



Current perspectives on the role of enzymes in brewing

Charlie Bamforth



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Beer has been drunk for more than 8,000 years

Ever since, it has become a staple part of the diet in many cultures.

And more besides...

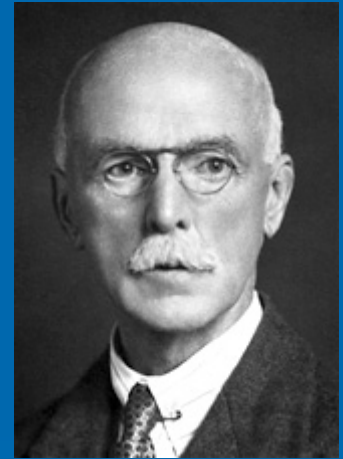
mouthwash, enema, douche, applicant to wounds



Steeped in enzymology



Eduard Buchner

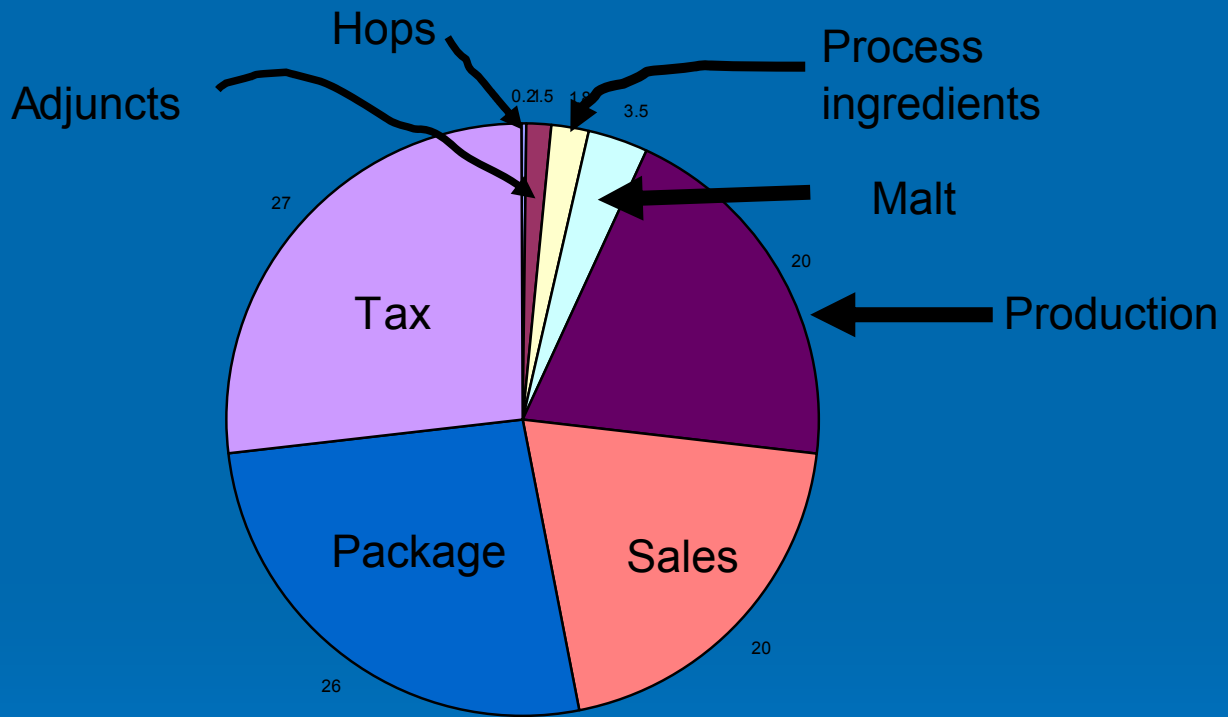


Arthur Harden

World Beer Volumes (million hectoliters)

Country	1970	1980	1990	1995	1999	2004
Denmark	7.1	8.2	9.0	10.1	8.0	8.5
France	20.3	21.6	21.4	20.6	19.9	16.8
Germany	103.7	115.9	120.2	117.4	112.8	106.2
Ireland	5.0	6.1	6.4	7.4	8.6	5.2
Netherlands	8.7	15.7	20.0	23.1	24.5	23.8
UK	55.1	64.8	61.8	56.8	57.9	57.4
South Africa	2.5	8.3	22.6	24.5	25.6	24.4
China	1.2	6.0	69.2	154.6	207.4	291.0
Japan	30.0	45.5	66.0	67.3	72.2	66.0
S Korea	0.9	5.8	13.0	17.6	14.9	20.2
Australia	15.5	19.5	19.4	17.9	17.3	17.6
Canada	15.8	21.6	22.6	22.8	23.0	23.1
US	158.0	227.8	238.9	233.7	236.5	233.2
Brazil	10.3	29.5	58.0	84.0	80.4	82.6
Mexico	14.4	27.3	39.7	44.5	57.3	68.5
WORLD	648.1	938.6	1,166.0	1,249.8	1,367.3	1,554.6

