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THE APPLICATION OF TRITICALE VARIETY ODYSSEY AS THE SUBSTITUTE FOR MALT IN WORT PRODUCTION

Olgica S. Grujić, Jelena D. Pejin and Srbislav S. Denčić

The objective of this work was to investigate the possibility of triticale application as the partial substitute for malt in wort production. For wort production, two series of experiments were performed in which triticale variety Odyssey, from experimental fields, Rimski Šančevi location (Serbia), was used as the substitute for barley malt in grist with and without the addition of commercial enzyme Ultraflo Max (Novozymes, Denmark). Triticale was added in each of the carried series of experiments as the substitute for malt: 0, 10, 20, 30, 40, 50, 60, 70 and 80% in grist. Experiments were carried out on laboratory scale by the application of infusion procedure for wort production. Regarding extract content, triticale variety Odyssey could be used as the substitute for malt up to 60% without the addition of commercial enzyme Ultraflo Max. With the addition of this enzyme triticale variety Odyssey could be used as a substitute for malt up to 80%, regarding the extract content. With the increase in the content of triticale in the grist, viscosity increased. The addition of commercial enzyme Ultraflo Max significantly reduced wort viscosity. The obtained results indicate that worts produced with the addition of triticale variety Odyssey to grist yielded good analytical quality parameters.

KEYWORDS: Triticale, malt, wort

INTRODUCTION

According to the definition given by the Bavarian law of the purity of beer production ("Reinheitsgebot") from 1516, beer is the product which must be produced only from malted barley, hops and water, using the brewer's yeast for fermentation (1). Brewing is a multistage process involving biological conversion of raw materials to final product (2). In modern brewing the use of adjuncts (unmalted cereals) is a well-established procedure (3).

From the technological point of view, an adjunct is primarily employed in brewing to provide carbohydrates that can ultimately be broken down into fermentable sugars, and maximum starch content is clearly desired in the use of a brewing adjunct (4). Adjuncts are also used in beer production to increase beer stability, and possibly to reduce the production costs (5). Despite of the undisputed economic role of adjunct utilization, beer

Dr. Olgica S. Grujić, Prof., Dr. Jelena D. Pejin, Assist. Prof., University of Novi Sad, Faculty of Technology, Bulevar Cara Lazara 1, 21000 Novi Sad, Serbia, Dr. Srbislav S. Denčić, Scientific Advisor, Institute of field and vegetable crops, Maksima Gorkog 30, 21000 Novi Sad, Serbia

quality is based on wort composition rather than on wort price. Thus, the brewer needs to ensure that wort prepared from mixed grists of malt and adjuncts does not diminish the traditionally high quality standards (6). Maize and rice are the most commonly used sources of starch-rich brewing adjuncts. Nevertheless, a wide range of other cereals, such as unmalted barley, wheat, or sorghum have also been employed (3).

Triticale (*Triticosecale* spp. Wittmack), the first man-made cereal, is the product of a cross between wheat (*Triticum* spp.) and rye (*Secale* spp.) (6). In modern times, it has been reported that triticale is cultivated in more than 30 countries worldwide (7) on araund 3.7 milion ha in total, yielding more than 12 milion tonnes a year (8). Triticale has agronomic advantages, it can be grown on more marginal land (arid, acidic, etc.) and requires less agricultural chemicals (fertilizer, agronomic chemicals, etc.) (9). Recent studies have shown that unmalted triticale may be suitable as a brewing adjunct. Most non-malt adjuncts do not contribute to enzyme activity. However, triticale goes beyond this specification, since some triticale varieties already contain high levels of amylolytic activity in their unmalted natural form, in conjunction with lower levels of proteolytic activity (10). Because of this and the low gelatinization range (59-65ºC), triticale is capable of degrading its own starch content with the efficiencies roughly equal to those of barley malt (3). Besides amylolysis and proteolysis, the degradation of non-starch polysaccharides during mashing is considered another essential parameter in brewing. Arabinoxylan and mixed linkage β-glucan have been recognised as factors that contribute to wort viscosity, decrease wort and beer filtration rates and cause subsequent problems such as haze formation or reduced extraction efficiency (4). When using triticale, mixed linkage β-glucans are negligible as a result of their minor content in the grains (11). In contrast, the solubilisation of triticale arabinoxylans slightly increases wort viscosity and may affect beer filtration rates (3, 6). In addition to these quality criteria, Glatthar *et al.* (6) showed that substantial savings (up to 25% in costs for raw materials) could be achieved by using triticale instead of brewing adjuncts currently in use.

