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# THE APPLICATION OF TRITICALE MALT AS THE SUBSTITUTE FOR BARLEY MALT IN WORT PRODUCTION

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*The aim of this work was the investigation of wort production for beer by the application of triticale malt, as the partial substitute for barley malt in grist. For wort production, three series of experiments were carried out in which malts were produced from three different triticale varieties taken from experimental fields Rimski Sancevi location (Serbia), crop 2006. Experiments were carried out on laboratory scale by applying infusion procedure for wort production. The obtained results indicate that the application of triticale malt gave worts that had good analytical quality parameters.*

KEY WORDS: Triticale malt, wort

## INTRODUCTION

Barley malt has traditionally been the grain of choice in the brewing industry. Barley malt is preferred because, among the other reasons, it has high potential for extract development for yeast growth and fermentation. However, it is not always economically viable to brew with 100% malted barley, and today's breweries are forced to minimise their costs without changing the quality or the character of their beer (1). In this context, the use of cereal-based brewing adjuncts to partially substitute malt in the grist is becoming a standard procedure (2). It is estimated that the current share of mixed grists of malt and adjuncts reaches 90% (3). Despite the undisputed economic role of adjunct utilization, beer quality is based on wort composition rather than 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 (2). Starch-rich adjuncts are usually considered nonmalt sources of extractable carbohydrate, which typically do not contribute to either enzyme activity or soluble nitrogen (3).

Triticale (*Triticosecale* spp. Wittmack) is the first manufactured cereal derived from an amphiploid between wheat (*Triticum* spp.) and rye (*Secale* spp.). Early plant breeders recognized triticale as a hybrid seed combining the favourable characteristics of two genera, but until recently, the realization of many of these goals eluded breeders.

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Now, research efforts have resulted in triticale becoming environmentally more flexible than other cereals, showing better tolerance to many diseases and pests than its parental species and being capable of producing much higher yields and biomass than other cereals. Consequently, a significant increase in the area of triticale production over recent years is a testimony to its future potential (2).

In addition to such agricultural considerations, triticale shows promising brewing properties (2). Some triticale lines contain high levels of amylolytic activity in their unmalted natural form, in conjunction with lower levels of proteolytic activity. Because of this and the low gelatinization range (59-65ºC), triticale is capable of degrading its own starch content with efficiencies roughly equal to those of barley malt. Some cultivars contribute considerable amounts of free amino nitrogen to the wort accompanied by an arabinoxylan content similar to that of all-malt worts. Based on these facts, it can be assumed that triticale could be used as a brewing adjunct that would provide high malt ratios (>30-50%) without the need for the addition of microbial enzymes during mashing, as currently practiced (3).

Triticale's high α–amylase activity has a positive side for malting and brewing. Using the same malting conditions, Pomeranz *et al*. (4) compared the malting quality of several triticales from the United States and Canada with U.S. barleys. Triticale had higher malt losses, but higher malt extracts, higher diastatic power, and higher α– and β–amylase activity than barley. Gupta *et al*. (5) confirmed the high malting value of triticale. Additionally, both duration of germination and steeping moisture significantly influenced malt losses; the highest malt losses and the highest enzymatic (amylase and protease) activity were achieved when 42% steeping moisture, instead of 38%, and 4 to 6 days of germination, in the presence of gibberelic acid, were used. In separate studies, Pomeranz *et al.* (4) and Gupta *et al*. (5) found that worts obtained from mashing triticale malts were high in nitrogenous compounds and dark in colour, indicating high malt proteolytic activity. Pomeranz *et al*. (4) found that triticale beers were, in general, darker than those from barley; six of ten triticale beers had satisfactory clarity stability, while seven showed satisfactory gas stability. The taste of triticale beer was acceptable.

Triticale presents two problems in malting and brewing: 1) high malt losses and 2) overly high proteolytic activity. The first may result in unsuitable malt yields, and the second in high levels of wort-solubilized protein which, in turn, may cause problems during fermentation and storage (protein precipitation), and may confer to the beer undesirable dark colour. Although there is malting quality in triticale, Holmes (6) indicated that it would be difficult to breed for this trait because there is no methodology available for rapid and simultaneous screening for both protein solubilization and carbohydrate modification (7).

The aim of this work was the investigation of wort production for beer by the application of triticale malt as a partial substitute for barley malt in grist. For wort production three series of experiments were carried out in which malts produced from three different triticale varieties were used as the substitute for barley malt in grist.