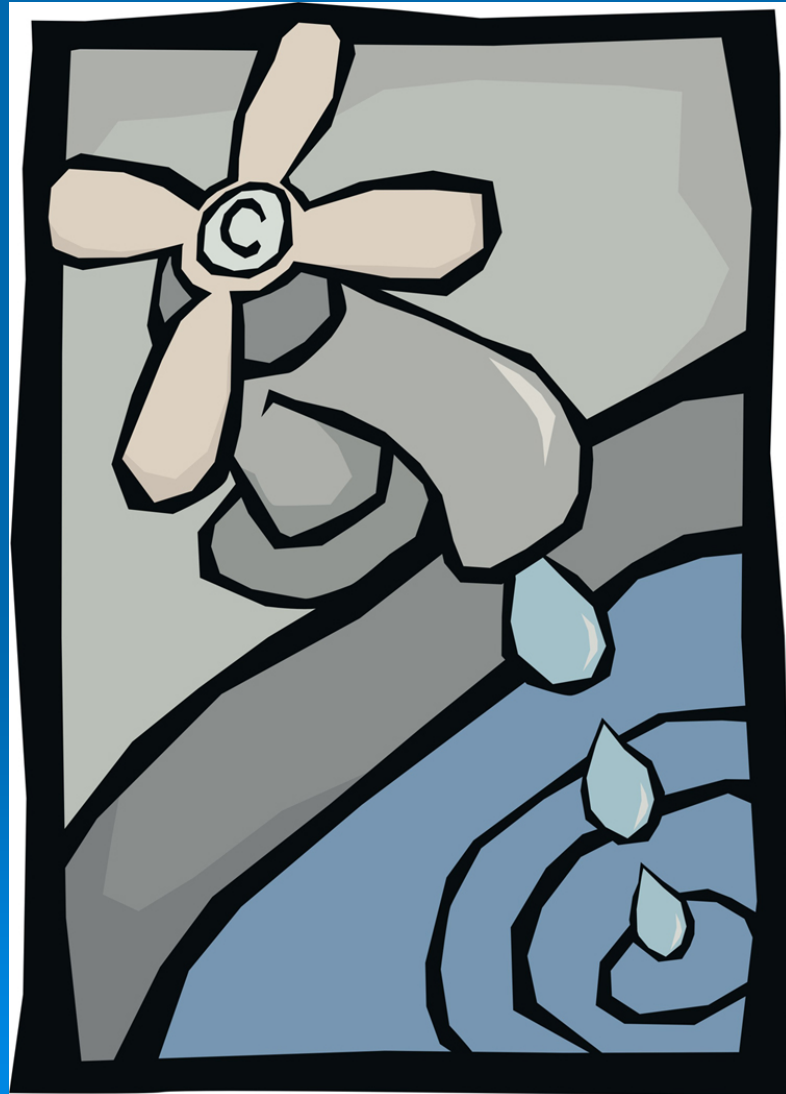
Brand	Volume (million hectoliters)
Budweiser and Bud Light	90.5
Skol	32.8
Corona	31.8
Snow	30.5
Brahma	25.0
Heineken	24.7
Coors and Coors Light	23.6
Miller Lite	21.6
Asahi Super Dry	17.5
Tsingtao	16.9
Yanjing	15.5
Jinxing	14.7
Polar	14.1
Busch	13.7
Harbin	13.7
Natural	13.3
Zhujiang	12.5
Antarctica	12.4
Carling Black Label	12.1
Carlsberg	11.7