The objective of this paper was to investigate the possibility of triticale application as the partial substitute for malt in wort production. For wort production, two series of experiments were performed in which triticale variety Odyssey, from experimental fields, Rimski Šančevi location (Serbia), was used as the substitute for barley malt in grist with and without the addition of commercial enzyme Ultraflo Max (Novozymes, Denmark).

EXPERIMENTAL

For wort production, two series of experiments were performed in which triticale variety Odyssey, from experimental fields, Rimski Šančevi location (Serbia), was used as the substitute for barley malt in grist with and without the addition of commercial enzyme Ultraflo Max (xylanase and β-glucanase) as recommended by the manufacturer (Novozymes, Denmark). Ultraflo Max is a beer filtration enzyme solution that lowers wort viscosity and levels of arabino-xylans, as well as levels of β-glucans. Triticale was added in each of the carried series of experiments as the substitute for malt: 0, 10, 20, 30, 40, 50, 60, 70 and 80% in grist based on extract content. Experiments were carried out on laboratory scale by the application of infusion procedure (30 minutes at 45°C; temperature in-

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crease to 70°C in 25 minutes; 60 minutes at 70°C, cooling to 20°C) for wort production. At the shares >40% of triticale, thermal treatment (temperature increase to 90°C; cooling to 70-75°C, addition of 1g of malt; temperature increase to the boiling and kept at this temperature for 10 minutes; cooling to 45°C) was used before the infusion procedure (for starch gelatinization). Triticale, malt and wort analyses were performed using the standard European Brewery Convention, Analytica-EBC (12) and/or MEBAK (13) methods.

RESULTS AND DISSCUSION

Results of malt analyses are given in Table 1. According to analytical parameters of malt analyses presented in Table 1, malt used in these experiments was of good quality.

Table 1. Results of malt analyses

Parameter	Malt
➢ Moisture content of grain, %	5.45
➢ Proteins, % DM	10.23
➢ Extract content, fine grist, % DM	80.64
– Saccharification, min	<10
– Wort clarity	Slightly opal
– Filtration, min	11
– Wort colour, EBC units	3.0
– Wort pH value	5.67
– Wort soluble nitrogen, mg/100 mL	88.90
– Viscosity, mPa·s, 8.6%e	1.648
– Wort formol nitrogen content, mg/100mL	28.13
➢ Extract difference, % DM	1.21
➢ Kolbach indice, %	49.24
➢ Hartong VZ 45°C, %	42.20
➢ Real attenuation, %	76.75
➢ Apparent attenuation, %	94.62

DM – dry matter

The results of triticale variety Odyssey analyses as an adjunct are given in Table 2.

Table 2. Results of triticale variety Odyssey analyses (as an adjunct)

Parameter	**Odyssey**
➢Moisture content of grain, %	10.06
➢Protein content, %DM	12.65
➢Extract content, fine grist, % DM	78.23
– Saccharification, min	15-20
– Wort clarity	clear
– Filtration, min	20
– Wort colour, EBC units	3.5
– Wort pH value	5.62
– Wort soluble nitrogen, mg/100 mL	80.51
– Viscosity, mPa·s, 8.6%e	1.959
– Wort formol nitrogen content, mg/100mL	26.85
➢Real attenuation, %	63.11
➢Apparent attenuation, %	77.93

DM – dry matter

The results of the worts analyses produced with triticale variety Odyssey are given in Table 3.

