

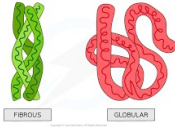
Agrifood Upcycling

Dr. Peter HANTZ
guest researcher

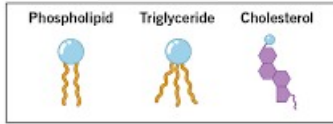


Composition

Proteins



Lipids



CARBOHYDRATES

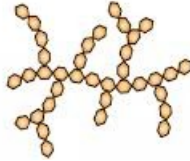
Monosaccharide



Disaccharide



Polysaccharide



Macros:

- proteins – reduced N
- fats
- carbs

simple carbs

MOSTLY POLYSACCHARIDES

“noble fibers”

starch

hemicellulose

pectin

MOSTLY CELLULOSE :(

lignin C6-C3 :(:(:(

“Noble organics”

antioxidants

vitamins

...

CONTAMINANTS:

organic toxins

Cd, As, toxic metals

C : N (:P : Mg :S : ...) ratios:
what for? which microbes?

Lot of N: → fast metabolism, protein-rich, nitrogen-hungry

Main source: Animals

proteins, ammonium → nitrification

meat substitute

"chopped": flavors

mushrooms, molds

Soil

TO: animals: organic nitrogen

fungi: NO_x; advantage @ organic N

carnivore plants: @ organic N

plants: mainly NO_x

Lot of C: → structural, slow turnover

Main source: Plants

sugars, starch, polysach, fats...

Nutritional fibers

EtOH

Siling

Fuel

Soil

TO: depends...

Fight for Bioavailable Nitrogen

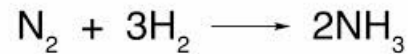


$\text{N}\equiv\text{N}$ strong, fight for bioavailable N (red./ox.),
Trump vs. Animals / plants



Guano wars: urea $\text{H}_2\text{N}-\text{C}(=\text{O})-\text{NH}_2$... $\rightarrow$ KNO_3

Ammonia Synthesis



Fritz Haber
(1868 - 1934)



Carl Bosch
(1874 - 1940)

N_2 - Nitrogen Gas

NO_2 - Nitrite

NO_3 - Nitrate

NH_4 - Ammonia



cca. 40% of our N:
Haber-Bosch

N-fixing microbes:
need LOT of energy

Use



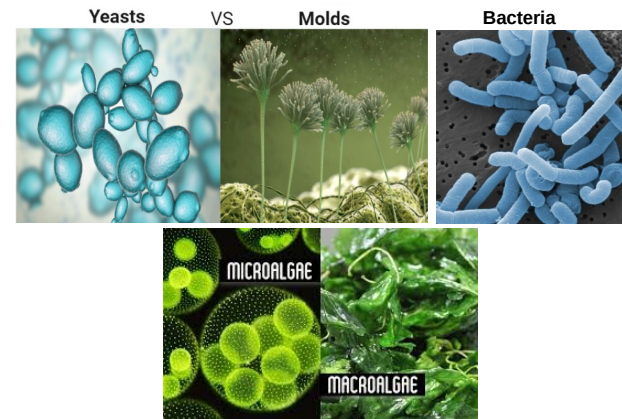
Bioconversion

- *Microbial fermentation
- *molds
- *bacteria: LAB, AAB, GAB, ...
- *yeasts

Algae

*Macro-fungi

Enzymatic transformation



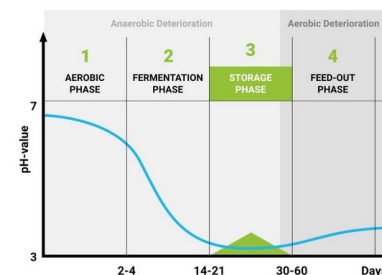
Human food

- *hydrogels /food, coat/ extracts
- *novel food combos
- bakery
- muesli



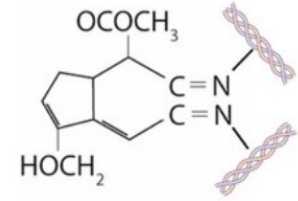
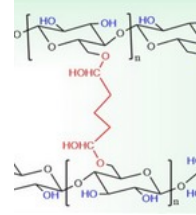
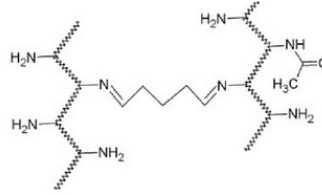
Animal feed

