Til : SBR

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Balling formula – origin.

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Introduction:
Every Master Brewer and brewery chemist knows the name ''Balling'', and we have all been introduced to ''Balling's formula'' and the ''Balling tables''. Most of us are aware, that Balling's tables at some point of time became replaced by Plato's table, which is nowadays our industry standard for the relation between % of extract in wort and specific weight of the wort. But who was the person Balling, where did he live, and what else did he contribute to our industry ?

Balling's observation in the laboratory:
Prof. Balling, Prague, discovered in 1843, that 2.0665 g extract in wort during fermentation to beer is converted to:

0.9565 g CO2
1.0 g alcohol
0.11 g yeast dry material

This observation allowed Balling to formulate the mathematical relation:

$$\%P = \frac{2.0665 \times A + E_R}{100 + 1.0665 \times A} \times 100$$

which since has carried the name ''Balling's great formula''.

The great Balling formula goes in hand with the relation ''Balling's little formula'':

$$P = (n - m) \times 4.3 + n$$

He published his findings in ''Die Gärungschemie'' I – IV in Prague 1845, for a long time an attenuation reference textbook throughout the German speaking part of Europe. The 3rd and last edition of this textbook was published in Prague in 1865 and since long remained the attenuation reference textbook throughout Europe, England and USA.

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The formula has over the years been challenged, as modern breweries produce less yeast and therefore more extract, and minor modifications to the Balling formula has been suggested. The more noteworthy challenge was published by Birger Trolle in Copenhagen in 1943, where he was awarded a rare Doctoral Thesis at the Technical University in Copenhagen for his work. Other people have since also challenged the Balling formula, lately Henning Nielsen, Karen Mette Krieger Lassen, Claudio Ekström and Axel G. Kristiansen in the Brauwelt Int. April 2007 issue.

The fact is however, that his formula still remains unchanged in more than 100 countries, and it seems not very likely, that the formula will be changed.

Balling and his early life

Carl Joseph Napoleon Balling lived 1805 – 1868. He was born in Gabrielahütten, near Cerveny Hradek (German: Rothaus) in the Saaz region of in Bohemia (Böhmen), a country nowadays known as Czech Republic. His family origined from England, and he was the 3rd child of Michael and Anne Balling, growing up in the aftermath of the end of the Napoleon wars ending 1815. His father Michael Balling finished his career as ''Oberschichtamtsdirektor'' with the Imperial Court. The young Balling finished high School in Plzen (Pilsen) in 1820, 15 years old, and he went straight to the Prague Polytechnic High school to study natural sciences, which then was composed by mathematics, mechanics, chemistry, mining and legal studies. He ended his studies in 1823 – 18 years old !, and after some field studies he became employed in 1824 at the Polytechnic Institute of the Estates, where he remained all his working life with the Chemistry Department. He felt like a German and spoke German, although living in Bohemia, a Czech region, but kept good relations to his Czech colleagues and students. His son and daughter both nevertheless became Czech, not German. They both became connected with the Polytechnic Institute of the Estates in Prague, but in other sciences than Brewing.
We may to day wonder, whether Balling was truly German, Bohemian, Austrian or Czech ?

Ballings carrer with Prague university

He started as an assistant (''Adjutant'' or Adjunct'') in the chemistry department in 1824, 19 years old, working for Professor J. Steinmann, who had founded a Chair in Brewing and malting in 1818, and Balling succeeded this Chair by year 1833. As from 1831, the founder of the university library in Prague, František Josef Knight Gerstner (1756 - 1832), gave Balling the responsibility to organize the scientific books, until then dispersed with individual professors in a university library, and between 1831 and 1865 he was responsible for the running of the university library. It was Balling who created the basic layer of the State Technical Library collections, consisting of five major groups: mathematics, civil engineering, chemistry, mechanics, and the military. Later, in 1833, Balling succeeded Professor J. Steinmann as Chair of Chemistry, and by year 1835 he was appointed Professor in ordinary Chemistry. Chemistry at the time was a large field of topics from glass, ceramics, colouring, agriculture, mining etc.. But chemistry also comprised brewing and malting sciences. In year 1848 Balling was proposed Director of Polytechnic Institute of the Estates in Prague, but in stead the selection commission appointed

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Professor Lambe. In year 1862/1863 the university decided to teach in both German and Czech languages to take effect from teaching year 1865/1866. The same year, Balling was elected Chancellor (Rektor) of the ''Polytechnic Prague'', the new name of the university. It was a time of cultural and language conflicts following the Napoleon wars throughout Europe, and by this time, Balling was getting ill and had to reduce his commitments to the university.