Table 3. Results of worts analyses produced with triticale variety Odyssey

Triticale content (%)	**0%**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**
Wort extract content, %	8.604	8.597	8.507	8.326	8.295	8.276	8.216	7.891	7.724
Saccharification, min	<10	<10	<10	10-15	10-15	15-20	15-20	>60	>60
Wort clarity	slightly opal	slightly opal	slightly opal	clear	clear	clear	clear	clear	clear
Wort colour, EBC units	3.0	3.0	3.0	3.0	3.0	3.5	3.5	3.5	3.5
Filtration, min	11	11	12	13	15	19	50	>60	>60
Wort pH value	5.67	5.65	5.65	5.64	5.64	5.63	5.63	5.62	5.62
Soluble nitrogen content, mg/100mL	88.90	88.77	86.80	80.15	78.40	77.70	74.90	54.60	51.10
Viscosity, mPa·s, 8.6%e	1.648	1.648	1.741	1.810	1.891	1.972	2.146	2.303	2.474
Wort formol nitrogen content, mg/100mL	28.13	27.85	27.39	27.13	27.06	26.88	26.69	26.41	26.22
Real attenuation, %	76.75	71.26	68.93	66.38	63.57	62.86	62.04	60.42	60.10
Apparent attenuation, %	94.62	88.03	85.11	81.92	78.44	77.51	76.57	74.51	74.18

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Substituting a share of malt with triticale variety Odyssey, the characteristic quality parameters of worts changed compared to the control wort produced of malt only as follows (Table 3):

- control malt yielded the highest extract content. Substitution of malt with triticale from 10% up to 80% resulted in a uniform extract decrease with increase of triticale share in grist (10.23% decrease at 80% of triticale share compared to the control wort);
- saccharification time was too high when the share of triticale was higher than 50%, whereas in case of 70 and 80% of triticale in grist the saccharification was nonsatisfactory and unacceptable;
- substitution of malt with triticale, 30-80%, had possitive influence on wort clarity;
- substitution of malt with triticale from 10% to 80% resulted in wort colour increase with the increase of triticale share in grist;
- filtration rate significantly increased when 60, 70 and 80% of malt was substituted with triticale;
- wort pH value slightly decreased with the increase of triticale share;
- wort soluble nitrogen content decreased with the increase of triticale content in wort (42.61% decrease at 80% of triticale share compared to the control wort);
- wort viscosity increased uniformly with the increase of triticale share (50.12% increase at 80% of triticale share compared to the control wort), reaching very high levels at 50, 60, 70 and 80%;
- wort formol nitrogen content slightly decreased with the increase of triticale share in grist (6.79% decrease at 80% of triticale share compared to the control wort), and
- real and apparent wort attenuation decreased with the increase in triticale content in wort.

The results of the worts analyses produced with triticale variety Odyssey and with the application of enzyme Ultraflo Max are given in Table 4.

Table 4. Results of worts analyses produced with triticale variety Odyssey and enzyme Ultraflo Max

Triticale content (%)	**0%**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**
Wort extract content, %	8.604	8.626	8.535	8.432	8.419	8.400	8.243	8.234	8.085
Saccharification, min	<10	<10	<10	10-15	10-15	10-15	10-15	>60	>60
Wort clarity	slightly opal	slightly opal	slightly opal	clear	clear	clear	clear	clear	clear
Wort colour, EBC units	3.0	3.0	3.0	3.0	3.0	3.5	3.5	3.5	3.5
Filtration, min	11	11	11	11	12	12	13	13	15
Wort pH value	5.67	5.65	5.65	5.64	5.64	5.63	5.63	5.62	5.62

Table 4. Continuation

Triticale content (%)	**0%**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**
Soluble nitrogen content, mg/100mL	88.90	88.86	86.75	80.14	78.38	77.69	74.92	54.57	51.05
Viscosity, mPa·s, 8.6%e	1.648	1.447	1.533	1.574	1.606	1.623	1.655	1.671	1.717
Wort formol nitrogen content, mg/100mL	28.13	27.81	27.37	27.09	26.97	26.86	26.60	26.39	26.21
Real attenuation, %	76.75	76.64	67.98	67.26	65.82	63.83	62.97	61.41	60.78
Apparent attenuation, %	94.62	94.50	83.79	83.01	81.19	78.72	77.69	75.80	75.07

