BIOLOGICAL SCIENCES

UNMALTED RAW MATERIALS IN BREWING

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Abstract
Purpose: The main raw material for beer production is malt. There is a tendency to use other grain crops in the production of beer. The using of unmalted materials gives opportunity for brewers and technologist for cost saving. But replacing of malt makes affects the quality of wort and beer. The purpose of the researches was to compare quality parameters of 100% malt beers and beer with part of malt replaced by unmalted barley. **Methods**: To solve the given problem the methods of the high-performance liquid chromatography, analysis and empirical methods are used. **Results:** Using a big amount of unmalted grits together with external enzymes gives brewers opportunity to receive product in the same composition and quality like high-quality product using only malt. **Conclusions:** For brewing with a very small amount of malt, barley is a very good choice for replacing part of it as it has some characteristics of malt. It is possible, economically profitable and technically reasoned to replace half of the malt in the grind. But it becomes necessary to use exogenous enzymes.

Keywords: barley; beer; cost; enzymes; malt; quality.

1. Introduction

Barley brewing

For brewing with a very small amount of malt, barley is a very good choice for replacing part of the malt, as it has some its characteristics:

- contains beta-amylase and peptidase
- can be added to the mash tun, since barley starch has a low gelatinization temperature
- has a husk, which provides good filtration in the lauter-tun (with proper crushing) [1-2].

It is possible to replace half of the malt in the grind. For example, 30% of corn and 70% of malt replace 30% of corn grist, 35% of barley and 35% of malt, and still produce high-quality beer. But it becomes necessary to use exogenous enzymes [3].

For experimental part external enzymes from Novozymes company were used.

There two options for brewers where found:

The first option is specially prepared mixtures equivalent to malt: Ceremix 2X L, consisting of alpha-amylase, protease and beta-glucanase; Ceremix 6X MG, which also contains cellulase and pentosanase; and Ceremix Plus MG, which possesses all the mentioned activities, including thermostable alpha-amylase. Products Ceremix are added during mashing.

The second option is to use as necessary individual preparations Ultraflo, Neutrase, Fungamyl and Termamyl.

The first option is simpler; the second option has the advantage that the brewer himself can more accurately choose a mixture of enzymes suitable for a specific composition of the mash. If the part of barley used is very high, then the final degree of fermentation of the wort will be reduced. It can be corrected by adding Fungamyl during fermentation or Promozyme - during mashing.

Brewing with barley and enzymes gives the brewer the following advantages:

- the enzyme dosage can be refined to obtain the required level of activity in the mash
- less dependence on supply fluctuations, the price and quality of the malt
- obtaining a wort with a lower viscosity, which means an easier filtration of wort and beer
- cost reduction.

Conditions:		
1	Malt	Extract content 75%
	Barley	Extract content 75%
	Corn grits	Extract content 75%
2	70% of malt + 30% of corn grits: 1000 kg of extract: 700 kg from malt + 300 kg from corn grits	
3	35% of malt + 35% of barley + 30% of corn grits: 1000 kg of extract: 350 kg from malt + 350 kg from barley + 300 kg from corn grits	

Enzymes	Activities	Dosage rate
Ceremix 2X L	alpha-a Table 1. Enzymes and dosage rates mylase, beta-glucanase, protease	1.4-1.8 kg per 1 ton of barley during mashing
Ceremix 2X MG	alpha-amylase, beta-glucanase, protease, xylanase, cellulase	0.5 kg per 1 per ton of barley during mashing
Ceremix Plus MG	alpha-amylase, beta-glucanase, xylanase, cellulase, protease	0.7-1.0 kg per 1 ton of barley during mashing
Ultraflo L	beta-glucanase, cellulase, xylanase	0.2-0.5 kg per 1 ton of barley during mashing
Neutrase 0.8 L	neutral protease	0,6-1,0 kg per 1 ton of grinding
Fungamyl Brew Q	maltogenic fungal alpha-amylase	1 kg per 1000 hl in fermentation tank
Promozyme Brew Q	deamylating amylase	0.5-1.5 kg per 1 ton of barley during mashing
Finizyme 250 L	fungal beta-glucanase	0.5 kg per 1000 hl in fermentation tank or BBT

2. Analysis of the latest research and publications

The exergetic performance of beer produced by the conventional malting and brewing process is compared with that of beer produced using an enzyme-assisted process. The aim is to estimate if the use of an exogenous enzyme formulation reduces the environmental impact of the overall brewing process. [5]

Whilst beers have been produced using various levels of unmalted grains as adjuncts along with malt, brewing with 100 % unmalted grains in combination with added mashing enzymes remains mostly unknown [6].

