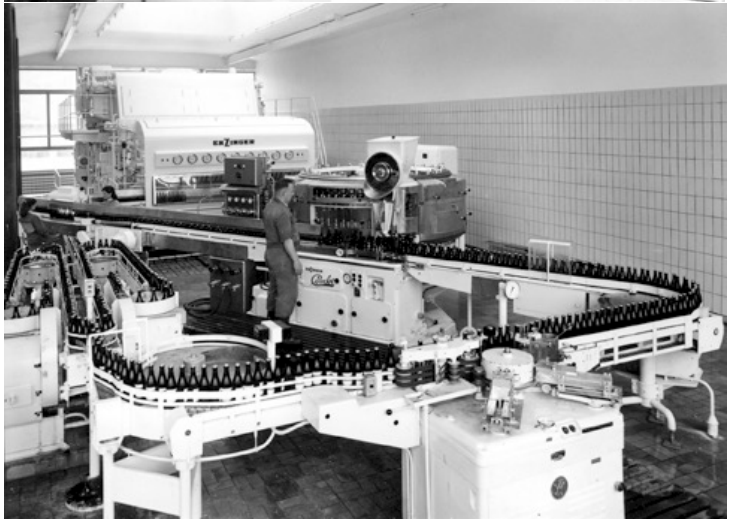
Food Rule I: Eat your grandma's diet

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

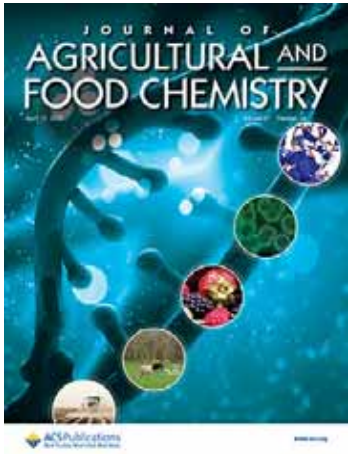
Paradigm change in the 1970s: Food science's golden age

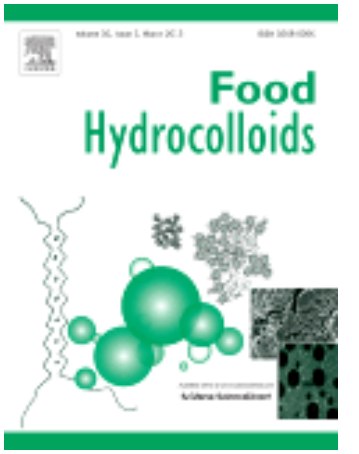
"Shift from eating food to eating nutrients"*

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

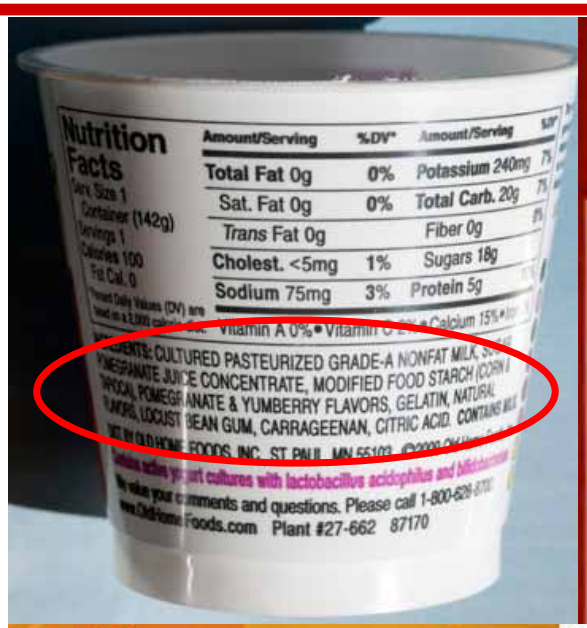
* Dietary Goals for the United States, FDA (January 1977), Report on Diet and Cancer, NAS (1982)

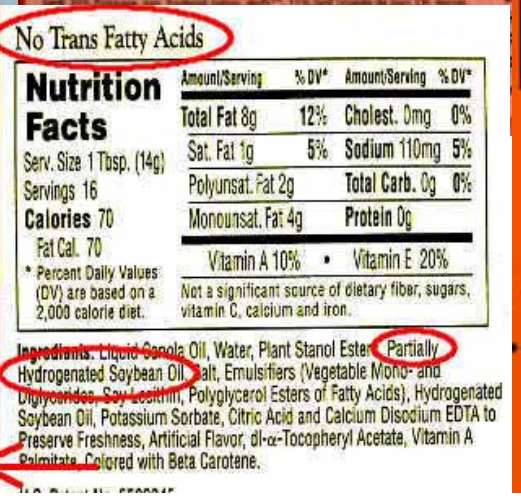
Paradigm change in the 1970s: The ingredients list

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 PYROPHOSPHATE (PRESERVE FRESHNESS), SODIUM BISULFITE (PRESERVE FRESHNESS), DIPOTASSIUM PHOSPHATE, ARTIFICIAL COLOR, CITRIC ACID (PRESERVE FRESHNESS), MIXED TOCOPHEROLS (PRESERVE FRESHNESS) AND LESS THAN 2% SILICON DIOXIDE ADDED AS AN ANTI-CAKING AGENT. **CONTAINS:** MILK, SOY.