The use of triticale variety Odyssey as the substitute of malt for wort production with the application of enzyme Ultraflo Max caused the changes of characteristic wort quality parameters compared to control wort produced of malt only as follows (Table 4):

- extract content in worts produced with triticale was lower than in control one, and the increase in triticale share caused a uniform extract content decrease (6.03% decrease at 80% of triticale share compared to the control wort);
- saccharification time was satisfactory for triticale shares up to 60%, whereas at 70 and 80% content it was unsatisfactory i.e. it was too long. Saccharification time was lower, up to the 70% malt replacement, comared to the worts produced without the application of Ultrflo Max enzyme;
- partial substitution of malt with triticale had a possitive effect on wort clarity change compared to the control one, but no difference was observed compared to the worts produced without the enzyme application;
- slight increase in wort colour was determined as a result of partial malt substitution with triticale. The results for the wort colour were identical to those of worts produced without the addition of the enzyme Ultraflo Max;
- filtration time increased slightly at triticale shares 70 and 80%. The filtration time was shorter comared to the samples produced without the addition of the enzyme, especially at higher trticale ratios (60-80%);
- increase of triticale share resulted in a slight decrease of the wort pH but the results were similar to those obtained without the enzyme addition;
- wort soluble nitrogen content decreased with the increase of triticale content in wort (42.58% decrease at 80% of triticale share compared to the control wort);
- 10-50% of triticale in grists caused wort viscosity decrease compared to the control wort, while the viscosity remained at the level of control wort at 60% of triticale. Wort viscosity increased uniformly with the furhter increase of the triticale share,
- wort formol nitrogen content decreased with increase of triticale share in grist (6.82% decrease at 80% of triticale share compared to the control wort) and
- substitution of malt with triticale from 10% to 80% resulted in uniform real and apparent attenuation decrease. Real and apparent attenuation values were slightly higher compared to the samples produced without the addition of Ultraflo Max.

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Comparative survey of the results of wort analyses produced by partial substitution of malt with different shares of triticale without and with the addition of enzyme Ultraflo Max

The influence of different triticale shares and the application of enzyme Ultraflo Max on the wort extract content is presented in Figure 1.

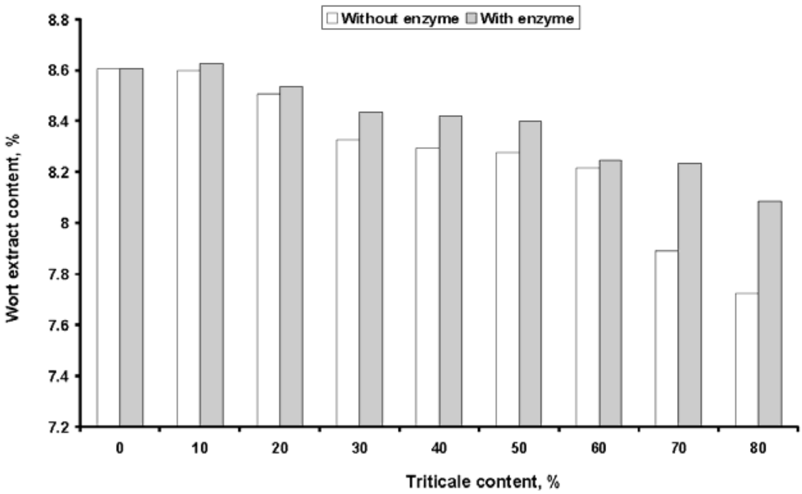

Figure 1. Extract content of the produced worts

The worts produced without the enzyme Ultraflo Max yielded lower extract content compared to those produced with the application of enzyme Ultraflo Max at the same shares and conditions of malt substitution. The increase of triticale share resulted in extract content decrease with and without enzyme addition. With the application of the enzyme Ultraflo Max, at 80% of triticale share, wort extract content was by 4.67% higher compared to the wort extract content with the same triticale share but without the enzyme addition. Regarding extract content triticale variety Odyssey could be used as the substitute for malt up to 60% without the addition of commercial enzyme Ultraflo Max. With the addition of this enzyme triticale variety Odyssey could be used as a substitute for malt up to 80%, regarding extract content.