## EXPERIMENTAL

For wort production, three series of experiments were performed in which malts produced from three different triticale varieties („NS TRITIC“, „ODISEJ“ and „AD 52“), from experimental fields, Rimski Šančevi location (Serbia), crop 2006, were used as the substitute for barley malt in grist. Micromalting was carried out by the standard procedure (8) using the micromalting plant „Seeger”, Germany. Tap water was used during micromalting.

Triticale malt was added in each of the series of experiments as the substitute for barley malt: 0, 10, 30, 50, and 70% in grist, based on extract content. Experiments were carried out on laboratory scale by applying infusion procedure (30 minutes on 45°C; temperature increase to 70°C in 25 minutes; 60 minutes at 70°C, cooling to 20°C) for wort production. Distilled water was used in wort production. Barley and triticale malt and wort analyses were performed using the standard European Brewery Convention, Analytica – EBC (9) and/or MEBAK (10) methods.

## RESULTS AND DISCUSSION

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

**Table 1.** Results of barley malt analyses

| *Parameter* | |
|---|---|
| Thousand-corn weight, g DM* | *36.27* |
| Hectolitre weight, kg/hL | *61.0* |
| Vitreosity, % | *0.00* |
| Moisture content of grain, % | *5.78* |
| Extract content, fine grist, % DM | *81.02* |
| Saccharification, min | *10-15* |
| Wort clarity | *opal* |
| Filtration, min | *8* |
| Wort colour, EBC units | *2.5* |
| pH of wort | *5.67* |
| Soluble nitrogen, mg/100 ml | *79.10* |
| Viscosity, mPa·s, 8.6%e | *1.612* |
| Extract difference, % DM | *1.41* |
| Kolbach index, % | *48.13* |
| Hartong index, VZ 45°C, % | *36.16* |

**DM – dry matter*

Results of the analyses triticale malt’s produced from triticale varieties „NS TRITIC”, „ODISEJ” and „AD 52“ are given in Table 2.

**Table 2.** Analyses of triticale malt produced from triticale varieties „NS TRITIC”, „ODISEJ” and „AD 52“.

| *Parameter* | *Triticale variety* | | |
|---|---|---|---|
| | *NS TRITIC* | *ODISEJ* | *AD 52* |
| Thousand-corn weight, g DM* | *35.52* | *35.73* | *40.24* |
| Hectolitre weight, kg/hL | *50.4* | *56.9* | *50.8* |
| Vitreosity, % | *4.44* | *2.13* | *0.52* |
| Moisture content of grain, % | *4.36* | *4.45* | *4.46* |
| Wort extract content, % | *8.906* | *8.915* | *8.886* |
| Extract content, fine grist, % DM | *82.63* | *82.66* | *82.70* |
| Saccharification, min | *<10* | *<10* | *<10* |
| Wort clarity | *slightly opal* | *clear* | *clear* |
| Filtration, min | *24* | *14* | *23* |
| Wort colour, EBC units | *7.5* | *6.0* | *9.0* |
| pH of wort | *5.78* | *5.78* | *5.66* |
| Viscosity, mPa·s, 8.6%e | *2.012* | *1.874* | *1.892* |
| Soluble nitrogen, mg/100 ml | *112.0* | *100.10* | *112.00* |
| Soluble nitrogen, % DM | *1.00* | *0.90* | *1.01* |
| Formaldehyde titration nitrogen, mg/100ml | *31.50* | *35.00* | *31.50* |
| Real attenuation, % | *60.04* | *57.74* | *65.10* |
| Apparent attenuation, % | *74.12* | *71.28* | *80.37* |

**DM – dry matter*

The hectolitre triticale malt weight is low (below 55 kg/hL) in all samples and points to good degradation. The thousand-corn weight in all triticale malt samples was somewhat higher (above 35 g DM) than in barley malt and this points to poor degradation. The vitreosity was below 5 % for all triticale malt samples suggesting good degradation according to Schuster et al. (8).

Wort extract content was good in all triticale malt samples (8.886-8.915 %). Saccharification was very good (<10 minutes). All samples had adequate filtration time (14 to 24 minutes) and wort pH value (5.66-5.78) which is good for beer production according to Schuster et al. (8) and Kunze (11). Wort colour was higher for all triticale malt samples (6.0-9.0 EBC units) than the colour of worts produced from barley malt (2.5-4.5 EBC units) (8). Viscosity of wort in all investigated triticale malt samples was high (1.892-2.012mPa·s) and indicates a poor activity of cytolytic enzymes group, β-glucanase especially (8). High contents of soluble and formaldehyde titration nitrogen point to good protein degradation in all triticale malt samples.