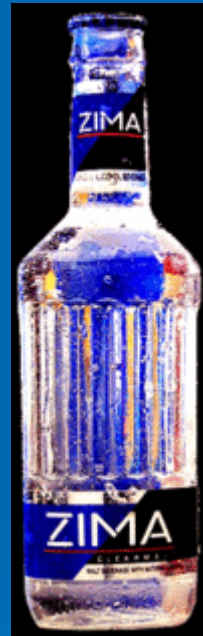
Happoshu/Third category



The Atkinsonian view



Malternatives



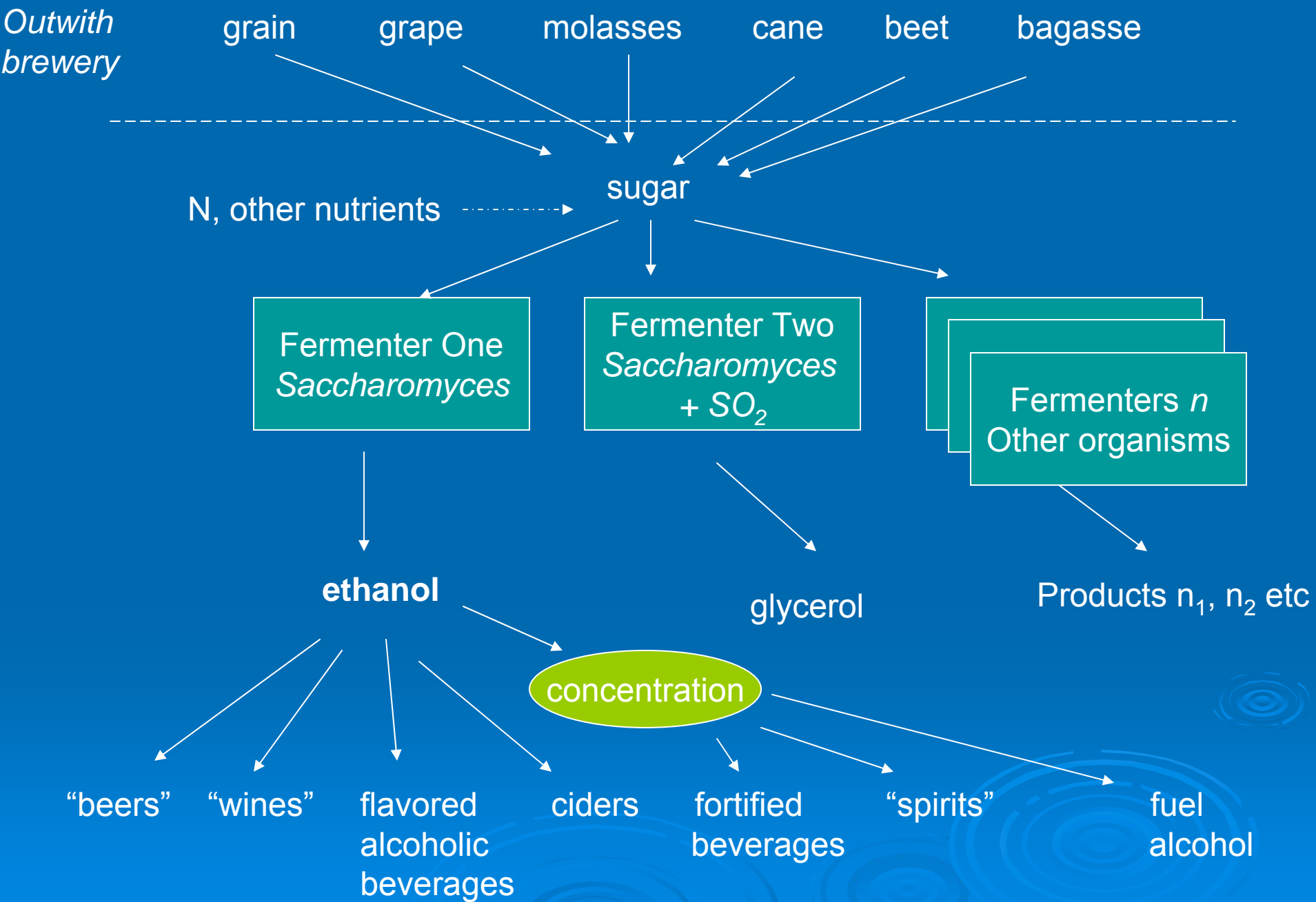
Anal retentivity



Wilhelm IV

Corn





Barley



2d steep; 4d germination; 1 d kiln

Malt