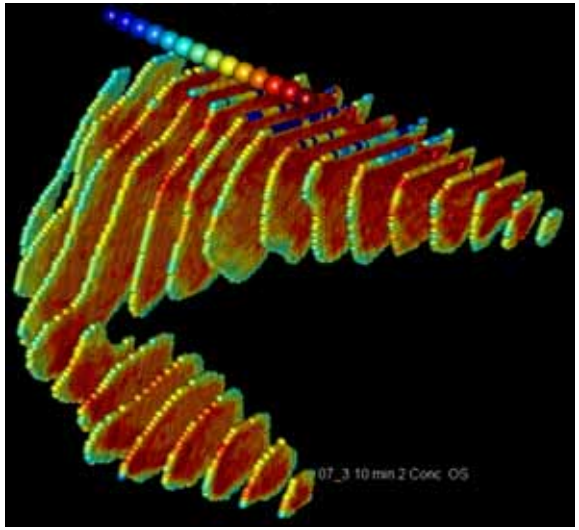
The ingredients list: Some more examples

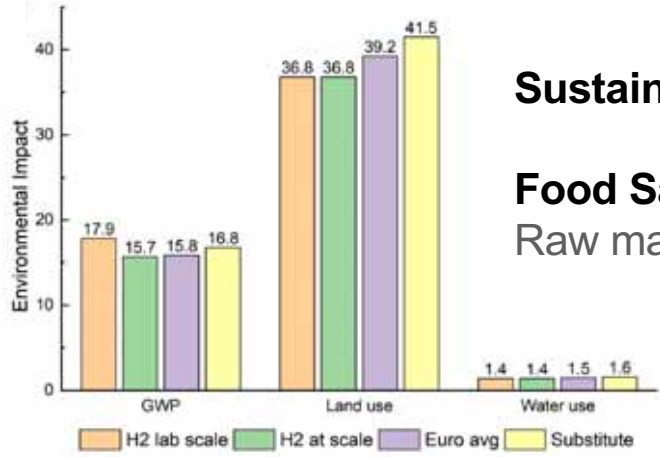




Skyrocketing expectation and some consequences

Food and Nutrition
Digestive emulsions





Sustainability

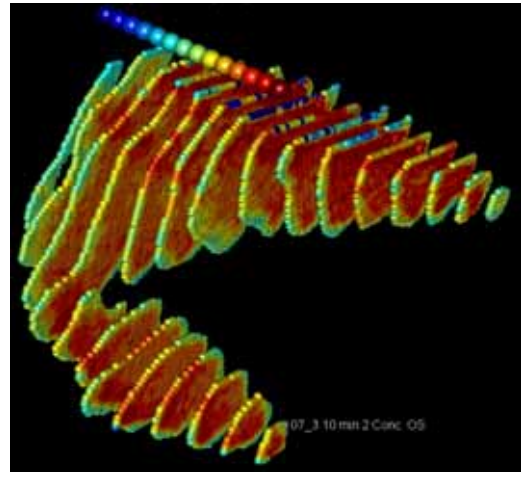
Food Safety
Raw material

Translation
From animal to plant
Meat analogues

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**, …

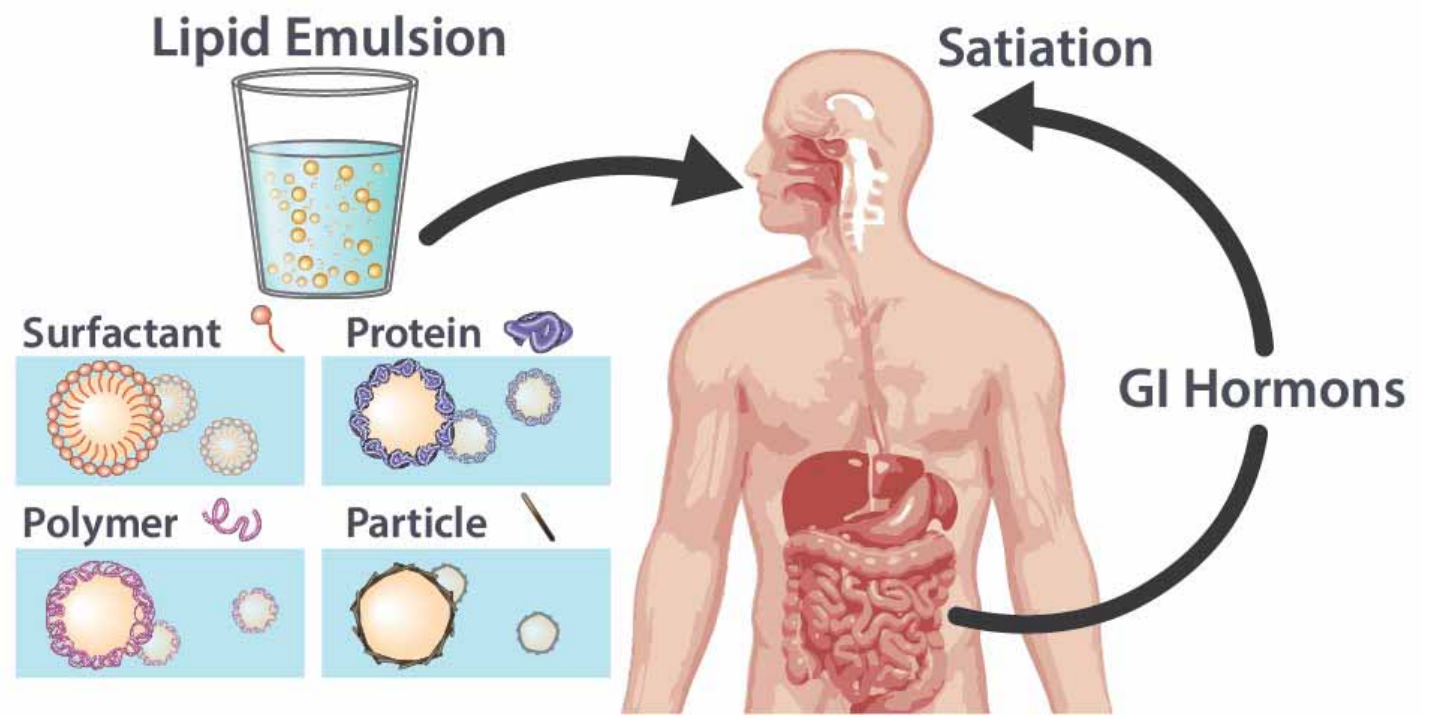
In **reverse engineering terms**: Food structures should fit our physiology.