The results of analyses of worts produced from triticale varieties „NS TRITIC”, „ODISEJ” and „AD 52“ are given in Tables 3-5.

**Table 3.** Analyses of worts produced with triticale variety „NS TRITIC”

| *Triticale malt content (%)* | *0* | *10* | *30* | *50* | *70* |
|---|---|---|---|---|---|
| Wort extract content, % | 8.763 | 9.157 | 8.939 | 8.823 | 8.763 |
| Saccharification, min | 10-15 | <10 | <10 | <10 | <10 |
| Filtration, min | 8 | 13 | 14 | 24 | 32 |
| Wort clarity | opal | slightly opal | slightly opal | clear | clear |
| Wort colour, EBC units | 2.5 | 7.5 | 7.5 | 8.0 | 8.0 |
| pH of wort | 5.67 | 5.63 | 5.68 | 5.75 | 5.80 |
| Viscosity, mPa·s, 8.6%e | 1.612 | 1.666 | 1.765 | 1.838 | 1.936 |
| Formaldehyde titration nitrogen, mg100ml | 27.65 | 26.25 | 25.38 | 24.50 | 23.63 |
| Soluble nitrogen content, mg100ml | 79.10 | 65.10 | 72.10 | 78.40 | 88.70 |
| Real attenuation, % | 69.10 | 75.82 | 74.37 | 70.65 | 67.59 |
| Apparent attenuation, % | 85.31 | 93.60 | 91.81 | 87.22 | 83.45 |

**Table 4.** Analyses of worts produced with triticale variety „ODISEJ”

| *Triticale malt content (%)* | *0* | *10* | *30* | *50* | *70* |
|---|---|---|---|---|---|
| Wort extract content, % | 8.763 | 9.018 | 8.960 | 8.891 | 8.743 |
| Saccharification, min | 10-15 | <10 | <10 | <10 | <10 |
| Filtration, min | 8 | 17 | 17 | 18 | 18 |
| Wort clarity | opal | slightly opal | slightly opal | clear | clear |
| Wort colour, EBC units | 2.5 | 6.0 | 6.0 | 6.0 | 6.0 |
| pH of wort | 5.67 | 5.91 | 5.95 | 5.98 | 6.04 |
| Viscosity, mPa·s, 8.6%e | 1.612 | 1.619 | 1.649 | 1.740 | 1.892 |
| Formaldehyde titration nitrogen, mg100ml | 27.65 | 25.38 | 24.50 | 22.75 | 22.75 |
| Soluble nitrogen content, mg100ml | 79.10 | 67.55 | 74.00 | 74.90 | 86.80 |
| Real attenuation, % | 69.10 | 65.26 | 63.50 | 48.57 | 47.90 |
| Apparent attenuation, % | 85.31 | 80.57 | 78.40 | 59.96 | 59.13 |

**Table 5.** Analyses of worts produced with triticale variety „AD 52”

| *Triticale malt content (%)* | *0* | *10* | *30* | *50* | *70* |
|---|---|---|---|---|---|
| Wort extract content, % | 8.763 | 9.074 | 9.069 | 8.980 | 8.924 |
| Saccharification, min | 10-15 | <10 | <10 | <10 | <10 |
| Filtration, min | 8 | 13 | 16 | 46 | 55 |
| Wort clarity | opal | slightly opal | slightly opal | opal | opal |
| Wort colour, EBC units | 2.5 | 11.0 | 11.0 | 12.0 | 12.0 |
| pH of wort | 5.67 | 5.55 | 5.62 | 5.67 | 5.72 |
| Viscosity, mPa·s, 8.6%e | 1.612 | 1.705 | 1.736 | 1.913 | 1.980 |
| Formaldehyde titration nitrogen, mg100ml | 27.65 | 26.75 | 24.50 | 23.63 | 20.13 |
| Soluble nitrogen content, mg100ml | 79.10 | 54.60 | 63.70 | 70.00 | 84.00 |
| Real attenuation, % | 69.10 | 64.51 | 62.66 | 61.81 | 40.35 |
| Apparent attenuation, % | 85.31 | 79.64 | 77.36 | 76.31 | 49.81 |

