A STUDY ESTABLISHING AN OPTIMUM MALTING DIAGRAM

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Abstract: *Malt is the main raw material used in beer manufacturing. This is why numerous investigations have been performed to improve its specifications. The quality of the malt used depends mostly on the quality of barley, of brewing barley from which it is obtained, as well as from the way the malting process was conducted. Micromalting constitutes a step through which every new variety of barley must pass. In general, one could say that malt has superior biotechnological qualities if it is easily processable, if it has a rich enzyme equipment, ensures high efficiency and if the resulting beer wort ferments well. The raw material used in the experiments was barley originating from England, which was first analyzed from organoleptic and physico-chemical points of view, then subjected to a micromalting process using four different technologies. The quality indices as determined by chemical analysis of brewing barley confirmed that it can be used as raw material in the manufacturing of malt for the brewing industry. Finally an option to set optimum malting technology, establishing technological parameters and working diagrams for each stage of malt production. The technological version of malting by resteeping which presented higher values for most physical and chemical indicators determined for the malt-finished product.*

Keywords: *brewing barley, micromalting, biotechnological characteristics, malting losses*

1. Introduction

Malt, considered by experts "the heart of beer", is the essential raw material used in beer manufacturing.

The modern malting and brewing industry makes use of a wide range of technical, biochemical, microbiological and genetic inventions [1, 2].

The basic processes in order to obtain malt have remained the same over time, with changes in technology, science and techniques enabling the shortening of production cycles and ensuring a constant quality of malt produced [3, 4]. The main purpose of malting is the accumulation of enzymes and the partial hydrolysis of macromolecular substances of the grain.

Administering on an industrial scale the malting process aims not only to obtain a high quality malt, but takes into account the economic aspect, namely to reduce the process' time and to achieve a high productivity [5, 6, 7].

The main factors influencing the quality of malt are: barley used as raw material, malting technology adopted and malting equipment used [8, 9].

This paper proposes, starting from a given raw material, an optimal way of malting, as well as determining the main technological parameters and working diagrams for each basic operation for obtaining malt

2. Experimental

The raw material used in the experiments was barley originating from England, the harvest of 2011. For analysis we used two average samples of barley from the same batch, taken as standards.

The results of organoleptic and physico-chemical analysis for the two barley samples studied are presented in Tables 1 and 2.

Table 1

Organoleptic analysis results for barley samples

Characteristics	SAMPLE 1	SAMPLE 2
Aspect	typically, coated with fine wrinkles	typically, coated with fine wrinkles
Colour	pale yellow, <5% grains showing black spots or peaks, <10% grain of matte colour	pale yellow, <2% grains showing black spots or peaks, <6% grain of matte colour
Smell	fresh straw, no hint of mould	fresh straw, no hint of mould
Taste	sweet, characteristic for fresh cereal	sweet, characteristic for fresh cereal

Table 2

Physicochemical analysis results for barley samples

Characteristics	SAMPLE 1	SAMPLE 2
Hectolitre weight	65.8	65.5
Mass of 1000 grains	41.5	42.2
Uniformity (assortment)	85	88
Foreign body. total. out of which:	3.2	2.8
- inert mineral body;	0.1	0.2
- inert organic body;	0.1	0.1
- weeds'' seeds;	0.6	0.5
- embrio-less seeds and broken grains;	2.0	1.5
- empty seeds.	0.4	0.5
Germinative energy	82	82
Germinative capacity	86	85
Water sensitivity	37	40
Moisture. %	13.4	13.8
Proteins. %	10.8	10.5
Starch as percentage dry weight	61.5	62

Evaluating the quality of the malt obtained through the experimental malting versions was done via a physico-chemical analysis of beer wort obtained in the laboratory by the "Kongress" method. using the following methods:

- humidity - oven drying method;
- glassines - with grain cutter;
- yield in extract - method Kongress;
- Colour - iodometric method;
- pH – potentiometric method;
- Hartong index - Kongress method;
- Kolbach index - Windisch-Kolbach method.