- processed
 - ***ensiling** (min. ~3% sugars, aw, ...)
 - *pelleting
- *aquaculture
- as-is



Materials

processed, extracted
pectin: sell it...
cross-linking
blending, composite
packing/paper industry



adobe

Soil

vermicompost
compost
fertilizer (hi-N)
soil conditioner
mix / fortify



Energy

biogas
home: <5 cook per day
> 20 oC
city wastewater - OK



MAY BE SEQUENTIAL

The Fanta story

Original Fanta:

Germany during World War II

Max Keith, head of Coca-Cola Deutschland

wartime substitutes

apple pomace

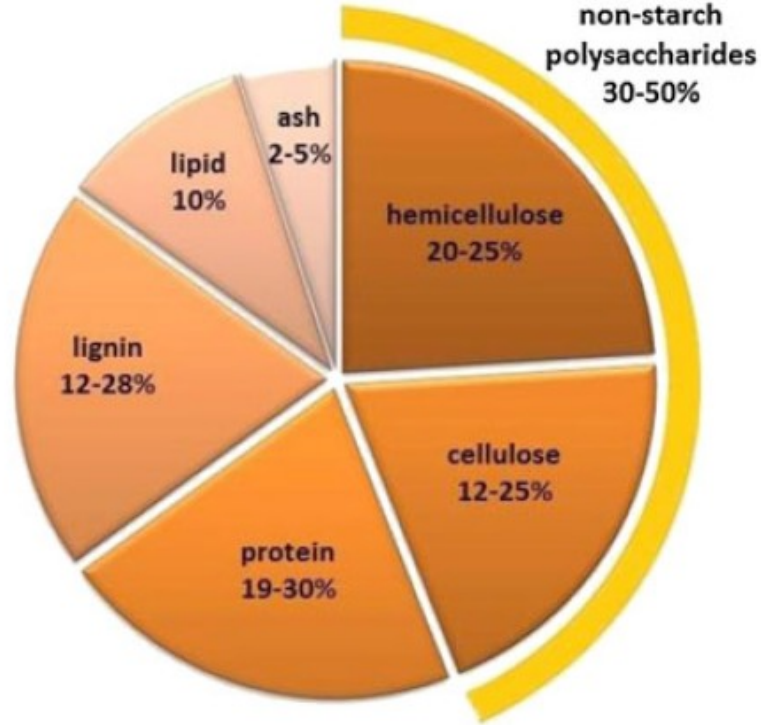
whey (a cheese byproduct)

discontinued

relaunched in 1955 (orange flavor)

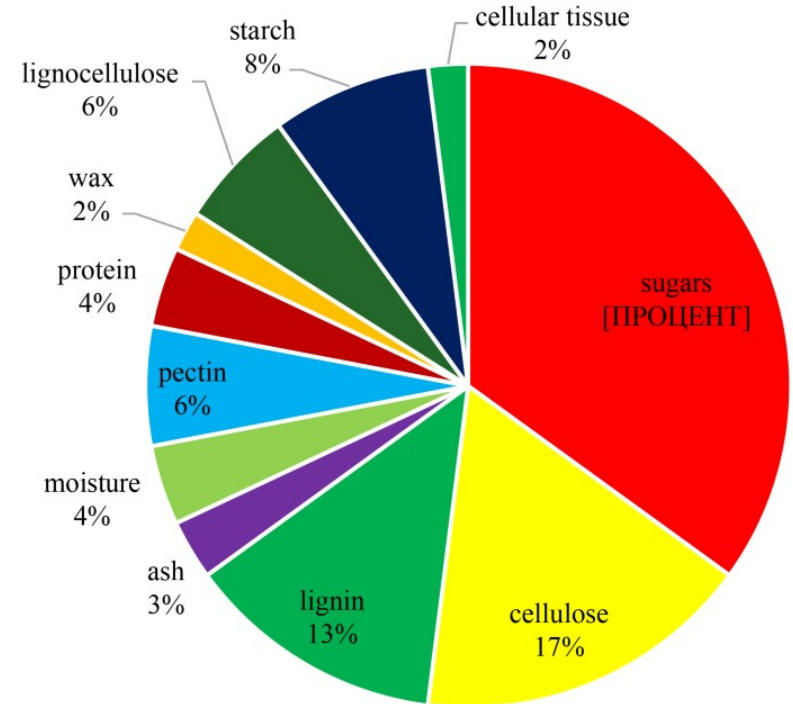


Beer/Milo Spent Grain



DOI 10.1002/jib.363
Brewers' spent grain: a review with an emphasis
on food and health, 2016

