The Yeast in the Brewery

Management – Pure yeast cultures – Propagation

Prof. Dr. sc. techn. Gerolf Annemüller

Dr. sc. techn. Hans-J. Manger

Dr. Peter Lietz

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Contact to the authors:
Prof. Dr. Gerolf Annemüller
Buschiner Str. 34A
12683 Berlin
Germany
g.annemueller@t-online.de

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Translated by
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List of Abbreviations

a	year
ADP	adenosine diphosphate
ADY	active dry yeast
AMP	adenosine monophosphate
ATP	adenosine triphosphate
BCE	before common era
C	cell(s)
CCV	cylindroconical vessel / cylindroconical storage tank
c_{EtOH}	ethanol concentration
c_H	yeast concentration
CIP	cleaning in place
c_P	permeability coefficient
CP	crude protein
CV	variation coefficient
DIN EN	European norm
DIN	German Norms Institute (Deutsches Institut für Normung e.V.)
DMS	dimethyl sulphide
DM_Y	dry matter yeast
DM_{YI}	dry matter yeast increase
DN	nominal diameter
DNA, DNS	deoxyribonucleic acid
E_{ap}	apparent extract (°P)
E_{apf}	final apparent extract (°P)
EHEDG	European Hygienic Equipment Design Group
EPDM	ethylene-propylene-diene-monomer
$F°_{ap}$	degree of fermentation apparent
$F°_{apf}$	degree of fermentation apparent final
$F°_{apsb}$	degree of fermentation apparent, sales beer
$F°_{realf}$	real final degree of fermentation (degree of fermentation, real final)
FDA	U.S. Food and Drug Administration
FDP	Fructose-1,6-diphosphate
GGB	Gesellschaft für Geschichte des Brauwesens e.V. (Berlin Society for Brewing History)
GMO	genetically modified organisms
h	hour
H	increment factor
HACCP	Hazard Analysis and Critical Control Points
index 0	Instant of start
index t	at time t
K	consistency factor
K	temperature in degrees Kelvin
L	litre
loc.cit.	already mentioned bibliographic reference
L_{PW}	litres pitching wort
m	mass
$\dot{m}$	mass flow

ME	unit of any measure
MIF	magnetic inductive flowmeters (electromagnetic flowmeter)
min	minute(s)
NBR	acrylonitrile butadiene rubber
NPT	normal temperature and pressure (0 °C; 1.013 bar)
OG	original gravity
OP	overpressure (p_O)
OTR	oxygen transfer rate
p	pressure
p.	page
PCS	process control system
PE	polyethylene
PLC	programmable logic controller
PMC	pressure measuring cell
PP	polypropylene
PTFE	polytetrafluorethylene
PU	pasteurisation unit
PYF	premature yeast flocculation
°P	percent extract by weight (“degrees Plato”)
R	correlation coefficient
R^2	coefficient of determination
RNA	ribonucleic acid
RPM	revolutions per minute
s	standard deviation
SB	sales beer
SIP	sterilization in place
T	temperature (in K)
TPP	thiamine pyrophosphate
t	time
t_G	generation time
V	volume
$\dot{V}$	volumetric flow
VDMA	Association of German Equipment Manufacturers (Verband Deutscher Maschinen- und Anlagenbau e.V.)
VLB	Brewing Institute in Berlin / GER (Versuchs- und Lehranstalt für Brauerei Berlin)
V_{PW}	volume of pitching wort
X	yeast concentration (grams DM_Y / unit of volume)
$\bar{x}$	average value

% m/m	% mass/mass
% v/v	% volume/volume

ρ	density
τ_0	flow limit
η	dynamic viscosity

ϑ	temperature (°C)
η_{CA}	*Casson* viscosity
μ	specific growth rate
Δ	difference
$\dot{\gamma}$	shear velocity
ν	kinematic viscosity

Preface

The brewing yeast *Saccharomyces cerevisiae var*. is the most important microorganism for the production of beer. Beside the raw materials malt, hops and water the properties of the yeast influence in a decisive way the quality of the end product beer and the productivity of the fermentation and maturation processes in the brewery.

The yeast management's task is in the first place to provide the brewer with pitching yeast in the required amount and quality and at the right time; further to choose and to take the best care of the yeast strain best suited for any particular brewery, to reproduce it, to design and run the yeast propagation plant and finally to best utilize the surplus yeast and treat the recovered beer extracted from it.

Due to the introduction of large cylindroconical tanks (CCV) for primary fermentation and maturation, the beer quality requirements have grown, particularly in regard to its shelf life and its stability: hence also the purity of the pitching yeast and the reliability of the yeast propagation plants had to be increased.

The purpose of this book is to provide information on the following topics:

- Yeast – systematic;
- The history of the development of pure yeast culture techniques;
- Requirements on the pitching yeast and need to regenerate the inoculum;
- Chemical composition of the yeast;
- Physical properties of the yeast (density, cell size, rheological parameters, osmotic pressure, surface charge);
- Structure and functions of the yeast cell;
- Yeast multiplication and its kinetics;
- Metabolic reactions and regulatory mechanisms;
- Nutritional requirements of the yeast;
- Oxygen requirements of the yeast;
- Equipment for yeast multiplication;
- Suggestions for the design of propagation plants;
- Yeast management in the brewery;
- Recovery of beer from surplus yeast.

The authors have endeavoured to put fundamental scientific knowledge in the centre of their considerations, in order to avoid the danger of dealing with their subject too subjectively: it is in fact their goal to offer objective information about yeast management and yeast multiplication, so contributing to a realistic evaluation of the different phases and possible steps.

The following exposition is not intended to substitute for what can be found in the technical literature on the subject "yeast". Beside the quoted publications the authors refer in particular to the book "The Yeasts" [127], which they consider a reference standard.

They are further indebted to several companies for kindly supplying documentation and to the following persons for valuable support during experimental work: *Udo Kriegel*

(GEA GmbH), Mrs. *Margret Lamers* and Dr. *Juliane Kunte* (Berliner-Kindl-Schultheiss-Brauerei GmbH).

Thanks are due also to Dr. *Peter Lietz*, who has written Chapter 2, containing some historical data about the cultivation of pure yeasts.

For a detailed description of the development of beer fermentation and ripening processes, as well as the formation and influencing of the fermentation by-products, see the literature [1]. The influence of the yeast on the clarification and filterability of the beers is described in [2]. The microbiological operational control is not covered by this publication (see also [222]).

In this context, we would like to express our special thanks to Dr. *Tullio Zangrando* from Pedavena, Italy, who with great enthusiasm translated the entire text of the 1st German edition into English.

In addition, we would like to thank *Kurt Marshall* and *Olaf Hendel* – both with VLB Berlin – for their intensive revision of the translation.

Preface to the 2nd English Edition

The positive feedback to the German edition of “Yeast in the Brewery”, which has been meanwhile published in the 2nd and 3rd edition, has encouraged us to additionally present this book to international experts as 2nd revised English edition.

Even if the subject of yeast in the brewery is discussed primarily from the viewpoint of the German purity law (Reinheitsgebot), we are sure that this book will be a valuable source of information for the international brewers’ community.

The presented 2nd English edition has been updated and corrections have been made, along with the addition of supplemental information in several chapters.

The authors like to thank *Christopher Bergthold*, Berlin, for the translation of the updated sections and the revision of the whole script.

Berlin, January 2018 *Gerolf Annemüller* and *Hans-J. Manger*