3. Results and Discussions

All malting versions were applied with the purpose of obtaining blond malt. as this type of malt can be produced on a larger scale than other types of malt (brown malt. special malts).

3.1. Malting process using constant temperature germination

Steeping in this first version of malting used the chart below (fig.1):

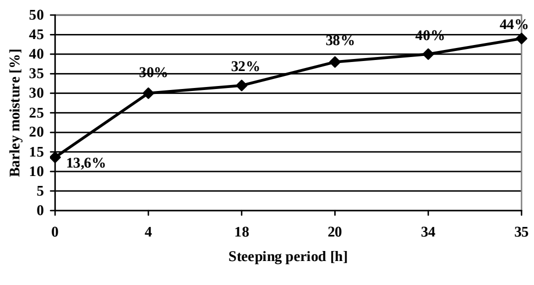

Figure 1. Steeping diagram for first experimental version

- wet steeping for 4 to 6 hours to a moisture content of 30%;

- dried steeping for 14 ÷ 6 p.m. when grain moisture increased slightly to 31 ÷ 32% due to water adhering to the beans. During this period CO_2 adsorption was performed at first regularly and then continuously;
- wet steeping until it reached 38% humidity for 2 to 4 hours;
- dried steeping for 14 ÷ 18 hours of temporary adsorption of CO2. barley moisture reaching is 40% in the end;
- wet steeping for 1 ÷ 2 hours. final moisture of 44 ÷ 46%. then barley was switched to germination.

Thus the total of 35 ÷ 48 hours of steeping. steeping wet lasted 7 to 12 hours. so approx. 25% of the duration of steeping. Steeping temperature was 12 ÷ 15°C.

Germination process applied in this version used a constant temperature of 15°C. the process of germination was 7 days.

Because the drying process under laboratory conditions does not influence decisively malt quality obtained. for all experimental versions the same drying diagram was used to obtain blond malt.

In preparing this diagram was intended to obtain pale malt with high enzyme activity. normal humidity and shorter final kilning operation which lasted on average 20 to 22 hours (fig.2).

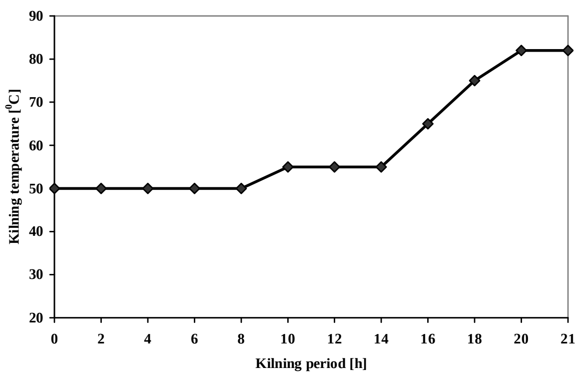

Figure 2. Kilning diagram for all experimental versions

3.2. Malting process with high germination temperatures

The steeping diagram in this version of malting was the following:

- wet steeping to a moisture content of 40%. steeping temperature of 11°C;
- dried steeping followed by sprinkled wet steeping. increasing temperature to for 14 ÷ 6 p.m. when grain moisture increased slightly to 15°C for 20 hours. until grain moisture reaches 43%;
- dried steeping followed by sprinkled wet steeping at 15°C for 12 hours until a final moisture of 46%.

From steeping. barley was passed for germination 6 to 7 days. Aeration of germinating green malt was made daily and malt humidity decreased. To achieve the desired humidity level at the end of germination (44 ÷ 45%). from the third day of germination. green malt was moistened by spraying with water.

3.3. Malting process with decreasing germination temperatures

Steeping diagram adopted in this version was as follows:

- wet steeping for 6 to 8 hours. with strong aeration. steeping temperature of 18°C. until grain moisture reached 36 ÷ 38%;
- dried steeping for 24 hours with ventilation to remove CO2;
- wet steeping up to a final moisture of 46 ÷ 48%. steeping temperature of 20°C. then barley was sent to germinate.