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

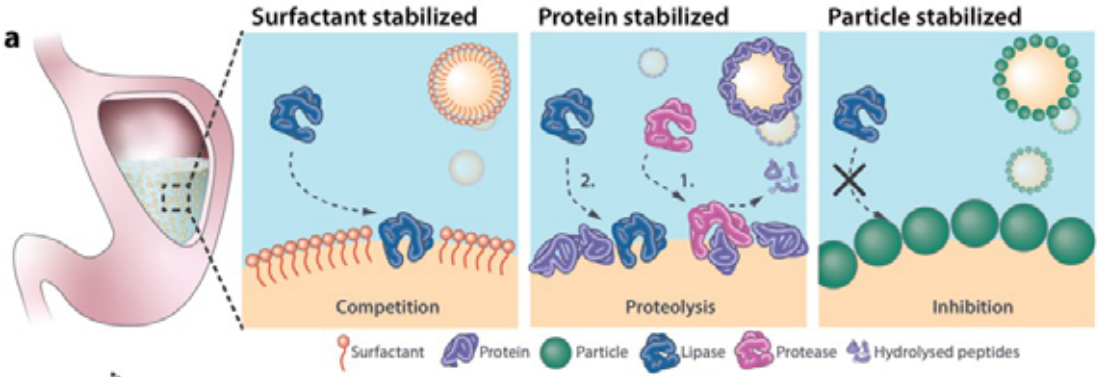
Increasing satiety by defined GI hormone release

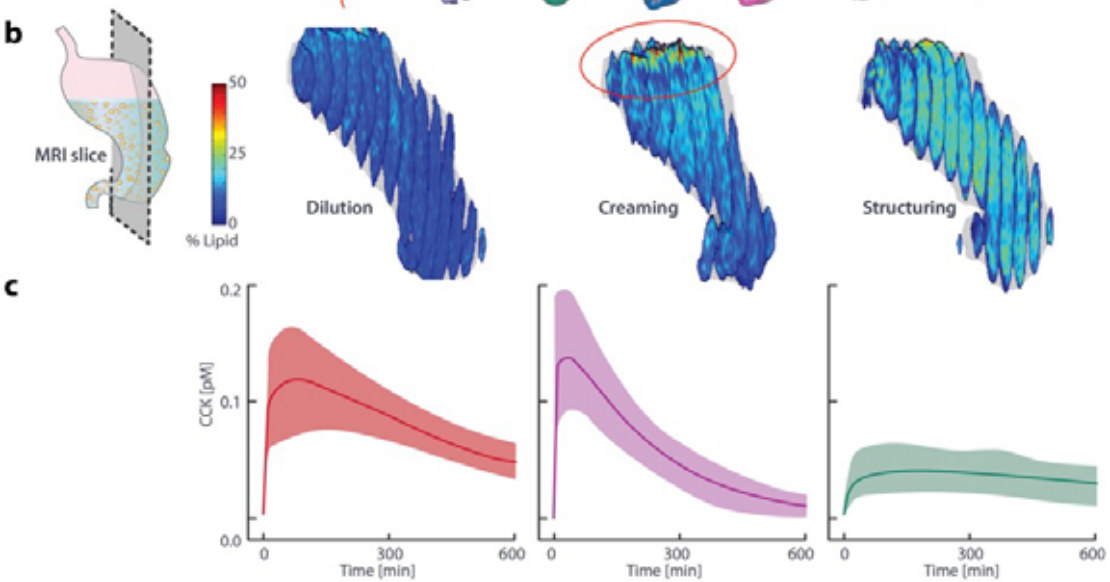


Idea*: Lipids in the small intestine will trigger satiety hormones
Problem: Lipid emulsions have to survive stomach

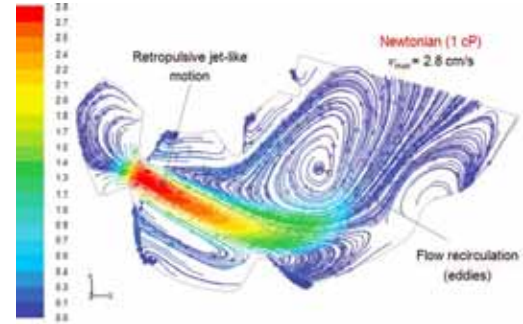
*Golding M, Wooster TJ: COCIS 15 (2010) 90