The influence of different triticale shares and the application of enzyme Ultraflo Max on the wort viscosity is presented in Figure 2.

It is obvious that the increase of triticale share affects viscosity increase which is in agreement with the results obtained by Glatthar *et al*. (3, 6). Higher viscosity values were found in worts produced without the application of enzyme Ultraflo Max. With the application of the enzyme Ultraflo Max, at 80% of triticale share, wort viscosity was by 30.60% lower compared to the wort viscosity with the same triticale share but without the enzyme addition. Regarding viscosity, triticale variety Odyssey could be used as the substitute for malt up to 50% without the addition of the enzyme Ultraflo Max while with the

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addition of this enzyme triticale variety Odyssey could be used as a substitute for malt up to 80%.

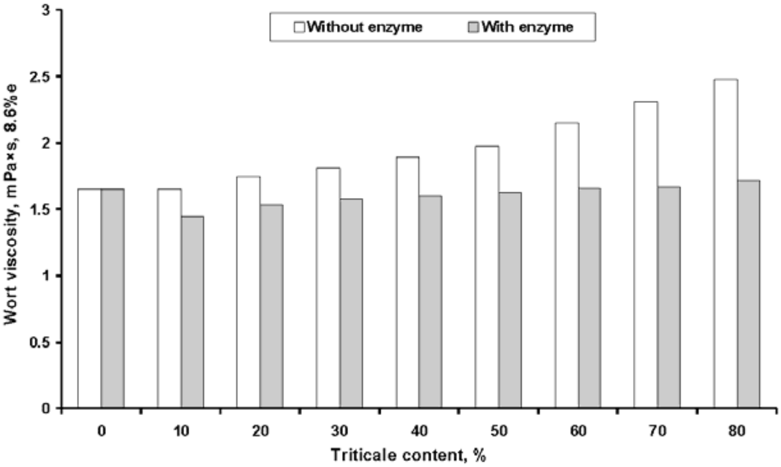

Figure 2. Viscosity of the produced worts

The influence of different triticale shares and the application of enzyme Ultraflo Max on the wort soluble nitrogen content is presented in Figure 3.

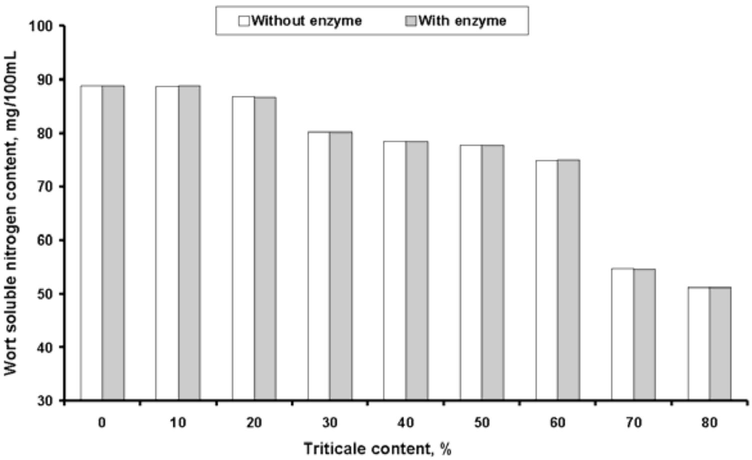

Figure 3. Soluble nitrogen content of the produced worts

The increase of triticale share resulted in a decrease of the wort soluble nitrogen content with and without enzyme addition, especially when triticale share was above 60%. It can be assumed that enzyme inactivation took place during adjunct boilng in the thermal pretreatment. Glatthar *et al.* (3) obtained similar results when using adjunct boiling during thermal pretreatment. The addition of the enzyme Ultraflo Max did not have any influence on wort soluble nitrogen content. Regarding soluble nitrogen content, triticale variety Odyssey could be used as the substitute for malt up to 30% with and without the addition of the enzyme Ultraflo Max.