The literature shows that the germination process with decreasing temperature is a modern malting process based on the fact that germination begins as early as steeping phase [9].

The barley introduced to germinate had a temperature of 18°C. with 30% seeds germinated (sprouted). After steeping. the maximum humidity reached 48%. with a drop in temperature to levels of 12 to 13°C. on the fourth day of germination.

3.4. Malting process with resteeping

In the literature this process is presented as a modern malting process based on repeated steeping of green malt plants even in germination fixtures. Noteworthy is the fact that the malt manufactured by this process has rootlets less developed but is rich in enzymes and malting losses can be reduced to only 5 to 6% for dry substance. The whole process of steeping - germination takes only 6 to 7 days.

The steeping process used the steeping diagram presented in the first experimental version. except that steeping was considered completed when grain moisture reached 40%.

The barley grains with this moisture were transferred to germination and maintained for approx. 60 hours at 17°C. during which the barley began to germinate quickly and uniformly. At this point resteeping was applied. namely the introduction of water with temperature of 17°C. After a period of 24 hours barley reached a moisture content of 50 ÷ 52%. Thus. the embryo was inactivated. but malt modification continued by enzymatic activity which maintained due to the high moisture of the germinating grains. Simultaneously. resteeping determined the rootlets losses to decrease. mainly due to low temperatures for germination.

3.5. Evaluating the quality of malt produced by the adopted experimental versions

Malt obtained in the four experimental variants was analyzed in laboratory conditions. knowing that only physico-chemical analysis are objective and decisive for assessing the biotechnological qualities necessary for brewing.

Sensory analysis results are presented in Table 3.

Malt obtained in all experimental variants corresponds from sensorial point of view to blond malt for brewing.

Physico-chemical analysis results for malt are presented in Table 4.

Table 3

Organoleptic analysis results for malt – finished product

Characteristic	**Experimental version**			
	V1	**V2**	**V3**	**V4**
Aspect	uniform sized and shaped grains	uniform sized and shaped grains	uniform sized and shaped grains	uniform sized and shaped grains
Colour	pale yellow	pale yellow. < 6% grey coloured grains	pale yellow.< 4% grey coloured grains	pale yellow
Smell	characteristic. no hint of mould	characteristic. no hint of mould	characteristic. no hint of mould	characteristic. no hint of mould
Taste	pleasant. sweet	pleasant. sweet	pleasant. sweet	pleasant. sweet

Table 4

Physico-chemical analysis results for malt – finished product

Quality index	**Experimental version**			
	V1	**V2**	**V3**	**V4**
Moisture. %	4.0	4.0	4.3	4.1
Friabilimeter value. %	87.5	85	87.5	93
- friable grains. %	85	83	86	90
- semivitreous grains. %	10	13	11	4
- vitreous grains. %	5	4	3	6
Colour. unit. EBC	3.4	2.9	3.1	3.0
Extract % based on dry weight	82.5	82.8	83	82.9
Saccharification rate. min.	15	12	15	10
Filtration rate. min.	55	53	45	40
pH of wort	5.7	5.90	5.8	5.6
Hartong index	4.0	4.2	3.9	5.6
Kolbach index	34.8	37.4	39.6	42.5
Extract difference % based on dry weight	1.4	1.7	1.0	0.7
Amylolitic capacity. ^{0}WK	255	230	265	305
Malting losses. % s.u.	12.0	14.2	12.8	8.5

Malt moisture. It is known that malt moisture is of great importance if one takes into account the gain of extract that is made from high water content. But due to high water content. malt quality suffers during storage. losing its flavour. its degree of solubility changes during storage. causing difficulties in milling and leads to some beers with lower taste quality and colloidal stability.

