

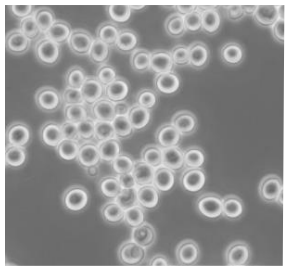

Acidic fermented beverages: Trends, functionality, production

Dr. Martin Senz

FIBW, Dept. Bioprocess Engineering and Applied Microbiology

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Content

- Acidic fermented beverages
- Co-cultures and means of control of the fermentation process
- Functionality (technological; nutritional; …)
- Product characteristics and life style
- Market forecast and current activities
- Ingredients of kombucha and water kefir
- Current knowledge about health effects
- Home brewing and industrial production and possible hurdles
- Summary

Acidic fermented beverages

+ Mainly in co-culture fermented beverages based on diverse raw materials
+ Different symbiotic cultures of bacteria and yeast
+ Most relevant fermentations for food & beverages: Acidic-, lactic- and alcoholic fermentation

- Kombucha
- Ginger Beer
- Kefir / Water kefir
- Kvass
- *Berliner Weiße*
- *Lambic Beer*
- *…*

Examples: Kombucha / Water kefir

+ Traditionally produced via **“Tea fungi”**

- Sweetened *(Sucrose, 60-80 g/L)* Tea *(black, green)* with tea fungi and 10% old kombucha
- *SCOBY = *Symbiotic Culture of Bacteria and Yeast*
- Mostly in big closed vessels with enough head space
- Incubation for 7 – 10 d, 18 ºC to 26ºC
- Characteristic sweet acetic taste, mild carbonized

Yeast
→ Usage of sucrose and production of alcohol

Oxygen

Bacteria (Acetic acid and lactic acid bacteria; AAB and LAB)
→ Alcohol to acid (AAB)
→ Formation of bacteria cellulose

+ Traditionally produced via **“Kefir-crystals”**

- Sweetened *(Sucrose, 60-80 g/L)* water with kefir crystals and dried fruits *(→ nitrogen source)*
- Mostly in big closed vessels with minor head space
- Incubation for 2 – 3 d, 18 ºC to 26ºC
- Characteristic sweet acetic, fresh and mild carbonized taste. Similarities to young fruit wine

Yeast
→ Usage of sucrose and production of alcohol

Bacteria (LAB, AAB)
→ Acid production (lactic and acetic acid)
→ Formation of Kefiran