The influence of different triticale shares and the application of enzyme Ultraflo Max on the wort formol nitrogen content is presented in Figure 4.

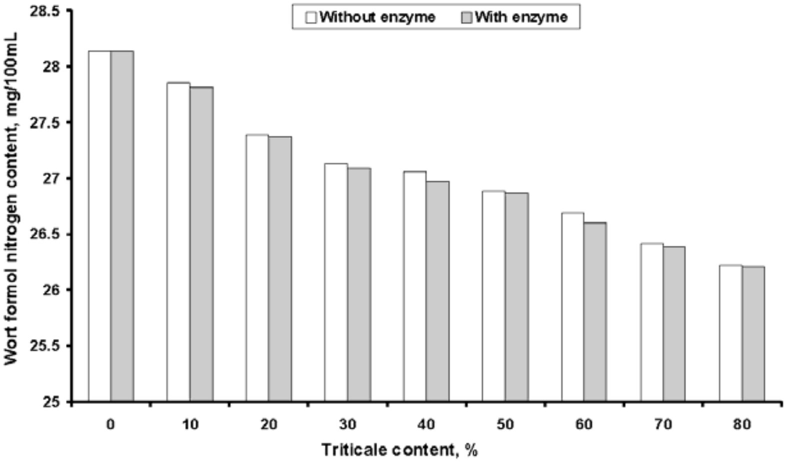

Figure 4. Formol nitrogen content of the produced worts

The worts produced with the enzyme Ultraflo Max yielded slightly lower formol nitrogen content compared to those produced without the application of enzyme at the same shares and conditions of malt substitution. The increase of triticale share resulted in a decrease of the wort formol titration nitrogen content with and without enzyme addition. Regarding formol nitrogen content, triticale variety Odyssey could be used as a substitute for malt up to 80% with and without the addition of the enzyme Ultraflo Max.

CONCLUSIONS

Regarding extract content, triticale variety Odyssey could be used as a substitute for malt up to 60% without the addition on commercial enzyme Ultraflo Max. With the addition of this enzyme, triticale variety Odyssey could be used as a substitute for malt up to 80%, regarding extract content. With the increase in the content of triticale in the grist, viscosity increased. The addition of commercial enzyme Ultraflo Max significantly reduced the wort viscosity. The obtained results indicate that worts produced with the addition of triticale variety Odyssey to the grist yielded good analytical quality parameters. Based on the obtained results it is suggested that triticale may serve as a convenient brewing adjunct.

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ПРИМЕНА ТРИТИКАЛЕА СОРТЕ ОДИСЕЈ КАО ЗАМЕНЕ ЗА СЛАД У ПРОИЗВОДЊИ СЛАДОВИНЕ

Олгица С. Грујић, Јелена Д. Пејин, Србислав С. Денчић

Циљ овог рада је био да се утврди могућност примене тритикалеа као делимичне замене за слад у производњи сладовине. За производњу сладовине изведене су две серије експеримената у којима је сорта тритикалеа Одисеј, из селекционих огледа са Римских Шанчева (Србија), коришћена уместо јечменог слада у усипку са и без додатка комерицијалног ензима Ultraflo Max (Novozymes, Данска). Тритикале је додаван уместо слада у усипку у следећим односима: 0, 10, 20, 30, 40, 50, 60, 70 и 80%. Експерименти су изведени у лабораторијским условима применом инфузионог поступка за производњу сладовине. У погледу екстракта, сорта тритикалеа Одисеј може заменити 60% јечменог слада без додатка комерцијалног ензима Ultraflo Max, док се са додатком ензима Ultraflo Max тритикале сорте Одисеј може користити уместо слада и до 80%. С порастом удела тритикалеа у усипку вискозност сладовина се повећавала. Додатак ензима Ultraflo Max је значајно смањио вискозност сладовина. Добијени резултати показују да су сладовине произведене уз примену тритикалеа сорте Одисеј уместо слада имале добре аналитичке показатеље.

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