*4 week storage; milling, mashing
lautering (hh)*

Sweet wort

1-2h boil

Boiled wort

Cool, 3-10 d fermentation

“Green” beer

*3d- n weeks maturation, cold stabil-
ization, filtering*

Finished beer

packaging

Packaged beer



Culms/CO₂, VOC

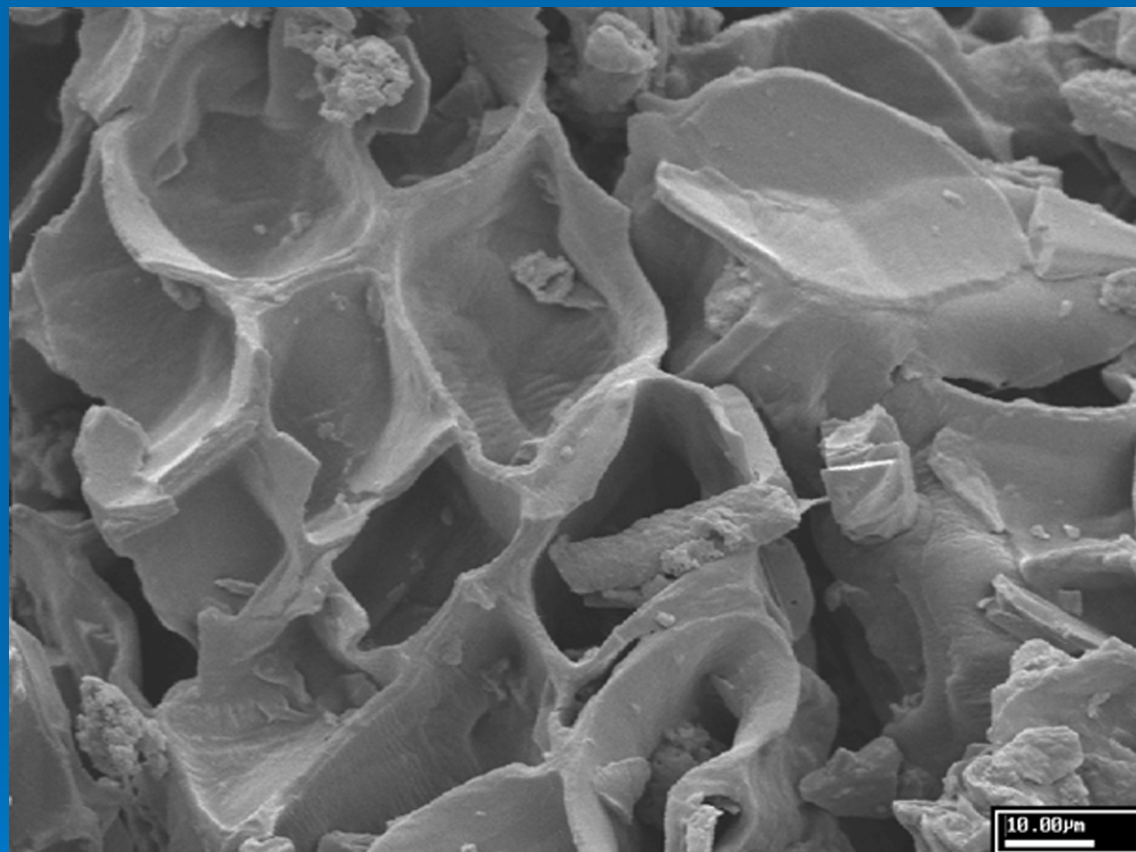