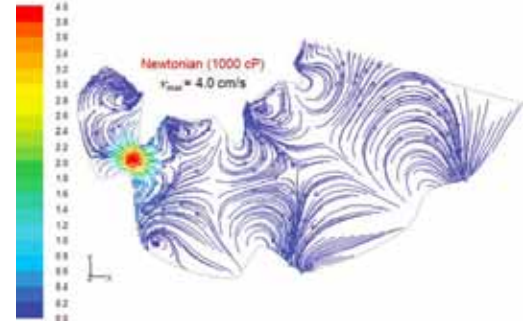
Stimuli-responsive emulsions: Summary & Tasks





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





Bertsch et al.: Food & Funct 13 (2022) 9010

Ferrua MJ, Singh RP: J Food Sci. 75 (2010) R151

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

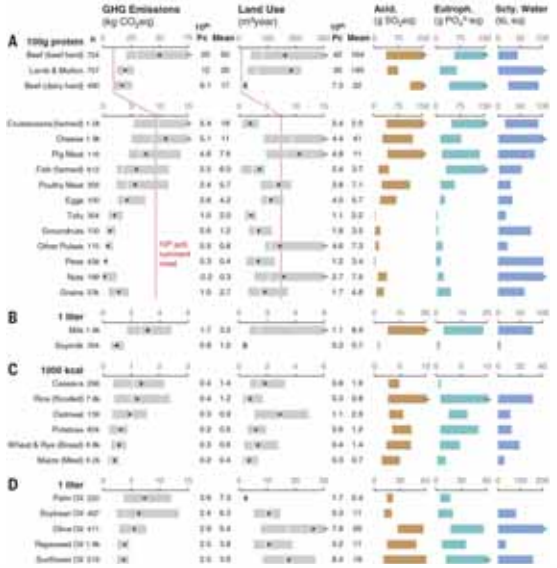
But before we get there: Sustainability

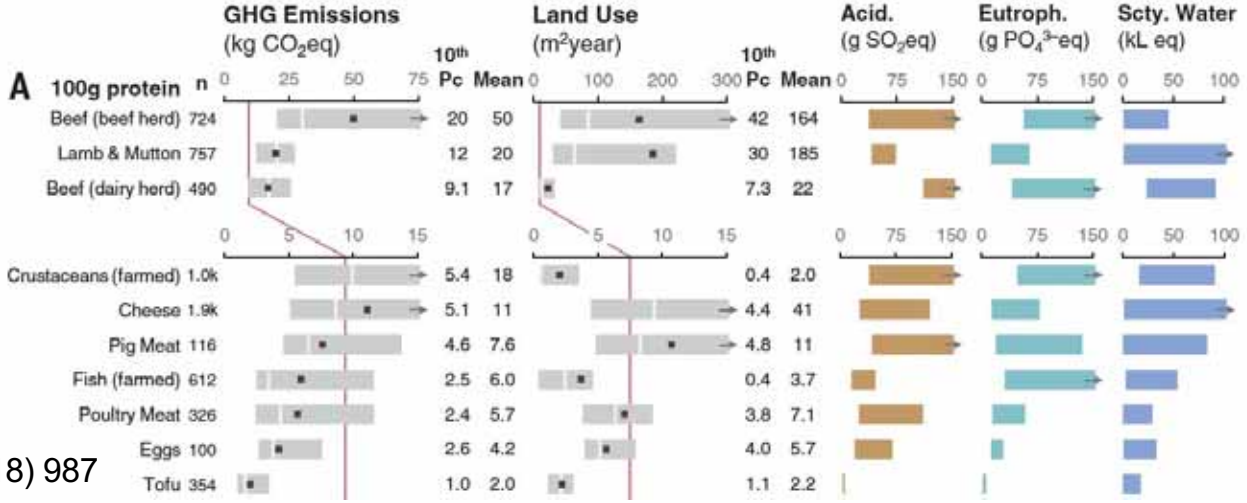
SUSTAINABILITY

Reducing food's environmental impacts through producers and consumers

J. Poore[1,2]* and T. Nemecek[3]

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.