Balling was honoured for his academic research in several countries, i.e. the Franz – Joseph Order, a Gold medal from Pronce Albert in England and a Diploma from the French Prince Napoleon. In 1849 he became member of the Royal Bohemian Academy for Science and later the Emperial Academy of Science in Vienna. In year 1868 he suddenly died, 63 years old. Already in year 1869 the new ''Polytechnic Prague'' got divided into a German and into a Czech Institute. Balling became succeeded in the Chemistry Chair by his assistant Professor Stolba (1839 – 1910), who worked in the Czech part of the now divided university. By 1875 the chemistry institute became subordinated the Austrian Ministry of Culture and Teaching.

Balling's scientific work.

While Balling in his younger scientific life was busy examining melting processes of iron for the local mining industry and research, he later studied the sugar industry. He was the first to use Calcium Chloride for clarification of sugar solutions and showed interest into gravity measurements of sugar solutions. earned most of his fame in brewing science. In 1843 he produced the Balling sugar tables, which – with 3 places of a decimal – offer a relation between specific gravity of wort/sacharose and % extract of wort/sacharose. He assume wrongly, that sacharose and wort would have the same % extracts at the same specific gravities.

Brix in year 1854 suggested to use sacharose in aquous solution and to use 20 ^{0} C as the measuring temperature. The Brix degrees became popular in the soft drinks and sugar industries, where this unit is still dominant, but Brix never became popular is a measuring unit with brewing industries.

In 1852 Balling introduced the hydrometer for measuring the gravity of beer. It became known as the Balling - sacharometer. This method of determining sugar concentration was popular, and it soon became the prefereed method also for exice duty / taxation officers to use. Balling was not able to work with 100 % sacharose for calibrating his % degree Balling to specific gravity, and the temperature, he used, was unfortunately 17.5 ^{0} C. Why unfortunately ? Because in most situations working environment temperatures are higher, and 17.5 ^{0} C becomes an impracticable temperature for the analyst to use.

Later on, the German Dr. Fritz Plato produced a revised sugar table using 20 ^{0} C as measuring temperature, and this table, published year 1900, defined one degree Plato as a 1% by weight sugar solution of *sacharose,* was presented to and approved by the German Imperial Commission. The Plato tables have in most countries, and certainly officially with EU, since replaced the Balling tables – but not the Balling formula ! There exist no simple correlation factor from degree Balling to degree Plato. For practical daily use, the differences in numerical values are not large.

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Balling published his most known work related to the Balling formula in ''Die Bierbrauerei Wissenschaftlich begründet und praktisch dargestellt'', vol. 1 – 4, 1865. This textbook became the reference book for developing the attenuation concept, i.e. study of metabolism of sugars during fermentation by comparing real with apparent gravity of fermented wort..

Balling's formula – and its modern relevance.
The formula has of course over the years been challenged, as modern breweries produce less yeast and more extract, and minor modifications to his formula has been suggested. The more famous challenge was the published by Birger Trolle in Copenhagen in 1943, where he was awarded a rare Doctoral Thesis at the Technical University in Copenhagen for his work. Other people have since also challenged the Balling formula, last Henning Nielsen, Karen Mette Krieger Lassen, Claudio Ekström and Axel G. Kristiansen in the Brauwelt Int. April 2007 issue.

The fact is however, that his formula remains unchanged in more than 100 countries, and it is not likely, that his formula will ever be changed, even if it is not precisely correct. Why ?

- It is nearly correct – ''good enough''
- In some cases, the extract calculated according to Balling's formula produces more convenient (lower !) extract loss figures in the modern brewery, than if a revised formula is applied
- It will become a challenge to change the minds of more than 100 countries' beer taxation systems, and probably few beer professionals have interest in starting such venture

Conclusion.
Balling did a relevant, early and sufficiently precise observation in 1843 into the metabolism of sugars into alcohol and CO_2. He managed to draw the right conclusions expressed in the ''Balling great formula'' still used, and he introduced the saccharometer into the breweries. He further developed the attenuation concept. Only his ''Balling table'' did not survive Plato's more practical Plato table calibrated to 20 ^{0}C rather than to 17.5 ^{0} C as did Balling's table. This is an amazing contribution, that Balling's work carries weight in more than 100 countries 164 years later on !

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