Spent grains

Trub

Yeast, CO₂

Filter aid

Water → ; Energy →

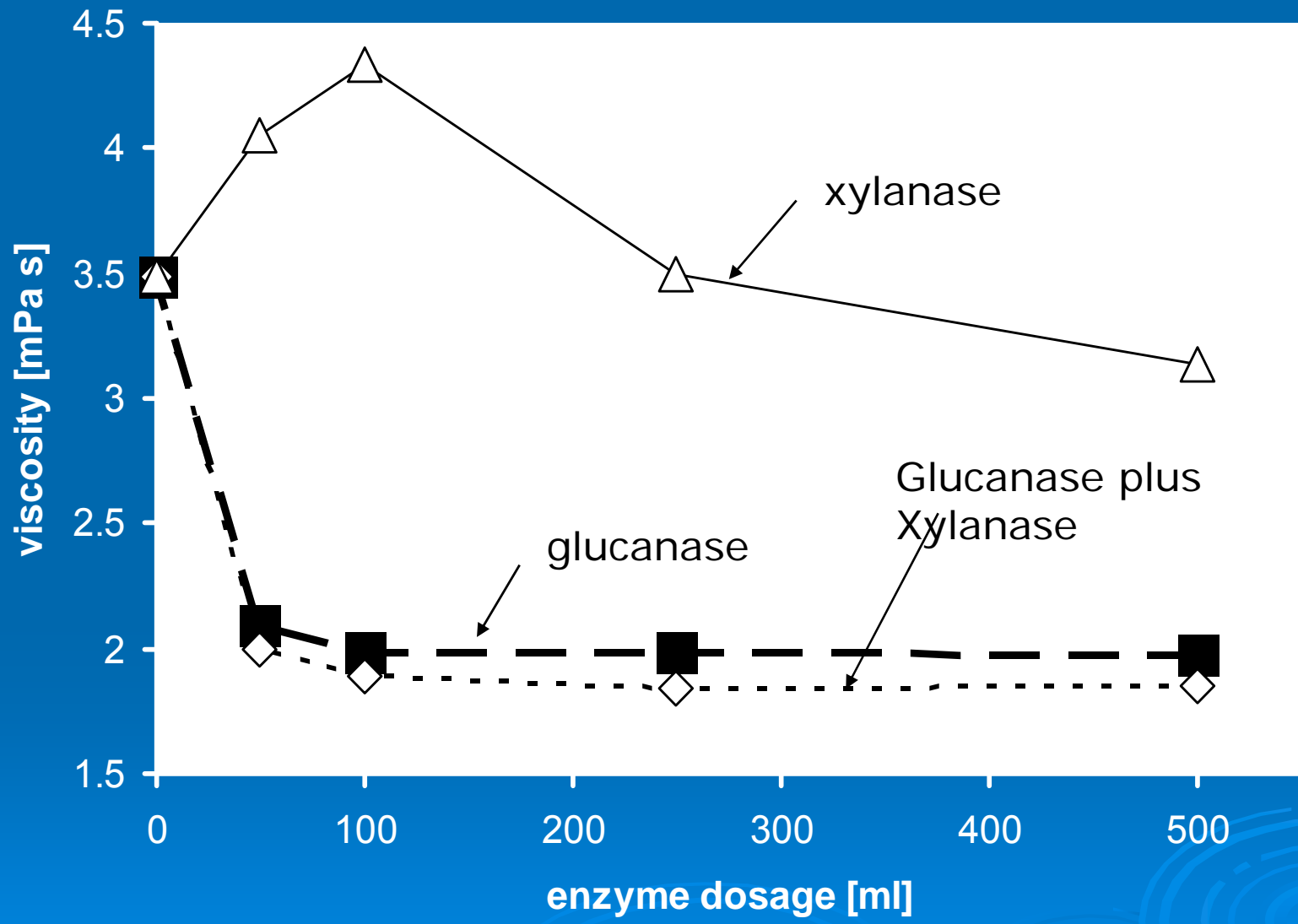


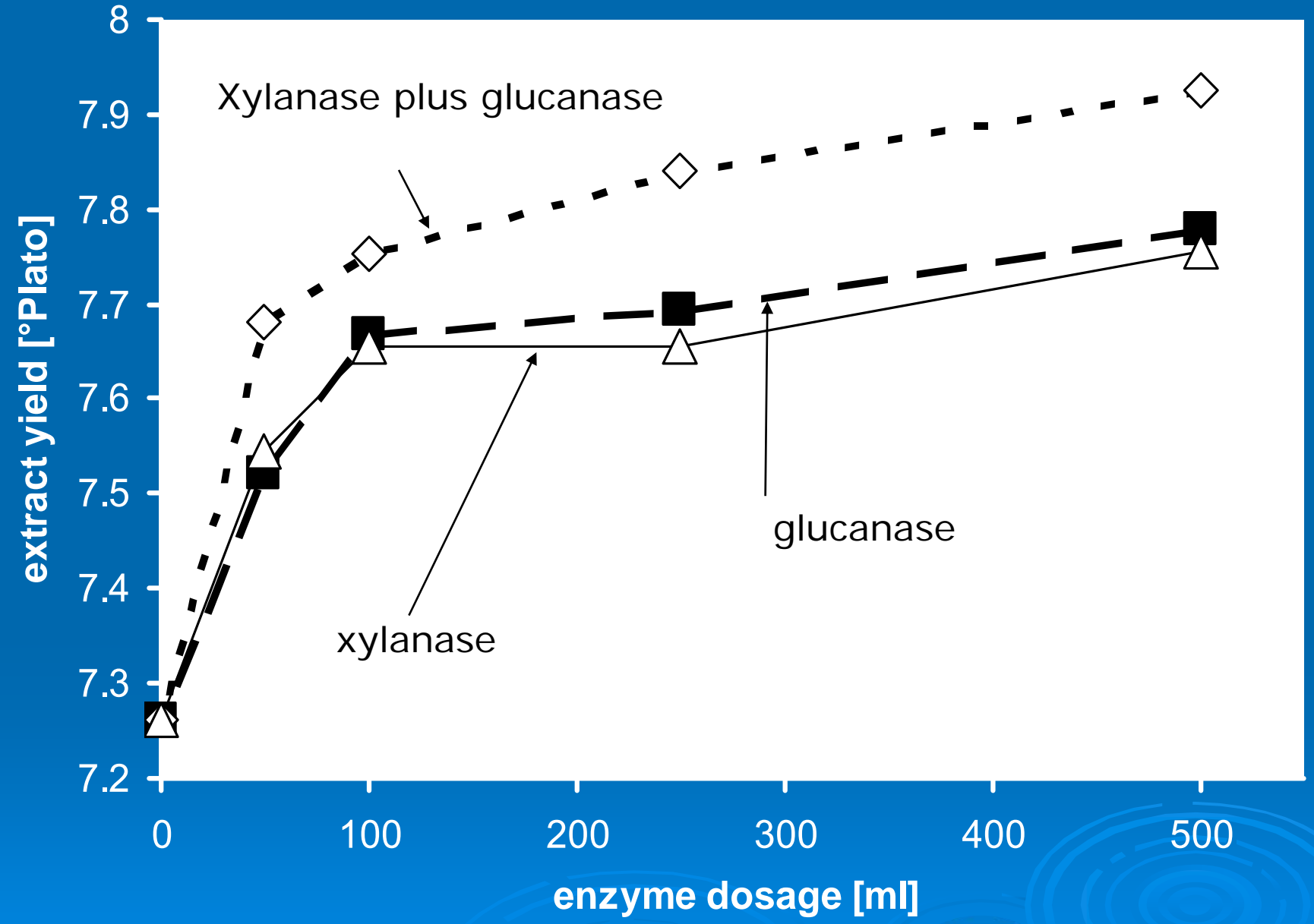
Solubilase

- Carboxypeptidase
- Acetylerase
- Feruloyl esterase
- Arabinofuranosidase
- Endo-xylanase