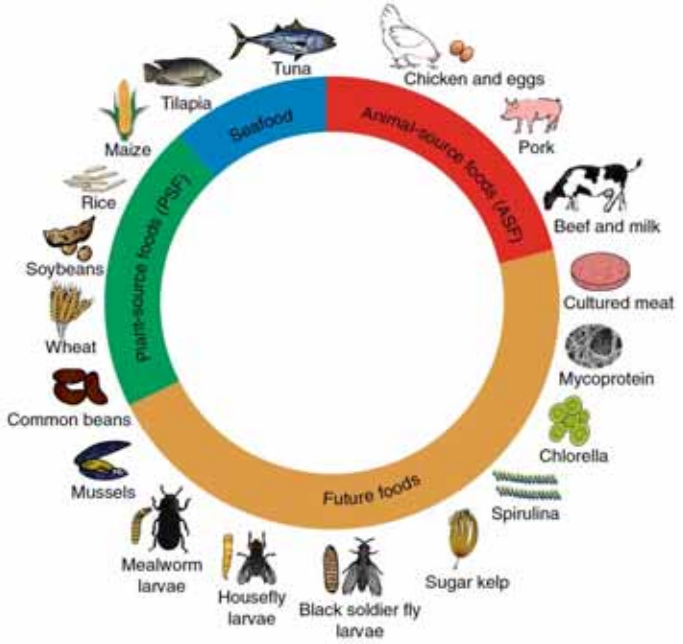
Poore et al.: Sci. 360 (2018) 987

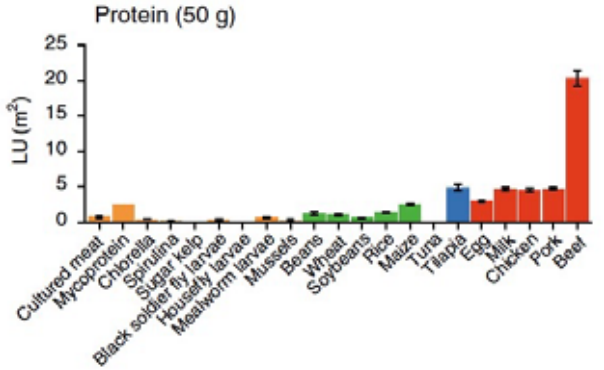
But before we get there: Sustainability & Health

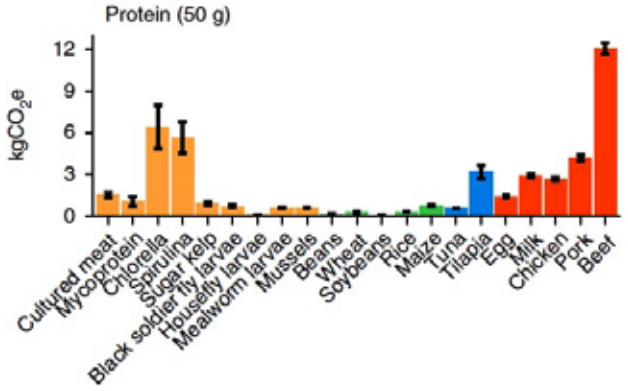
ARTICLES
https://doi.org/10.1038/s-41893-018-0189-7
nature sustainability
Corrected: Author Correction

The potential of future foods for sustainable and healthy diets

A. Parodi[1], A. Leip[2], I. J. M. De Boer[1], P. M. Slegers[3], F. Ziegler[4], E. H. M. Temme[5], M. Herrero[6], H. Tuomisto[7,8,9], H. Valin[10], C. E. Van Middelaar[1], J. J. A. Van Loon[11] and H. H. E. Van Zanten[1*]



