A C T A A L I M E N T A R I A P O L O N I C A

Vol. XIII (XXXVII), No. 4 1987

TADEUSZ KUCHCIAK
STANISŁAW MASIOR
JÓZEF SURMIŃSKI

ACCUMULATION OF α-AMYLASE IN MALT. III. QUALITY OF WORT AND BEER

Institute of Fermentation Technology and Microbiology, Technical University, Łódź

Key words: wort, beer, barley, malt, gibberellic acid, amylolytic enzymes.

Worts and beers were produced with Grit brewer's barley and with Diva non-brewer's barley. Malt with a high α-amylase content produced according to a previously developed method and a control malt made with barley steeped to 43% humidity and without gibberellic acid were used. 30% unmalted barley was added to malt mash. The quality of beers made with α-amylolytic malts was found to be superiour to the quality of beers made with the control malt. The shelf life of the former beers increases by 3-4 days, and organoleptic assessment is 8.7-10 points higher.

INTRODUCTION

The effect of steeping degree, malting temperature and gibberellic acid (g.a.) addition on α-amylase accumulation in malt was reported in [7]. A subsequent publication [8] described the effect of the time of adding gibberellic acid to the final water during barley steeping on α-amylase content in malt. The third and final stage of research, performed in the years 1984-1985, involved the checking of the usefulness of malt with high α-amylase content in beer production.

MATERIALS AND METHODS

The α-amylolytic malts were initially produced from the Grit variety of brewer's barley and from the Diva non-brewer's barley (both from the 1984 crop), either with or without the gibberellic acid (g.a.) addition. The following conditions, established in previous studies, were maintained during malts production: degree of barley steeping — 46%, temperature of steeping water — 14°C, aeration: 15 min/h in the water phase, and continuous in the air phase; malting with g.a. at 18°C lasted 5 days, and without g.a. — 6 days; temperature of second drying of malt was 79°C (in agreement with results reported in [5] indicating the positive effect of reduced second drying temperature on enzymes content). Gibberellic acid was added to the last steeping water (pH 6.5) during about 20 h; the acid dose was 0.2 mg/kg barley.

The control malt was produced with barley steeped to 43% humidity at 18°C; the malting process lasted 6 days.

The following were determined in the experimental malts: humidity, extractivity in flour and grist, losse of firmness saccharification time, wort colour in Hellige's neocomparator, total protein, tannin protein according to Lundin, the Kolbach number, total tannins in wort by the colourimetric method with Fe ions, wort viscosity, diastatic activity, α-amylase content by Briggs' maltose method [2] with 3,5 dinitrosalicylic acid, endo-β-glucanases (cellulase) content according to Bernat [1] with carboxymethylcellulose sodium salt, and endopeptidases content by the method of Kreit et al. [3].

The mash was produced with 30% of unmalted barley raw material (grist.) 35% of amylolytic malt and 35% of ordinary malt were added. In the second variant only α-mylolytic malt (70%) was used.

The mashes with 30% of unmalted barley raw material were produced according to the method worked out at the Institute of Fermentation Technology and Microbiology, Łódź Technical University, whereby the barley grist is mashed separately with a 10% addition of α-amylolytic malt, and then mashed further with malt by single-gile method.

The control mashes were produced with a 30% addition of unmalted barley raw material and ordinary malt.

During the production of α-amylolytic malt, the malting losses were checked against those in ordinary (control) malt. The following determinations were made in the experimental worts: pH, total nitrogen, α-amino acid nitrogen, viscosity, the final apparent degree of fermentation, time of wort saccharification [6].

After boiling 12°Blg worts with hop (single dose of 2 g/dm^3 wort) beer was produced from them by inoculating the cooled worts with 0.5% brewer's yeast (Bratislava B-S race). The worts fermented for 10-12 days at 8-10°. The beer was stored at 2°C for 14 days.

The determinations in experimental beers included: pH, colour, apparent and real extract, alcohol, strength of basic wort, apparent degree of fermentation, higher alcohols (by the Ribereau-Gayon method), Hartong's stability test, shelf life at 12°C, and organoleptic assessment (100-point scale) [6].

Tables 1-4 give results of analyses of the Grit and Diva barleys used in the experiments, of the experimental malts made with them, as well as the composition of worts and experimental beers.