Endo- β 1 \rightarrow 3,1 \rightarrow 4-glucanases







Proteinolysis

- >42 endo-peptidases
- Carboxypeptidases
- inhibitors

Starch hydrolysis

- α -amylases
- β -amylases
- Limit dextrinase

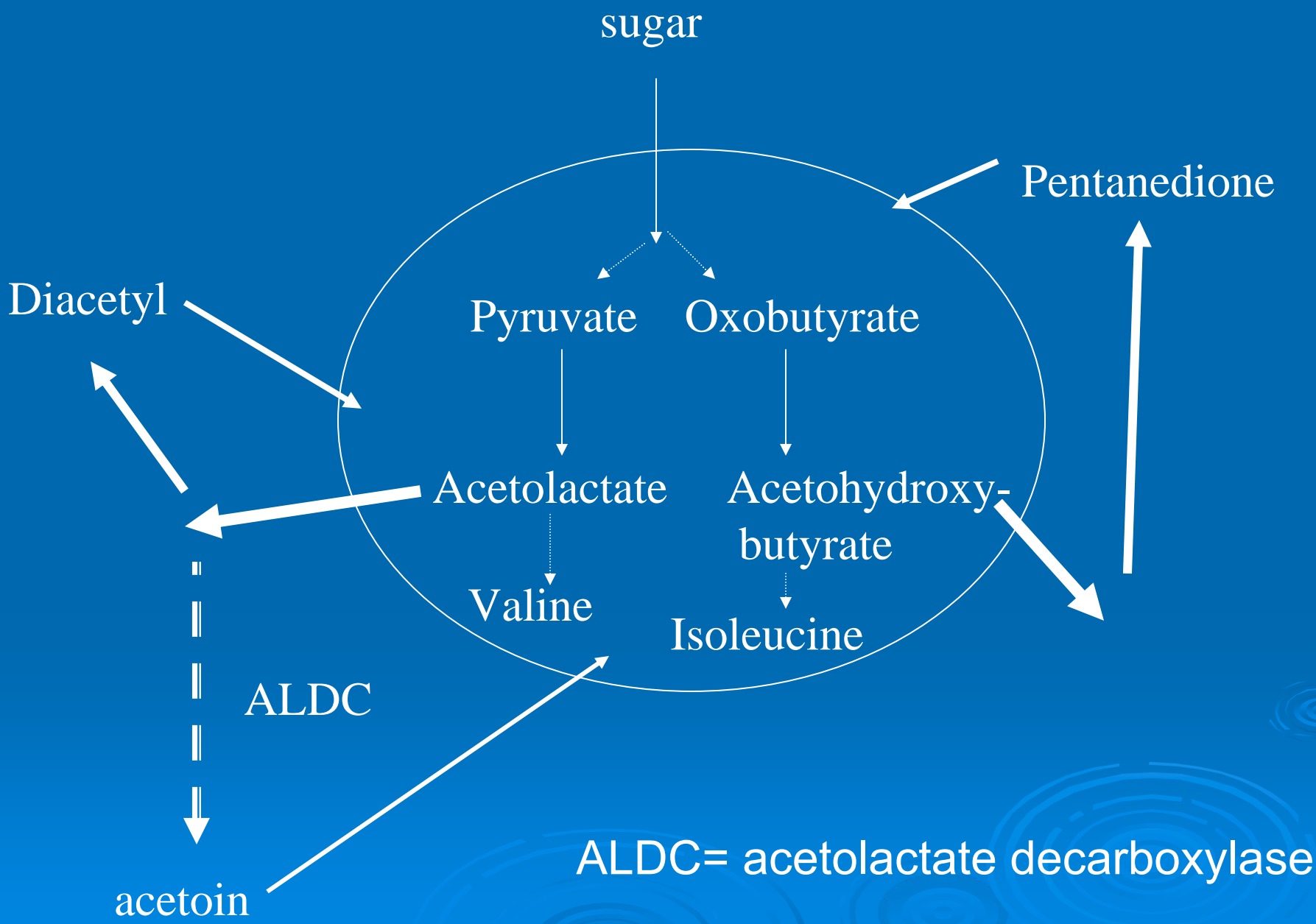
- Glucoamylase
- Pullulanase



Maturation

➤ Acetolactate decarboxylase





ALDC= acetolactate decarboxylase

Colloidal stabilization

- Papain
- Prolyl endopeptidase (*coeliac potential?*)