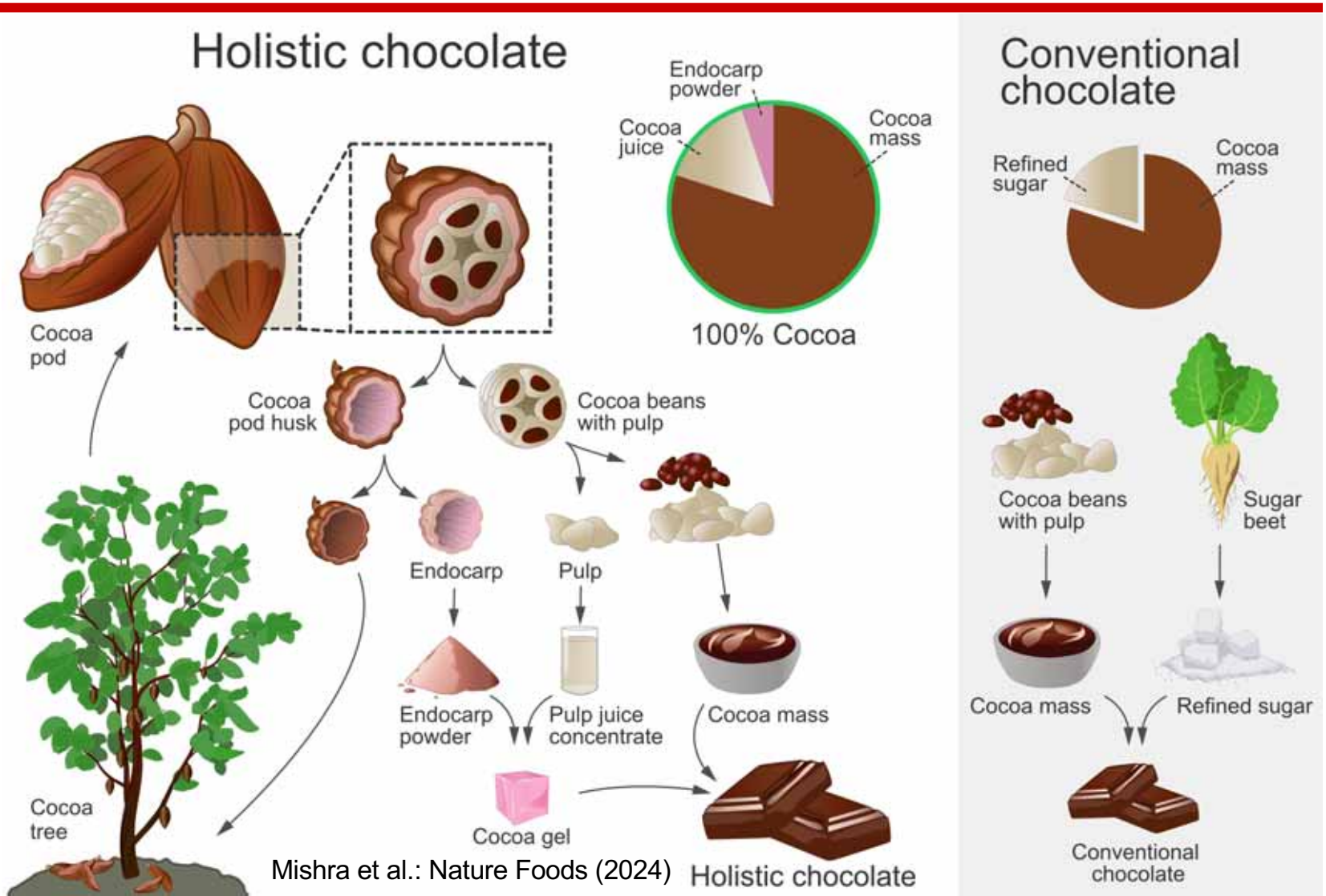




Waht needs to be done**?**

Parodi et al., Nature Sust. 1 (2018) 782

Sustainability & Health: Holistic chocolate (side streams)



Mishra et al.: Nature Foods (2024)

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

Structuring of plant protein melts

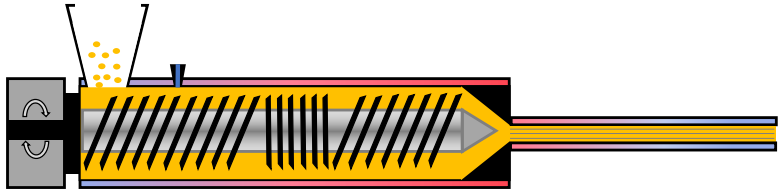
Milling and milk making

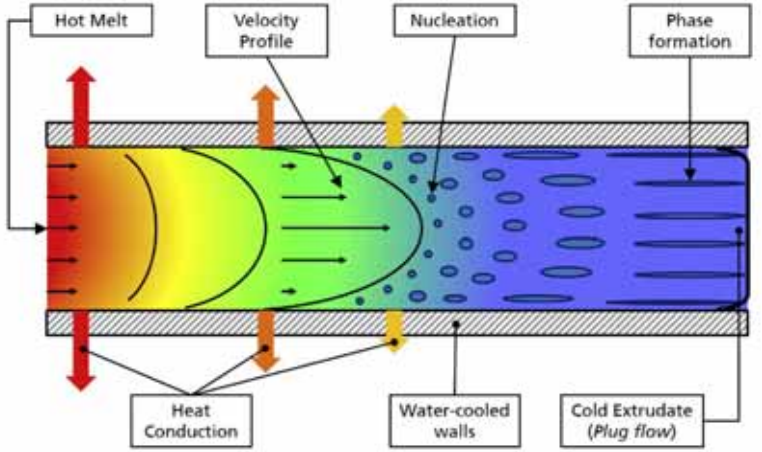
Meat analogues:
Extrusion of protein melts to mimic the structure of meat

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

How plant proteins are structured in extrusion?

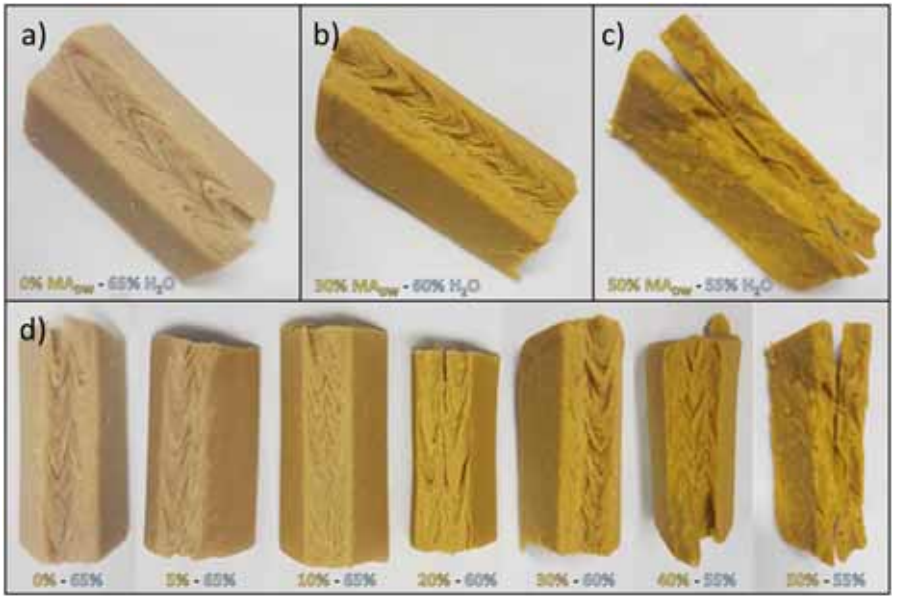
High moisture extrusion: Melt & Flow leads to Structure