The conversion of barley into beer represents mankind's oldest and most complex example of applied enzymology. Barley is one of the most ancient crops, and it has evolved through domestication to today as a major world crop based on acreage and production. It has great potential to reclaim some of its prominence as a food grain, largely due to its high nutritional value [7].

3. Purpose and objectives of the study

The main raw material for beer production is malt. There is a tendency to use other grain crops in the production of beer. The using of unmalted materials gives opportunity for brewers and technologist for cost saving. But replacing of malt makes affects the quality of wort and beer. The purpose of the researches was to compare quality parameters of 100% malt beers and beer with part of malt replaced by unmalted barley.

4. Materials and methods of research

Using a big amount of unmalted grits together with external enzymes gives brewers opportunity to receive product in the same composition and quality like high-quality product using only malt. To solve the given problem the methods of the high-performance liquid chromatography, analysis and empirical methods are used.

5. Research results

Barley milling

As for malt milling and for milling of barley suitable as a dry or wet method of milling, you need only a minimal adjustment.

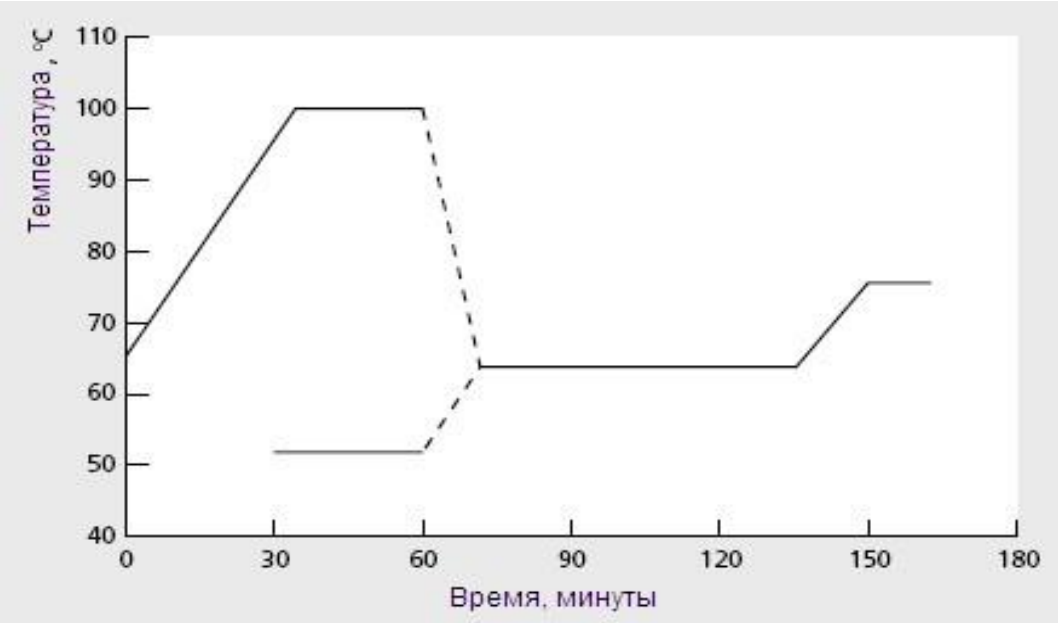
The wet method of milling is well suited in which the grains and their husks soften during steeping (but only when working with lauter tun) [8].

When malt is replaced by a small amount of unmalted barley, the barley is mixed with the malt before milling, but with a high proportion of the barley used it is preferable to mill the barley separately using two-rollers mill with a 0.2 mm gap between the rollers (normal gap for malt is 0.3-0.5 mm) [9-10].

Example 1

As an example of obtaining 1000 kg of extract from malt, barley and corn grits, the following variant can be proposed:

Mash composition	Malt (extract content 76%	475 kg
	Barley (extract content 68%)	475 kg
	Corn grits (extract content 82%)	400 kg
Enzyme for liquefaction:	Termamyl 120 L	0,15 kg
Enzymes for mashing:	Ultraflo XL	0,3 kg
	Neutrase 0.8 L	0,3 kg



Pic.1. Mashing process, example 1.

Corn grits is liquefied separately using Termamyl stabilized with a total Ca2 + content of about 100 mg / L, with water: additives ratio of about 4: 1. Milled malt and barley mashed at the temperature of 52 ° C.

After 30 minutes the boiled part is added to the barley and malt mush to increase its temperature to 63-66°C.