Co-culture fermentation control

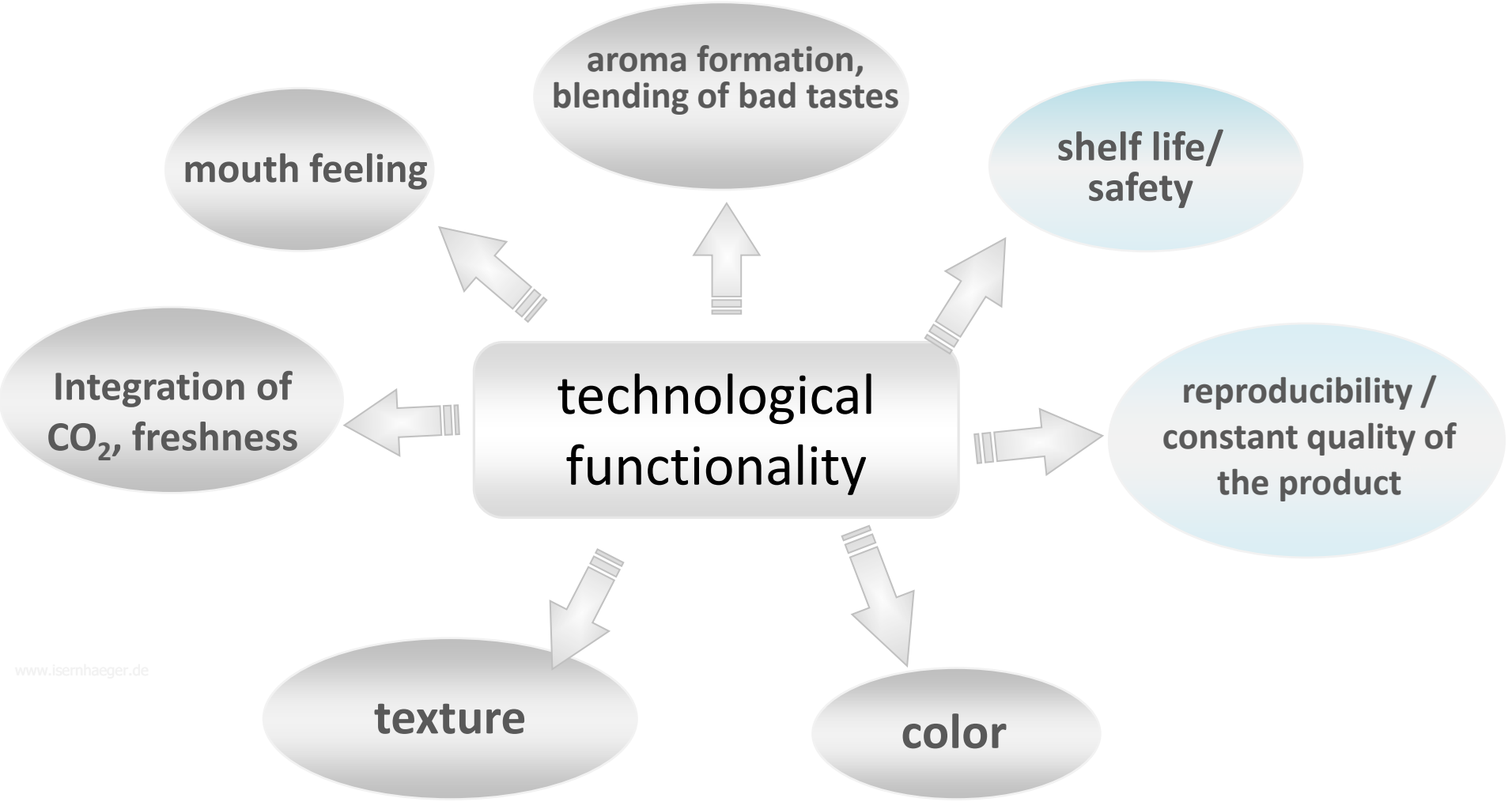
Process parameters:

- Type and combination of starter cultures
- Quality of starter cultures
- Type and concentration of raw materials
- Concentration and adding regime of inoculation
- Temperature
- pH value
- Oxygen regime and redox potential

→ Are used to control the production process

→ Influences the functionality of the beverage

Impact on functionality: technological point of view



Impact on functionality: nutritional & physiological point of view

antibiotic, antioxidative antihypertensive, cholesterol-lowering, stimulating ...

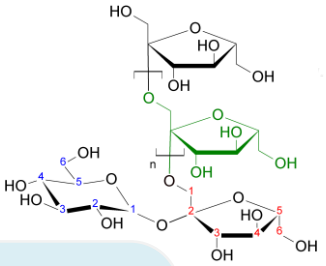
Secondary plant products (phenols, flavonoids, carotenes, etc.)

Probiotic cultures

Competitive exclusion of pathogens; altered metabolism/energy utilization; immune stimulation; treatment of infectious diarrhea; etc.