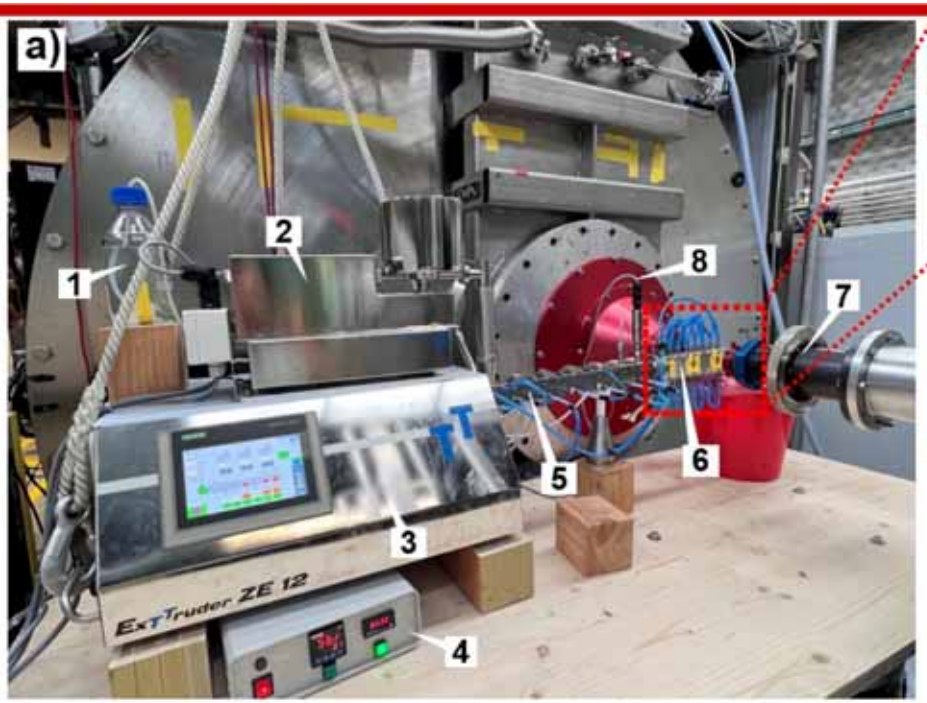


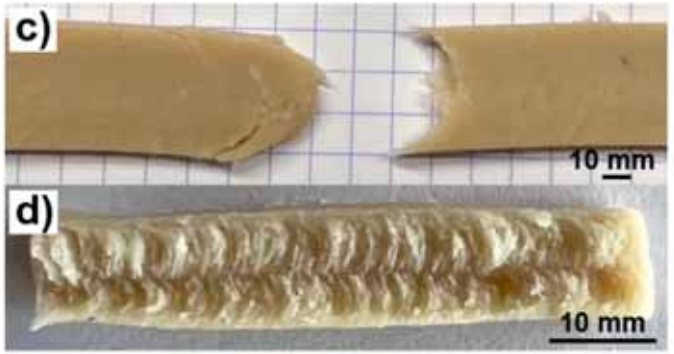
High moisture extrusion:

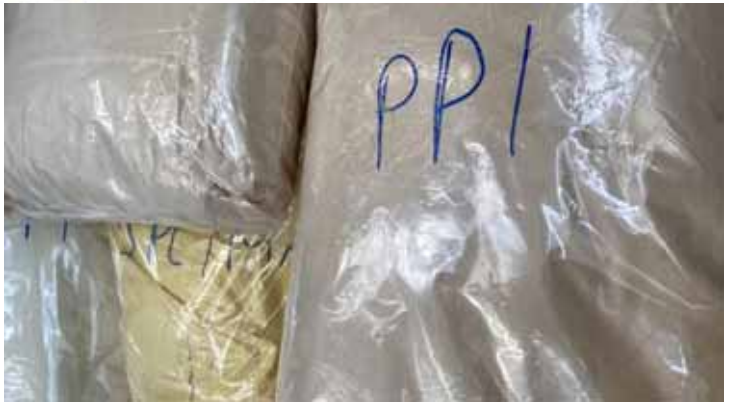
- Aqueous **protein flours**
- Heating to **130-150° C**
- **Denaturation** and shearing
- Cross-linking of **protein-melt**
- **Alignment** of protein
- **Fiber** formation
- Cooling and **solidification** of melt flow