After 60 minutes, the combined mash is heated to 76-78 ° C and kept at this temperature until complete saccharification. Then the wort separation process follows.

The wort / beer properties will be similar to the wort / beer properties obtained using 70% malt and 30% corn grits.

Example 2

Table 2

Gives some results of lab tests of mashing 50% of malt and 50% of barley using the products of Ceremix.

Parameters, units	**Control**	**Ceremix 2X L**	**Ceremix 6X MG**		
Enzymes dosage, w/w of barley	0	0,14	0,1	0,05	0,025
Extract content, %	19,15	19,65	19,64	19,65	19,71
Total nitrogen, mg /l *	820	1123	1120	1068	945
FAN, mg/l	131	213	208	184	143
Viscosity, mPa*s *	2,84	1,75	1,59	1,63	1,69
Beta-glucan, mg / l *	2203	<30	<30	<30	114
* - for 12% wort					

Example 3

The results of full-scale tests before the start of using barley brewing at the breweries in Bulgaria several years ago.

Table 3

Raw materials and mashing type

	Control		Variant 1		Variant 2	
	%	kg	%	kg	%	kg
Malt	85	5950	60	4200	60	4200
Barley	15	1050	40	2800	40	2800
Ceremix 2X L			0,15	4,2	0,15	4,2
Mashing type	decoction		infusion		decoction	

The technical characteristics of the mashing process are in Table 4.

Table 4

Technical characteristics of the mashing process

Characteristics	Control	Variant 1	Variant 2
pH during mashing	5,50	5,50	5,50
Saccharification time, min	10-15	10-15	10-15
Wort filtration time, min	208	170	200
Speed of filtration, l / m2 / min	13,3	15,7	12,9
Yield, %	68,8	72,3	75,3

6. Discussion of results

From the table:

The saccharification time in experimental brews does not differ from the saccharification time in the control variant and is within 10-15 minutes.

For decoction mashing method the filtration speed of the experimental wort was almost identical to the control. The wort obtained by the infusion method had a higher speed of filtration.

The extract yield in the experimental brews is higher than in the control one, and does not depend on the amount of used unmalted barley. The yield using the decoction mashing method is 3% higher than using infusion one.

Physico-chemical parameters of the wort quality are in Table 5.

Table 5

Physico-chemical parameters of the wort quality

Characteristics	Control	Variant 1	Variant 2
Extract, %	9,35	9,15	9,13
pH	5,25	5,35	5,40
Color, EBC*	17	17	17
Viscosity, mPa*s *	1,72	1,70	1,64
Beta-glucan, mg / l *	590	167	339
Soluble nitrogen, mg / l *	826	954	937
Alpha-amine nitrogen, mg / l *	139,00	149,00	142,00
Zn2 +, mg / l	0,22	0,21	0,23
* - for 9% wort			

It should also be noted that the sugar spectrum determined by HPLC (high-performance liquid chromatography) were almost identical. As can be seen from Table 5 total soluble nitrogen and free amine nitrogen are higher in brews using barley and enzymes.

Content analysis of individual amino acids shows (together with higher values of free amine nitrogen) that the concentration of individual amino acids is the same or higher in the experimental brews than in the control one. The only amino acid present in the experimental brew at a lower concentration is arginine, in the control variant, 9.3 mg / 100 ml of arginine was found, compared to 8.6 and 8.4 mg / 100 ml in the experimental brews.

Finished beer analysis are in Table 6.

Table 6

Finished beer analysis

Characteristics	Control	Variant 1	Variant 2
First wort extract content, % mass.	9,30	9,14	9,08
Visible extract,% of mass.	2,20	2,10	1,90
Alcohol,% of mass.	2,91	2,89	2,95
Apparent degree of fermentation,%	76,3	77,1	79,1
The difference between the final and reached degree of fermentation,%	0,2	0,4	0,4
pH	4,4	4,5	4,5
Color, EBC*	14	13	13
Viscosity, mPa*s *	1,65	1,58	1,58
Beta-glucan, mg / l *	211	61	158
Foam stability, Ross and Clark	130	136	136
VDK, mg/l*	0,31	0,24	0,25
Esters, mg / l	22,4	27,1	20,3
Higher alcohols, mg / l	75	79	78
* - for 9% wort			

Surprisingly, that VDK content was high in all variants - this could be corrected using the Maturex.

Conclusions:

Using big amount of unmalted grits together with external enzymes gives brewers opportunity to receive wort/beer in the same composition and quality like high-quality wort/beer using only malt.

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