Apple Pomace



<https://link.springer.com/article/10.1186/s13568-023-01649-1>

AI-generated tables:

Component (% DM)	Wild Blueberry Pomace	Cultivated Blueberry Pomace	Raspberry Pomace
Protein	6–9	4–7	10–15
Fat (lipids)	2–4	1–3	12–20
Ash (minerals)	2–4	1.5–3	2–4
Total carbohydrates	75–85	80–88	60–70

Carbohydrate fraction (% DM)	Wild Blueberry Pomace	Cultivated Blueberry Pomace	Raspberry Pomace
Sugars (glucose, fructose)	5–10	8–15	3–8
Starch	<1	<1	<1
Total dietary fiber	55–65	60–70	45–55
└ Cellulose	20–30	25–35	15–25
└ Hemicellulose	10–15	12–18	8–12
└ Pectins	10–15	12–18	15–20
Other carbohydrates (oligosaccharides, polyphenol-bound carbs)	5–8	5–8	5–7

Note: oat/barley bran rich in beta-glucan

Fibers

Developed world:

only cca. 50% of recommended daily fiber intake

GUT MICROBIOME PROBLEMS if < 30-50g

	Fermentable	Non-fermentable
Soluble	pectin beta-glucan alginate inulin xanthan gum	polydextrose*
Insoluble	resistant starch hemicellulose (partly)	lignin cellulose (mostly)

:) Grass? Straw? Wood?: Lignin. Cellulose. Silicon



Almatörkölyös kenyér



Apple Pomace Snack - fiber supplement
Hydrocolloid innovation - good consistency

Apple pomace fortified bread
more fiber
better water retention

BSG / MSG

fiber, protein, nutty flavor
(up to 10-30% in recipes)

- Bakery goods
flour enrichment: protein, fiber
- Protein bars and snacks
- Beverages
protein isolates – “milk”
coffee substitute’s main part
- Plant-based meat alternatives



Biertreberbrot (German Spent Grain Bread)

By [Clarice Lam](#) Updated on 09/26/23
Tested by [Joan Velush](#)

★★★★★ (45)

Save Write a Review Print



This Drink Is Made Entirely From Spent Grains



BSG / MSG Fiber-boba (w/o molds)

Tapioca pearls
Anti-retrogradation tapioca pearls
Ca-alginate pearls



BSG
Milled BSG
extras

Tapioca: boil
Alginate: spherification



Added fiber...



Molds: Koji

***A. oryzae* (...) mold**

mostly : amylases

also : proteases

hemicellulases



Mix with starch-rich?

Improvement:

taste
digestibility

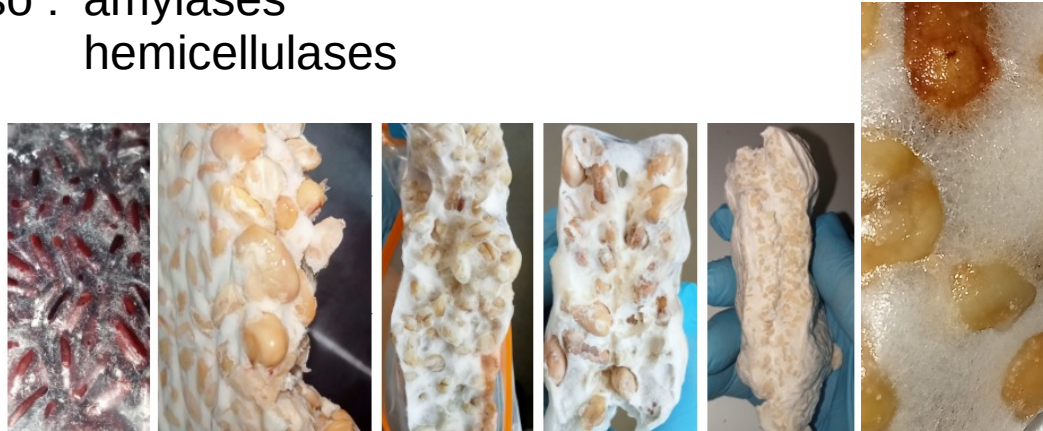
Molds: Tempe

***R. oligosporus* mold**

mostly : proteases

also : amylases

hemicellulases



Mix with protein-rich ?