↑ vitamins
↓ ANS

nutritional functionality

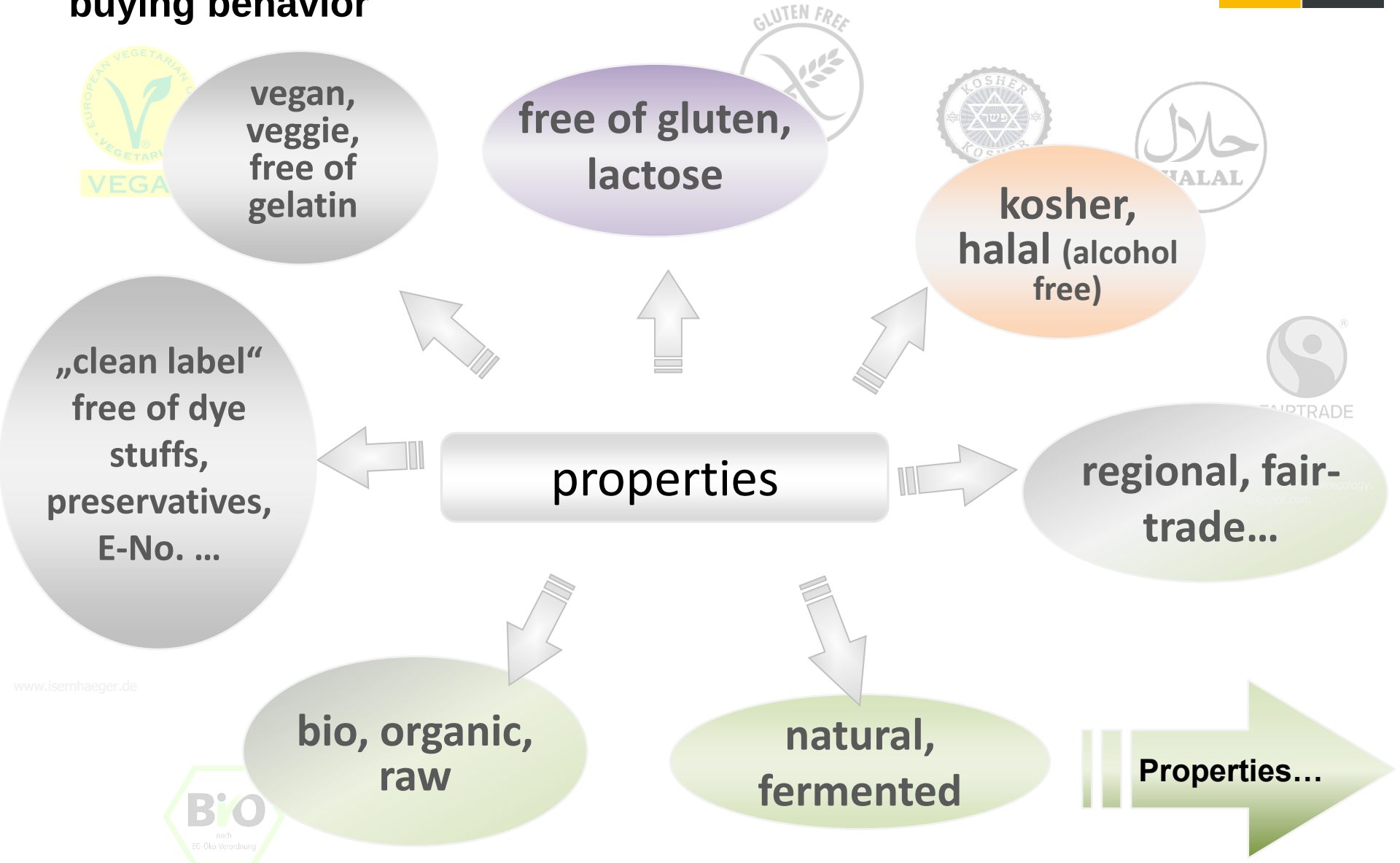


↑ digestion

prebiotics

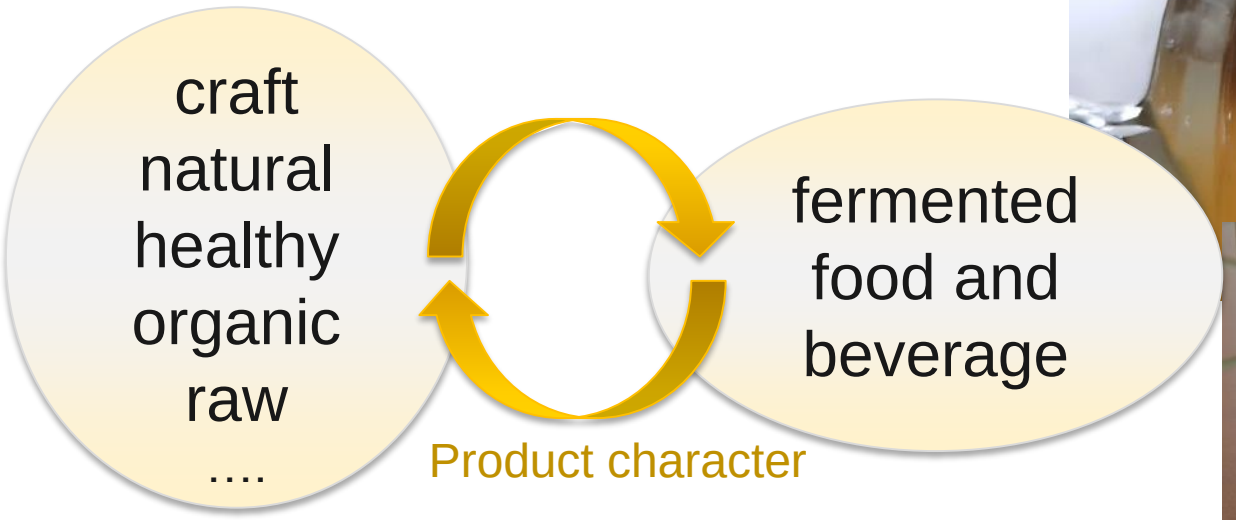
di.- oligo- and polysaccharides, inulin, lactulose, raffinose, fructane, etc.

Further relevant properties of the beverage that impacts the buying behavior



… resp. the product character has to comply with the individual life style:

„Health style meets life style“



Further trends:

- Partly renaissance of traditional processing techniques (e.g. fermentation-workshops)
- Home brewing
- Diversity, individuality
- Raising impact of popular literature and social-media

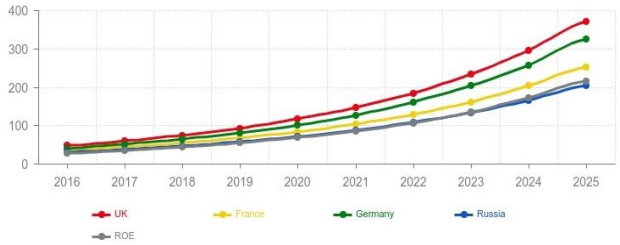
„The rules of social media era apply also for water kefir. In case of the beverage it means: More important than the beverage that you drink is the picture you put on the Web to impose your followers“

(Frederik Eikmanns, Süddeutsche Zeitung)

Promising market forecasts

- The Europe Kombucha market generated nearly $180 million for the year 2016. Europe Kombucha market is expected to progress with a healthy 25.25% CAGR for the forecast period of 2017-2025, generating a total of approximately $1365 million by the end of 2025 (INKWOOD Research, Market Research Report; www.inkwoodresearch.com/reports/europe-kombucha-market; Abrufdatum: 2.Okt.2018)

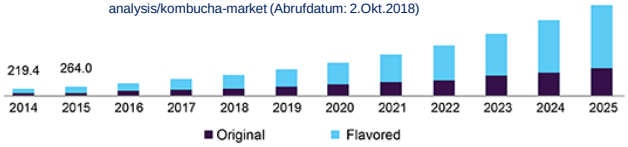
Europe kombucha market , by country 2017-2025 (USD Million)
Quelle: INKWOOD Research, Market Research Report; www.inkwoodresearch.com/reports/europe-kombucha-market



- The global kombucha market size was estimated to be USD 1.24 billion in 2017. (*40,1% North America*). (Market research report 2018; www.grandviewresearch.com/industry-analysis/kombucha-market, Abrufdatum: 2.Okt.2018)