Table 1. Characteristic of barley (1984 crop)

Determination \ Variety	Diva	Grit
Humidity (%)	9.7	9.8
Extract (% dry substance)	74.6	76.9
Protein (% dry substance)	12.1	11.3
Starch (% dry substance)	58.5	63.1
1000 grains weight (g dry substance)	35.2	37.4
Germination energy after 3 days (%)	96	97
Germination energy after 5 days (%)	97	98
Size and uniformity of grain (%)	79.1	82.5

RESULTS AND DISCUSSION

Comparative analyses of the experimental malts revealed differences analogous to those found in the previous stage of research [7, 8]. Malts produced with g.a. exhibit better qualitative parameters (α-amylase, distatic activity, endo-β-glucanases, endopeptidases, saccharification time, loss of firmness than malts obtained without the g.a. addition at the same level of grain steeping (46%); their superiority with respect to control malts produced with grain of 43% humidity is even more pronounced.

The experiments demonstrate that the increase of α-amylase content in Grit barley with g.a. was about 38%, and of diastatic activity about 9% in comparison to the control malt. In the Diva variety with g.a. both the α-amylase content and diastatic activity were about 28% greater than in control malt.

The endo-β-glucanases content, an important factor determining stability and viscosity of beer, was ca. 73% higher in the Grit variety with g.a. and ca. 47% higher in the Diva barley with g.a. than in the control malt.

Saccharification time in the Grit variety with g.a. was 10-15 min, compared with 15-20 min in the control malt. Loss of firmness in the experiment with g.a. was 1.9 while in the control malt it was 2.7. Similar differences in saccharification time and loss and firmness (3.2 and 4.0) were recorded in experiments with the Diva variety.

It must be noted however that the malting yield in the case of malt produced with Grit barley and g.a. is about 2.7% lower than in the control malts. Also in the malts made with Diva barley and g.a. this yield was lower than in control, by about 1.5%.

Table 2. Chemical analysis of malts made from 1984 barley (Grit and Diva varieties) at malting temperature 18°C: I — steeping to 46% humidity, 20 h of contact with gibberellic acid, 5 days of malting; II — steeping to 46% humidity, no gibberellic acid, 6 days of malting; III — steeping to 43% humidity, no gibberellic acid, 6 days of malting (control malts)

Determination	Grit barley			Diva barley		
	I — with g.a.	II — without g.a.	III — control malt	I — with g.a.	II — without g.a.	III — control malt
Humidity (%)	6.60	7.65	6.82	6.80	7.32	6.79
Extract in flour (% dry substance)	80.3	79.1	78.2	78.8	77.7	76.6
Extract in grist (% dry substance)	78.3	76.6	75.3	75.6	74.0	72.6
Loss of firmness (% dry substance)	1.9	2.4	2.7	3.2	3.7	4.0
Saccharification time (min)	10-15	10-15	15-20	10-15	15-20	15-20
Wort colour (EBC units)	5.1	4.5	4.8	5.0	4.2	3.5
Total protein (% dry substance)	10.7	10.7	10.9	11.5	11.6	11.7
Tannin protein (% dry substance)	1.69	1.40	1.31	1.85	1.91	1.70
Kolbach number (%)	47.0	45.7	44.3	39.0	35.1	34.3
Wort viscosity (mP · s)	1.558	1.578	1.590	1.872	1.596	1.609
Diastatic activity (W-K units dry substance)	420	405	387	355	313	276
α-amylase (F-S units/g dry substance)	747	645	539	600	533	468
endo-β-glucanase (units/100 g dry substance)	255	183	148	199	162	134
Endopeptidases (units/100 g dry substance)	17.9	12.2	11.3	15.9	10.6	9.5
Malting yield with respect to dry substance	82.0	84.6	84.7	79.7	80.7	81.2