Glassines malt. All malt samples analyzed have values close of this indicator gives information on the degree of malt modification but only malt obtained with version 4 of malting with resteeping corresponds to quality standards. with a value of 7%.

Malt colour. Malt obtained in all experimental versions matches the type of blond malt. the palest malt was obtained by process of malting with decreasing temperatures to germination - version 2. This quality indicator does not provide reliable information about future colour of beer. but the malt analysis gives us information on the type of malt.

Saccharification rate. This indicator shows similar values falling within the standard limits for all four samples analyzed.

Filtration rate. General observation that emerges from comparison of this indicator is that none of the samples analyzed has reached or exceeded the recommended maximum EBC rules. namely 60 minutes. from which malt is considered insufficiently soluble. Malt modification is best obtained by malting with resteeping. experimental version 4.

PH of wort value. Influences enzymatic decomposition processes and determines protein solubilization. the bitter substances of hops and the boiling wort colour. There is dependence between the pH of the wort and beer produced from it. Beers with high pH values are subjected to physico-chemical disturbances due to insufficient coagulation of proteins at boiling phase.

PH value on malt samples analyzed is approximately constant. which shows that the technological process for obtaining malt went normally. without variation of process parameters in the four experimental versions.

Hartong index. This index is a summary of physical and chemical methods of assessing the quality of malt and gives information on how the main malting operations were conducted. Assessment of malt modification according to Hartong index after EBC criteria shows that:

- Malt obtained by malting versions 1. 2 and 3 is slightly weathered. with a low enzyme output;
- Malt obtained by malting with resteeping. version 4. is well weathered. rich in enzymes and appropriate for producing beers with good stability.

Malt extract yield varies between 82.5% (version 1) and 83% (version 3). so they have very close. high values. this index summing the total of soluble substances.

Kolbach index. It is known that the quality indicator is a measure of proteolytic disintegration of malt and is a hint on proteolytic enzymes content of malt. Analyzing the data shown in Table 5 we can say that:

- malt obtained by versiont 1 of malting is an insufficient disaggregated malt;
- malt obtained by malting versions 2 and 3 is a well weathered malt;
- malt obtained by version 4 of malting is a highly disaggregated malt.

Yield difference between fine and coarse milling is an important criterion for malt modification. as well as for hemicelluloses and enzymatic capacity of malt. All samples analyzed showed a good malt cytolytic modification. one presents the best value obtained by malting with resteeping - version 4.

The largest diastatic power was obtained by malting version 4. This malt will lead to wort with high degree of fermentation.

With regard to malting losses. the lowest values were recorded for version 4. malting process with resteeping. which can be explained by reducing losses due to grains forming rootlets and limit breathing. From the pooled analysis presented from blond malt assessment in laboratory conditions. it can be observed that. of the four versions of malting applied. the best results. as reflected in indices determined were obtained by applying the malting process with resteeping - version four.

4. Conclusions

Administering the malting process is generally aimed at achieving quality malt with superior biotechnological characteristics. with minimum costs of production and an increased productivity. Through a rational management of technological parameters during the malting process. these objectives can be achieved.

The raw material used was barley. the origin of 2011 harvest England. The main physical and chemical quality indices of two samples taken from the same batch of barley were determined that they meet the technical requirements for manufacturing quality malt for beer industry.

Data from the literature provided the malting methods that were suitable for analysis of barley's technological qualities. Parameters were established for each technological operation and diagrams were drawn for four different malting versions.

Malt - finished product was analyzed from organoleptic and physico-chemical points of view. Based on the results presented. the paper showed that malt obtained by version 4 - malting with resteeping – has higher values for most indicators determined. which recommends it as an optimal option for malting the barley samples taken. Also. the lowest losses were obtained for version 4. and so from an economical point of view. malting process with resteeping is most advantageous.

A verification of the optimal manufacturing conditions established under laboratory conditions is required. Completing the work charts is advisable to be carried out only after going through a malting cycle inside a factory.

5. References

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