Improvement:

texture
digestibility
B-vitamins

Also: “living biofoam”

Mix: Amylolysis

Saccharomycopsis fibuligera
Amylomices rouxii

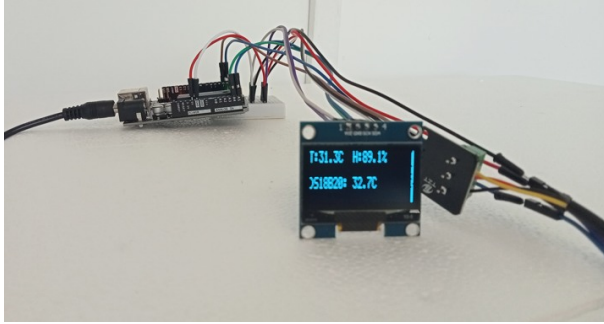


Mix: Extrusion

Single-screw direct expansion extruder

Parameter	Optimal Range
Moisture content	12-16%
Starch content	>60%
Protein	<15%
Fat	<5%
Sugar	<5%
Fibre - soluble	<10-12%
Fibre - insoluble	<5%
Temperature (die)	150-200°C
Pressure	20-80 bar

Molds: Cheap home “Fermentor”



Specialized microcontrollers
Self-assembled Arduino systems

Commercial solutions
Bakery proofer, climate chamber, egg incubator
... solid-state fermentor





Climate chambers with some airing:
Hestia, Remma, Memmert, Binder, ...



Induction Hokker (sámli)
Double-walled beakers



uC-driven dryers
Untroma, ...

Mushrooms / Molds:



Heating: 4–5 kW,

Oil-filled radiators

Electric space heaters (indirect airflow)



Humidification: 4–6 L/hour, with humidistat

Industrial ultrasonic humidifiers

Ultrasonic foggers in a water tank (DIY system)



Ventilation: regular or continuous

Exhaust fan with fresh air inlet

Timed ventilation (several air exchanges per day)