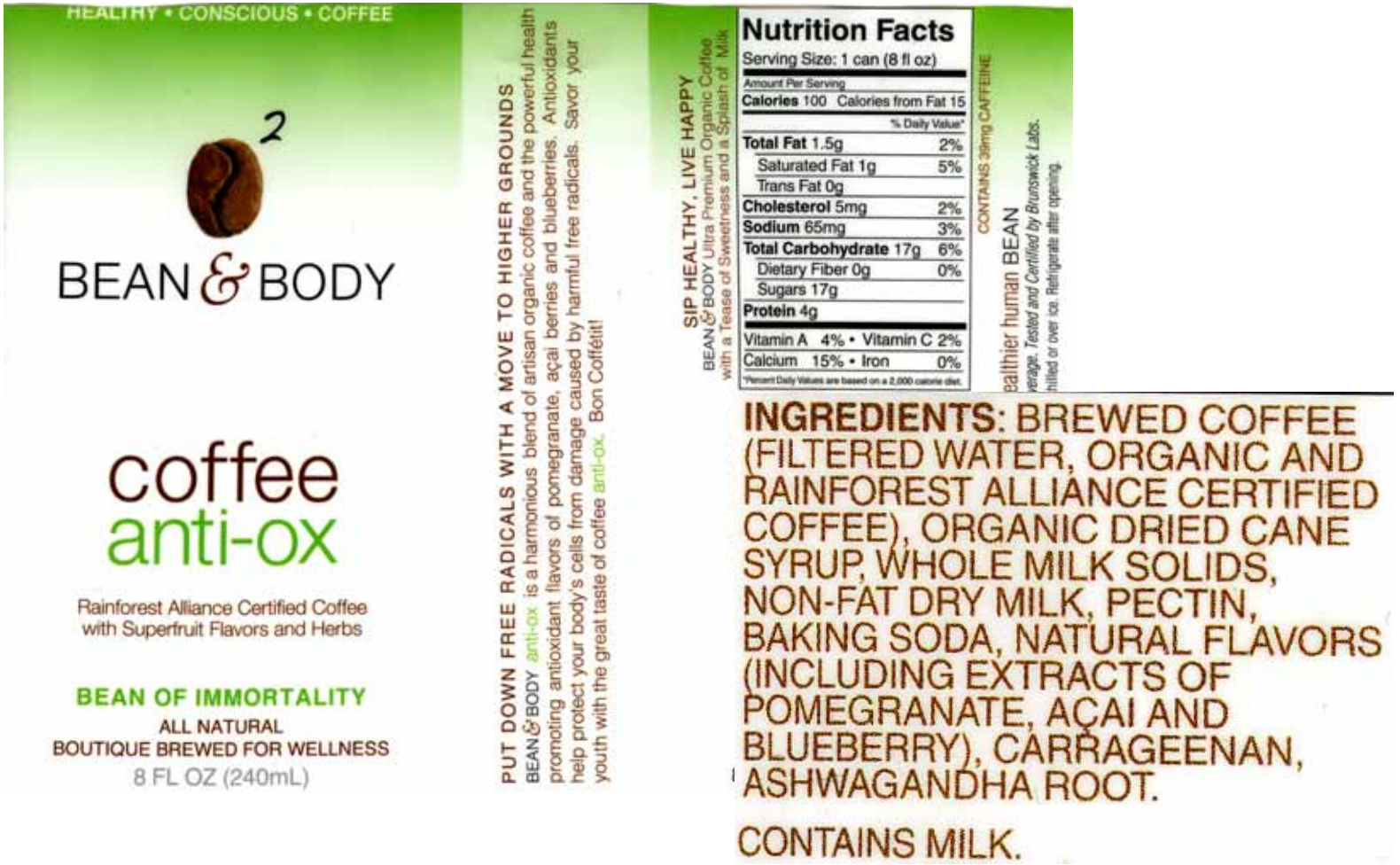
SANS: Placing an extruder in the beamline





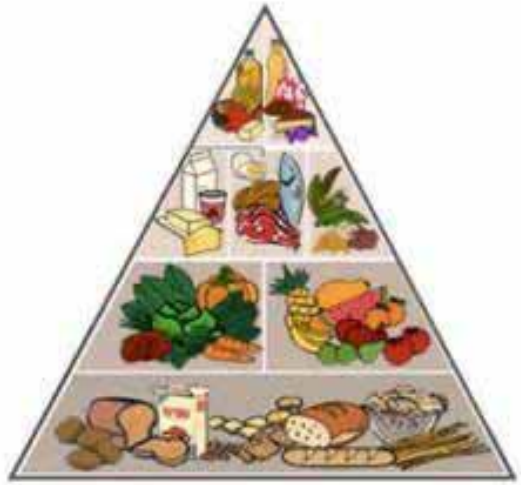


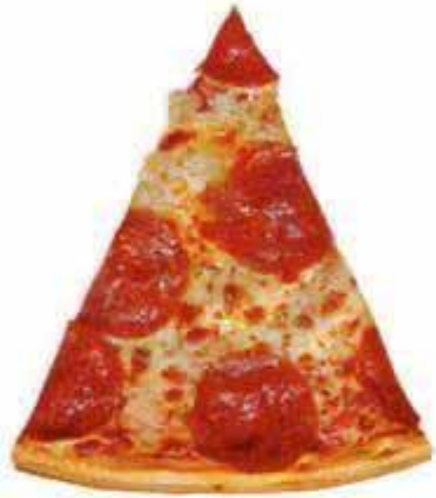
Food Rule II: Do not eat anything with health claims

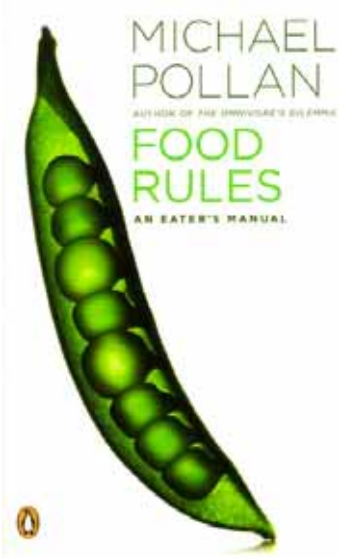


Mini problem: The anti oxidant is a natural ingredient of the coffee bean!

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







CLOSE ENOUGH.

Pollan M: In defense of food: An eater's manifesto (2008)
Michael Pollan: Food Rules (2010)

Thanks for listening

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

Featured in Physics

Culinary fluid mechanics and other currents in food science

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Mathijssen et al.: Rev. Mod Phys. 95 (2023) 025004