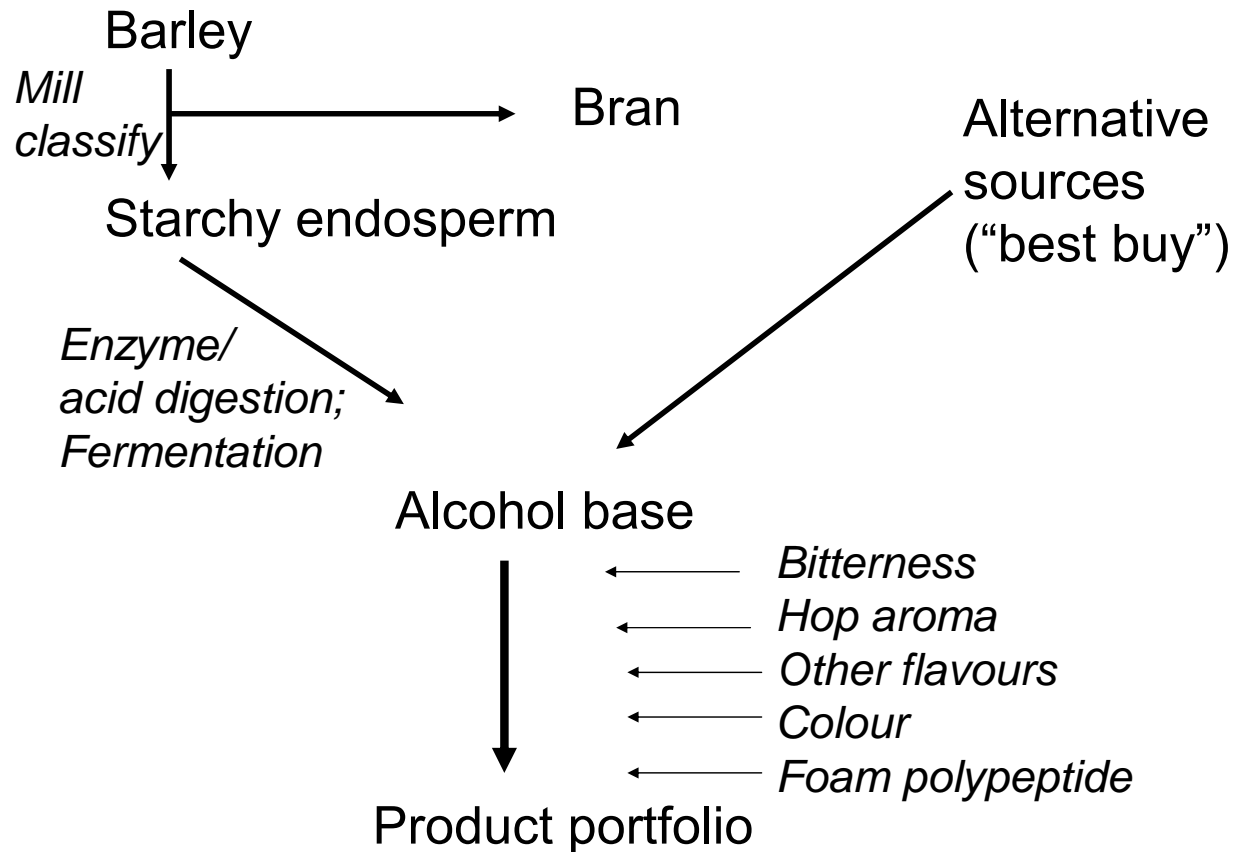
Flavor stability

- Lipoxygenase
- Glucose oxidase/catalase
- Peroxidase
- Superoxide dismutase/catalase

Hydrolysis of spent grains



Milling technology



Quality

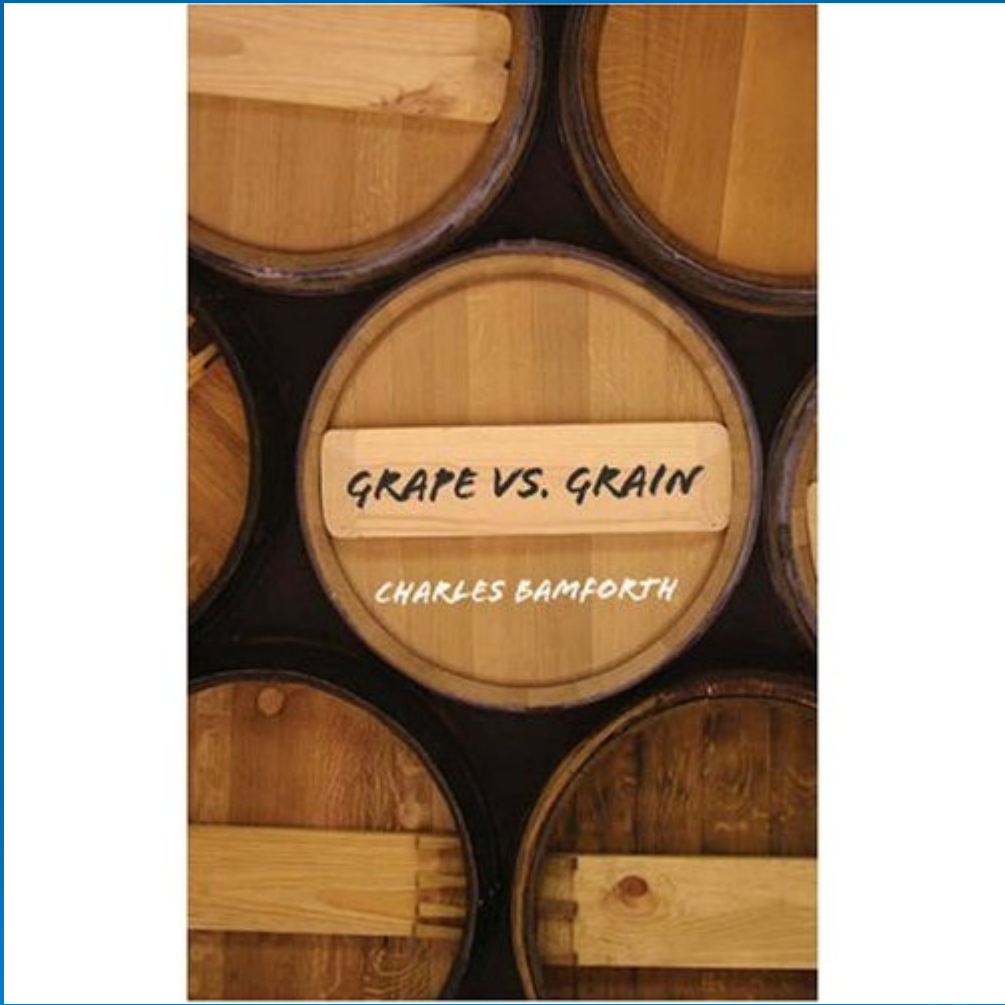
- Color
- Flavor
- Flavor Stability
- Foam
- Colloidal stability
- Health and wholesomeness



Does the future hold...

- Mass production of alcoholic beverages according to a new paradigm?
- “Slow” beer, produced traditionally?





GRAPE VS. GRAIN

CHARLES BAMFORTH