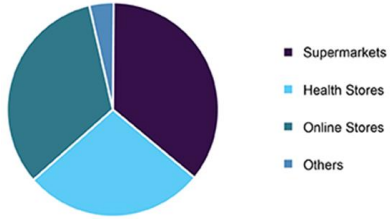
- Global Kombucha market is expected to progress with 23.0% CAGR leading to a total of approximately USD 5.54 billion by the end of 2025. The global consumption for kombucha was estimated to be 82,960.9 kilo liters in 2016 (≡ ca. 4% of beer [~2 billion hl]). (Source: www.grandviewresearch.com/industry-analysis/kombucha-market; Abrufdatum: 2.Okt.2018)

U.S. kombucha market size, by flavor, 2014-2025 (USD Million)
(Quelle: www.grandviewresearch.com/industry-analysis/kombucha-market (Abrufdatum: 2.Okt.2018)



- Global kefir market is expected to progress with 7.3% CAGR till 2023. → Increase from 1.18 billion USD in 2016 to 1.93 billion USD in 2023. (www.reuters.com/brandfeatures/venture-capital/article?id=18632; Abrufdatum: 2.Okt.2018)

Global kombucha market share, by distribution channel, 2016 (%)
(Quelle: www.grandviewresearch.com/industry-analysis/kombucha-market (Abrufdatum: 2.Okt.2018)



Current activities reflect the market forecasts

+ VLB: Increased request for corresponding product developments
+ Diversification of the product range of well known companies:

  2018… *Coca-Cola* buys the Australian kombucha producer *Organic & Raw Trading Co.* with the brand *Mojo.*

  2018… *Molson Coors* takes over *Clearly Kombucha.*

  2018… *Starbucks* enters the kombucha category via *Evolution Fresh* brand.

  2016... PepsiCo takes over the kombucha giant *Ke-Vita*.

Kombucha compounds

RAW MATERIALS

Polyphenols
→ antioxidant
→ detoxify

Caffeine
→ stimulating

+

SCOBY

→

KOMBUCHA

↑ **Vitamins**
B_1, B_2, B_6, B_{12}, C
Coenzymes

↑ **Gluconic acid**
→ Mild acid for the taste

↑ **Acetic acid**
→ Microbial control

↑ **Glucuronic acid**
→ Detoxification
→ Phenol transportation/ Antioxidant transportation and bioavailability

↓ **Sucrose**
→ Energy source for the microorganisms

↑ **Ethanol**
→ Present in low concentration
→ Prevents cardiovascular disease

Modified according Martínez Leal et al. (2018) A review on health benefits of kombucha nutritional compounds and metabolites, CyTA - Journal of Food, 16:1, 390-399, DOI: 10.1080/19476337.2017.1410499

Kombucha compounds

RAW MATERIALS

Polyphenols
→ antioxidant
→ detoxify

Caffeine
→ stimulating

SCOBY

ELSEVIER

Food Research International 33 (2000) 409–421

FOOD RESEARCH INTERNATIONAL

www.elsevier.com/locate/foodres

Tea, Kombucha, and health: a review

C. Dufresne, E. Farnworth *

Food Research and Development Centre, Agriculture and Agri-Food Canada, 3600 Casavant Blvd. West, Saint-Hyacinthe, QC, Canada J2S 8E3

Received 21 June 1999; accepted 1 December 1999

↑ Acetic acid
→ Microbial

B1, B2, B6 ... C
Coenzy...

→ Mild acid for the

JOURNAL OF MEDICINAL FOOD
J Med Food 17 (2) 2014, 179–188
© Mary Ann Liebert, Inc., and Korean Society of Food Science and Nutrition
DOI: 10.1089/jmf.2013.0031

REVIEWS

Current Evidence on Physiological Activity and Expected Health Effects of Kombucha Fermented Beverage

Ilmāra Vīna, Pāvels Semjonovs, Raimonds Linde, and Ilze Deniņa

Laboratory of Industrial Microbiology and Food Biotechnology, Institute of Microbiology and Biotechnology, University of Latvia, Riga, Latvia.