Low-speed continuous ventilation

Best of Vietnam



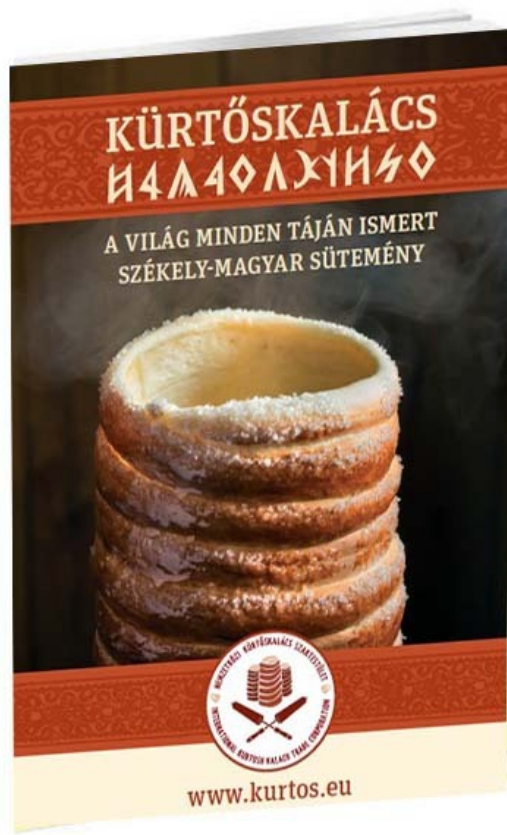
Best of Cambodia



Best of Cambodia



Best of Transylvania



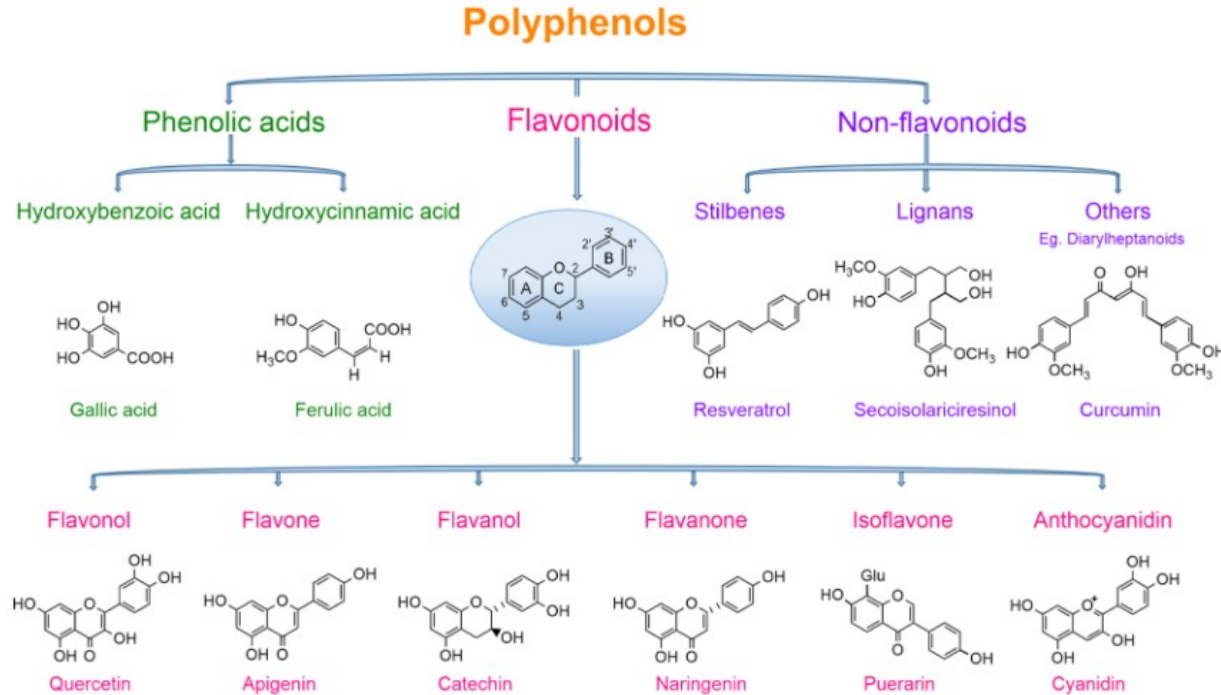
Thanks for your attention!



The knowledge is stored between heads,
not inside them.

Think
Outside the
Box

Antioxidant extraction



“gallic acid equivalent”

Apple core
Blueberry pomace
BSG

Food Source	Total Phenolics (mg GAE/g)
BSG (Average)	1.3 – 7.1
Blueberries	2-6
Apples	1-2
Citrus Fruits	1.5-3

After Instant Coffee: spent coffee grounds SCG

Typical composition ranges (dry weight basis):

Hemicellulose: ~30–40%

Lignin: ~20–30%

Cellulose: ~8–25%

Proteins: ~13–17%

Lipids: ~7–21%

“antinutrients” – metal abs.

Production, Composition, and Application of Coffee and Its Industrial Residues

Review Paper | Published: 31 March 2011

Volume 4, pages 661–672, (2011) [Cite this article](#)

The chemical composition of exhausted coffee waste

[D. Pujol^a](#), [C. Liu^a](#), [J. Gominho^c](#), [M.À. Olivella^b](#), [N. Fiol^a](#), [I. Villaescusa^a](#)  ,
[H. Pereira^c](#)

Spent coffee grounds: A review on current research and future prospects

[Rocio Campos-Vega^a](#)  , [Guadalupe Loarca-Piña^a](#),
[Haydée A. Vergara-Castañeda^c](#), [B. Dave Oomah^{b 1}](#)

Crosslinking

Glutaraldehyde (toxic)

–NH₂ groups via Schiff-base –C=N–

–OH groups

BTCA (butanetetracarboxylic acid), citric acid

–OH ester bounds

Genipin

amines –NH₂, –NH–, –N–.

TEMPO radical: -hard

Plasticizer: PEG>500

Enzymes: transglutaminase, laccase

U can't make nice microstructure...