Table 3. Analysis of 12° Blg worts with 30% addition of unmalted barley

Wort made of	Malt with g.a.				Malt without g.a. and with 46% humidity				Control malt with 43% humidity	
	Grit		Diva		Grit		Diva		Grit	Diva
Determination	70%	35%	70%	35%	70%	35%	70%	35%	70% of control malt	
pH	5.75	5.76	5.77	5.70	5.82	5.83	5.84	5.76	5.72	5.77
Total nitrogen (mg/dm^3)	1367	1108	1156	1036	1096	1042	1038	1014	1025	1026
α-amino acid nitrogen (mg/dm^3)	365	274	296	209	285	265	221	203	256	205
Viscosity (mPa · s)	2.03	2.08	2.05	2.09	2.10	2.13	2.12	2.19	2.19	2.27
Final apparent degree of fermentation	77.5	76.3	76.3	76.1	76.3	76.7	75.9	75.2	75.3	74.7
Time of wort saccharification (min)	10-15	15-20	10-15	15-20	15-20	20-25	15-20	20-25	15-20	20-25

70%, 35% — additions of α-amylolytic malt

Table 4. Analyses of beers produced with 30% additions of unmalted barley

Determination / Wort made of	Malt with g.a.				Malt without g.a. and with 46% humidity				Control malt with 43% humidity	
	Grit		Diva		Grit		Diva		Grit	Diva
	70%	35%	70%	35%	70%	35%	70%	35%	70% of control malt	
Colour (EBC units)	14	13	15	14	13	14	16	16	16	17
pH	4.80	4.67	4.93	4.78	4.77	4.87	4.86	4.79	4.88	5.01
Real extract (% weight)	4.56	4.42	4.40	4.34	4.52	4.37	4.46	4.47	4.76	4.78
Apparent extract (°Blg)	2.9	2.9	3.0	2.9	2.9	2.8	2.9	3.0	3.2	3.3
Alcohol (% weight)	3.9	3.9	3.8	3.7	3.9	3.7	3.7	3.7	3.7	3.6
Trength of basic wort (°Blg)	12.0	11.8	12.1	11.7	12.1	11.6	11.7	11.7	11.8	11.7
Apparent degree of fermentation (%)	76.4	75.5	75.4	75.2	75.5	75.4	75.8	74.4	72.8	72.2
Higher alcohols (mg/dm³)	49.2	52.2	43.2	44.6	46.1	44.6	46.1	50.7	49.2	47.7
Hartong's test	1.2	1.1	1.0	1.1	1.2	1.0	1.0	0.9	0.8	0.8
Stability (days)	13	11	13	10	11	10	11	9	9	8
Organoleptic assessment according to IPF (points)	79.8	78.1	76.8	79.2	76.8	75.2	74.1	71.2	71.1	66.8

70%, 35% — additions of α-amylolytic malt

The worts produced with α-amylolytic malt have a clearly better composition than those made of the control malt (Tab. 3). Total nitrogen and α-amino acid nitrogen contents are higher when 70% α-amylolytic malt produced with g.a. is used: in Grit barley the former is about 35% higher, the latter by about 43%; in the Diva variety the respective figures are ca. 13% and ca. 45%.

The viscosity of worts made with 70% α-amylolytic malt with g.a. is much lower: in the Grit variety — by 0.16 mPa·s, and in the Diva variety — by 0.22 mPa·s (Tab. 3).

The final apparent degree of fermentation in worts made with 70% α-amylolytic malt is slightly higher, by 2.2% and 1.6% in the Grit and Diva varieties, respectively.

The differences between worts made with 35% α-amylolytic malt and with 35% control malt are much smaller.

The chemical and organoleptic analyses of experimental beers shows that beers made with α-amylolytic malts are clearly superior to those made with control (ordinary) malts.

The apparent degree of fermentation of beer made with 70% of α-amylolytic malt is higher than in beer made with the control malt: by 3.8% in Grit and 3.2% in Diva barley. In these same conditions Hartong's stability test gives values 0.4 points higher for Grit and 0.2 points higher for Diva (Tab. 4), while shelf life increases by 4 and 5 days, respectively. Of particular importance is the marked improvement of organoleptic assessment (100-point scale) of beers obtained with 70% α-amylolytic malt compared with the ratings of beer made with the control malt: the Grit beer was rated 8.7 points higher and the Diva beer 10 points higher.

When 35% α-amylolytic malt and 35% control malt was used, the organoleptic assessment of the resultant beers was also higher than of beers made with control malt only: by 7.0 and 12.4 points in the case of Grit and Diva barleys, respectively.

The good quality of beers with the 30% addition of unmalted barley produced with α-amylolytic malts on laboratory scale encourage experiments on semi-industrial and industrial scale, especially with the Diva barley variety.