↑ Glucuro...
→ Detoxi...
→ Phenol transportation/ Antioxidant transportation and bioavailability

→ Energy source for the

...hol
... in low concentration
→ Prevents

CYTA – JOURNAL OF FOOD, 2018
VOL. 16, NO. 1, 390–399
https://doi.org/10.1080/19476337.2017.1410499

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A review on health benefits of kombucha nutritional compounds and metabolites

Jessica Martínez Leal[a], Lucía Valenzuela Suárez[a], Rasu Jayabalan[b], Joselina Huerta Oros[a] and Anayansi Escalante-Aburto[a]

[a]Department of Nutrition, University of Monterrey, San Pedro Garza García, NL, México; [b]Food Microbiology and Bioprocess Laboratory, Department of Life Science, National Institute of Technology, Rourkela, India

Many studies regarding (tea-) compounds and kombucha

Modified according Martínez Leal et al. (2018) A review on health benefits of kombucha nutritional compounds and metabolites, CyTA - Journal of Food, 16:1, 390-399, DOI: 10.1080/19476337.2017.1410499

Kombucha – SCOBY Microorganisms

+ *Main isolated yeasts:*

***Zygosaccharomyces** bailii*
Schizosaccharomyces pombe
Torulospora delbreuckii
Rhodotorula mucilaginosa
***Brettanomyces** bruxellensis*
Candida stellata
Saccharomycodes ludwigii
***Saccharomyces** spec.*
Pichia spec.

+ *Main isolated bacteria:*

Acetic acid bacteria

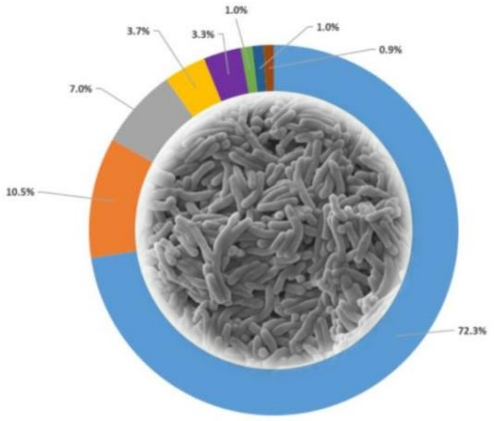
***Gluconacetobacter** xylinus*
Gluconacetobacter kombuchae sp.
***Acetobacter** pasteurianus*
Acetobacter aceti
Acetobacter intermedius
***Gluconobacter** oxydans*

Lactic acid bacteria

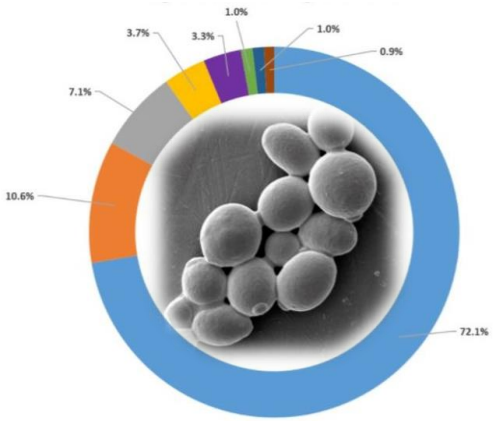
***Lactobacillus** spec.*

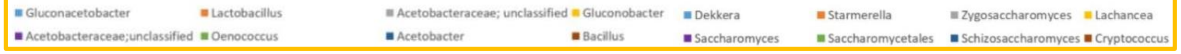
KBI OSU DNA Sequence Study Analysis Report:
Study of the Oregon State University & Kombucha Brewers International, with nearly 100 sequenced samples of 70 participants

Bacteria profile of average KBI SCOBY



Fungal profile of average KBI SCOBY





www.kombuchabrewers.org/kbi-osu-dna-sequence-study-analysis-report/

Common declarations for kombucha: *„probiotic cultures“*

- Russian nobelist *Ilja Metchnikoff as founder of the probiotic term*

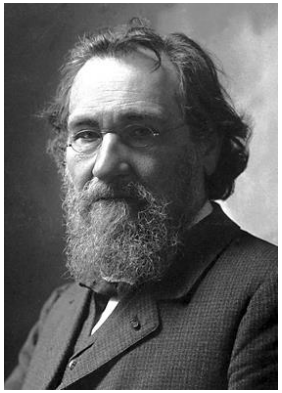
  Thesis: LAB reduce putrefaction in the gut → altered composition of microbiota as therapy

- Definition probiotics according FAO/WHO, 2002:

  „live microorganisms which when administered in adequate amounts confer a health benefit on the host “.

- Probiotics: *most relevant genera in 2015 Lactobacillus (59%), Bifidobacterium (31%) and Streptococcus (6%)* [1]

→ So far no established beneficial (probiotic) effects of acetic acid bacteria and the dominant yeast in kombucha!



www.wikipedia.org/wiki/Ilja_Iljitsch_Metschnikow

[1] Probiotic Ingredients Market Analysis By Ingredients (2015) Report ID: GVR-1-68038-395-9

Common declarations for kombucha: vitamins and organic acids
– *own studies* -

Results

Common declarations for kombucha: vitamins and organic acids

+ Data from scientific publications

Substanz	g/L	g/L	Fermentations-zeit (Tage)	Quelle
Glucoronsäure	0,003	100	21	Loncar (2000)
Glucoronsäure	0,016	100	21	Loncar (2006)
Glucoronsäure	0,57	50	14	Talawat (2006)
Glucoronsäure	1,30	100	21	de Filippies (2018)
Glucoronsäure	1,69	100	9	Jayabalan (2007)
Glucoronsäure	1,71	100	18	Jayabalan (2007)
Gluconsäure	12,00	70	10	Blanc (1996)
Gluconsäure	31,00	70	25	Blanc (1996)
Gluconsäure	2,80	70	10	Sievers (1995)
Gluconsäure	6,00	70	20	Sievers (1995)
Gluconsäure	8,90	70	30	Sievers (1995)
Gluconsäure	2,44	unknown	7	Chakravorty (2016)
Gluconsäure	6,38	unknown	14	Chakravorty (2016)
Gluconsäure	7,36	unknown	21	Chakravorty (2016)
Gluconsäure	1,20	unknown	unknown	Pietschmann et al. (1996)
Gluconsäure	2,30	100	21	de Filippies (2018)
Gluconsäure	39,00	100	60	Chen and Liu (2000)
Ethanol	0,28	unknown	7	Chakravorty (2016)
Ethanol	0,14	unknown	14	Chakravorty (2016)
Ethanol	0,07	unknown	21	Chakravorty (2016)
Ethanol	4,07	70	7	Velicanski (2013)
Ethanol	5,50	100	20	Chen and Liu (2000)
Ethanol	3,60	70	10	Sievers (1995)
Ethanol	7,00	70	30	Sievers (1995)

+ Recommended daily doses of Vitamin B12:

3 µg/day (DGE Reference value)

Comparison: 1 Liter milk ~4µg

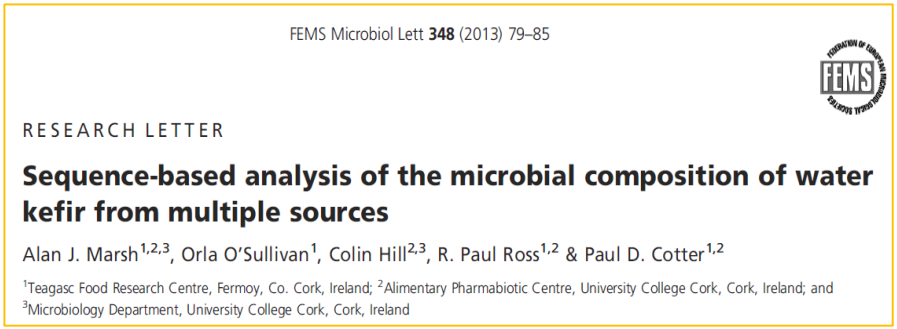
50g Edamer ~1 µg

100g calves 'liver ~60µg

Microorganisms in water kefir

+ ***Yeasts:***

Kluyveromyces marxianus
Candida kefyr,
Kluyveromyces lactis var. *Lactis*
Debaryomyces hansenii
Dekkera spec.