CONCLUSIONS

1. Worts made with 30% unmalted barley and 70% α-amylolytic malt produced with Diva and Grit barley varieties are much superior as regards composition to worts made with the control malt. Total nitrogen content is 13-35% higher, and α-amino acid content is 43-45% higher. The final apparent degree of fermentation increased by 1.7-2.2%.

2. The assessment of chemical composition and organoleptic qualities

of beers with the 30% addition of unmalted barley produced with α-amylolytic malts was much more favourable than in the case of beers made from the control (ordinary) malt, and this in the case of both barley varieties. The apparent degree of fermentation increases from 3.2% to 3.8%, shelf life increases by 3-4 days, and organoleptic assessment improves considerably — by 8.7-10 points.

3. The good quality of beers with the 30% addition of unmalted barley produced on laboratory scale with α-amylolytic malts must be checked in semi-industrial and industrial production.

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Manuscript received: October, 1986
Authors address: 90-924 Łódź, Stefanowskiego 4/10

T. Kuchciak, S. Masior, J. Surmiński

NAGROMADZENIE α-AMYLAZY W SŁODZIE, CZ. III. JAKOŚĆ BRZECZKI I PIWA

Instytut Technologii Fermentacji i Mikrobiologii, Politechnika, Łódź

Streszczenie

W niniejszym, końcowym etapie pracy sprawdzano użyteczność słodów o wysokiej zawartości α-amylazy do produkcji brzeczki i piwa. Do doświadczeń użyto odmianę jęczmienia browarniczego Grit i odmianę niebrowarnianą Diva ze zbioru w 1984 r., z dodatkiem i bez dodatku kwasu giberelinowego (KG). Podczas produkcji słodów doświadczalnych stosowano następujące parametry: stopień namoczenia jęczmienia 46%, temperaturę wody moczącej 14°C. Słodowano z KG w temperaturze 18°C w ciągu 5 dni, a bez KG — 6 dni. Temperatura dosuszania słodu wynosiła ok. 79°C. KG wprowadzano do ostatniej wody moczącej o pH 6,5 w ciągu ok. 20 h, stosując dawkę 0,2 mg KG/kg jęczmienia. Słód kontrolny produkowano przy namoczeniu 43% w czasie słodowania wynoszącym 6 dni, w temp. 18°C. Zaciery (brzeczki) sporządzano z dodatkiem 30% niesłodowanego surowca jęczmiennego (śruty). Do zasypu dodawano 35%

słodu α-amylolitycznego i 35% słodu zwykłego (kontrolnego). W drugim wariancie używano wyłącznie słód α-amylolityczny (70%) z dodatkiem 30% surowca niesłodowanego.

Przy sporządzaniu zacierów z dodatkiem 30% niesłodowanego surowca jęczmiennego zastosowano metodę zacierania opracowaną w naszym Instytucie przy zastosowaniu oddzielnego zacierania śruty jęczmiennej z 10% słodu α-amylolitycznego i dalszego zacierania ze słodem metodą jednowarstwową. Jako kontrolne sporządzane były zaciery z dodatkiem 30% niesłodowanego jęczmienia przy użyciu słodu zwyczajnego.

Brzeczki uzyskane z zastosowaniem 30% jęczmienia niesłodowanego i 70% słodu α-amylolitycznego wykazały wyraźnie korzystniejszy skład niż przy użyciu słodu kontrolnego. Zawartość azotu ogólnego wzrastała od 13 do 33%, azotu α-aminokwasowego od 43 do 45%, ostateczny pozorny stopień odfermentowania wzrastał o 1,7 do 2,2% (tab. 3).

Ocena jakości piw z dodatkiem 20% jęczmienia niesłodowanego przy użyciu słodów α-amylolitycznych wypadła dla obu odmian znacznie korzystniej niż piw ze słodu kontrolnego. Pozorny stopień odfermentowania podwyższył się o 3,2 do 3,8%, trwałość handlowa piw wzrosła o 3-4 doby, ocena organoleptyczna poprawiła się znacznie o 8,7 do 10 punktów (tab. 4).

Korzystne wyniki jakości piw z dodatkiem 30% jęczmienia niesłodowanego uzyskane przy użyciu słodów α-amylolitycznych w skali laboratoryjnej wymagają dla potwierdzenia wykonania doświadczeń w skali pół- i pełno-przemysłowej.