FEMS Microbiol Lett **348** (2013) 79–85

RESEARCH LETTER

Sequence-based analysis of the microbial composition of water kefir from multiple sources

Alan J. Marsh[1,2,3], Orla O'Sullivan[1], Colin Hill[2,3], R. Paul Ross[1,2] & Paul D. Cotter[1,2]

[1]Teagasc Food Research Centre, Fermoy, Co. Cork, Ireland; [2]Alimentary Pharmabiotic Centre, University College Cork, Cork, Ireland; and [3]Microbiology Department, University College Cork, Cork, Ireland

+ ***Bacteria:***

Lactic acid bacteria
L. ***kefiri, L. kefiranofaciens, L. casei, L. paracasei,*** *L. parakefiri, L. plantarum, L. acidophilus, L. amylovorus, L. brevis, L. buchneri, L. crispatus, L. delbrueckii, L.diolivorans, L. gallinarum, L. gasseri, L. nagelii, L. ghanensis, L. helveticus, L. johnsonii, L. otakiensis, L. parabuchneri, L. reuteri, L. rhamnosus, L. rossiae, L. sakei, L. salivarius, L. sunkii, Lc. garvieae, Lc. lactis, Leuconostoc mesenteroides, O. oeni, Pediococcus* sp., *Tetragenococcus halophilus*

Acetic acid bacteria
Komagataeibacter hansenii,
Zymomonas spec.

Traditional vs. industrial production

- Traditionally produced in small scale:
  private, pharmacies, …
- Reuse of the SCOBY
- Limited control:
  - Unknown age of the cultures
  - Composition of the SCOBY is unknown and not constant
  - Risk of mold formation
  - Incomplete process → high alcohol
    to long process → vinegar

- Industrial process should be done under quality assurance under quality management and control aspects:
  - Process knowledge essential
  - Reproducible product properties
  - Control points mandatory
- Application of defined starter cultures
- Control of process and parameter (if possible online)

…Process knowledge is the basis to meet the challenges of desired product variations

E.g.:

+ Enrichment with metabolites (vitamins, org. acids, …)
+ Defined sugar profile after fermentation
+ Enrichment with beneficial microorganisms
+ Alcohol concentration and tits stability
+ Raw products
+ Standardization and classification of acidic fermented beverages
+ …

Summary

- Steady growth of co-culture fermented acidic beverages that is accompanied with the increasing healthy life style of the population
- Many possibilities to bring functionality with innovative character into the beverage
- For producers: The desired product properties has to be harmonized with the production conditions
- Growing market of diverse fermented products → Need for standardization and classification
- Latter can contribute to have products with correct and clear declarations on the market

Thank you very much!

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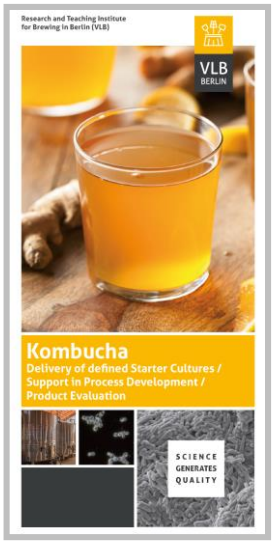

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- Martínez Leal et al. (2018) A review on health benefits of kombucha nutritional compounds and metabolites, CyTA - Journal of Food, 16:1, 390-399, DOI: 10.1080/19476337.2017.1410499

Video: Water-kefir fermentation