Replacement of a share of barley malt with triticale malts produced from triticale varieties „NS TRITIC”, „ODISEJ” and „AD 52“ resulted in the changed characteristic quality parameters of worts compared to the control wort made of barley malt only (Tables 3-5):

- wort produced with 10% of all triticale malts yielded the highest extract content. Worts produced with 10-50% of triticale malt produced from triticale varieties „NS TRITIC" and „ODISEJ" and 10-70% of triticale malt produced from triticale variety „AD 52" had higher extract content than control wort. Substitution of barley malt with triticale malt from 10% up to 70% resulted in a uniform extract content decrease with increase of triticale malt share in grist;
- saccharification time was very good for all worts produced from triticale malt (<10 minutes),
- filtration rate decreased when 50 and 70% of barley malt was replaced by triticale malts produced from triticale varieties „NS TRITIC" and „AD 52", but was still adequate, while an increase in the share of triticale malt produced from triticale variety „ODISEJ" did not influence filtration rate,
- replacement of barley malt with triticale malt produced from triticale varieties „NS TRITIC" and „ODISEJ", 10–70%, had good influence on wort clarity, which was not the case in the application of malt produced from triticale variety „AD 52",
- 10-70% of triticale malt in grits caused wort colour increase compared to control wort,
- pH of wort increased with increased triticale malt share,
- wort viscosity increases uniformly with the increase of triticale malt share,
- formaldehyde titration nitrogen content in wort decreased with increase of triticale malt share in wort,
- soluble nitrogen content in wort increased with the increased triticale malt share in wort, and
- real and apparent wort attenuation decreased with increase of all triticale malts share in grist. Worts produced with 10-50% of triticale malt obtained from triticale variety „NS TRITIC", yielded higher real and apparent attenuation than control wort.

*Comparison of analytical results obtained by partial replacement of barley malt with triticale malt*

The influence of different varieties and shares of triticale on extract content in wort is presented in Figure 1.

Malt produced from triticale variety „AD 52“ gave higher wort extract content compared to „NS TRITIC“ and „ODISEJ“ variety at the same share and conditions of malt replacement except for 10% share. Increase of triticale share resulted in decrease of extract content for all varieties.

Comparison of wort viscosity dependence on content and variety of triticale is presented in Figure 2.

It is obvious that the increase of triticale malt causes viscosity increase, whereas higher viscosity values were found in the worts produced from „AD 52“ variety. Higher viscosity, found for all wort samples, points to poor activity of cytolytic enzymes group, especially of β-glucanase.

The comparison pH values of worts obtained from the different varieties and shares of triticale in grist is presented in Figure 3.

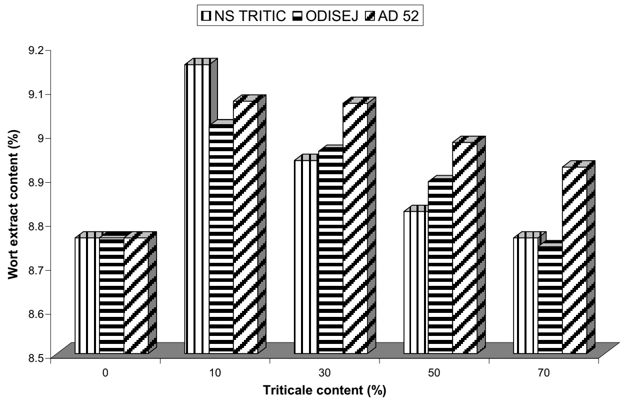


**Fig. 1.** Extract content in the obtained worts

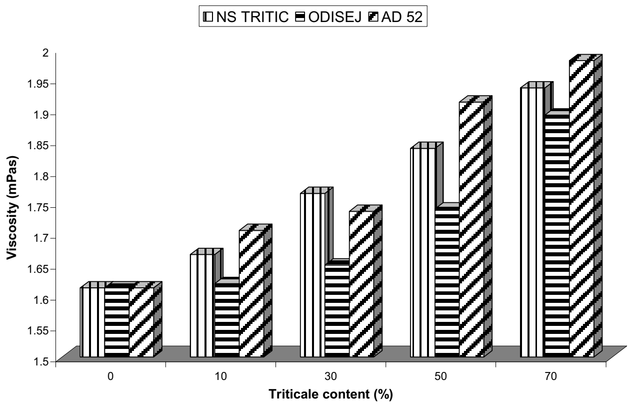


**Fig. 2.** Viscosity of the obtained worts (mPa·s, 8.6%e)

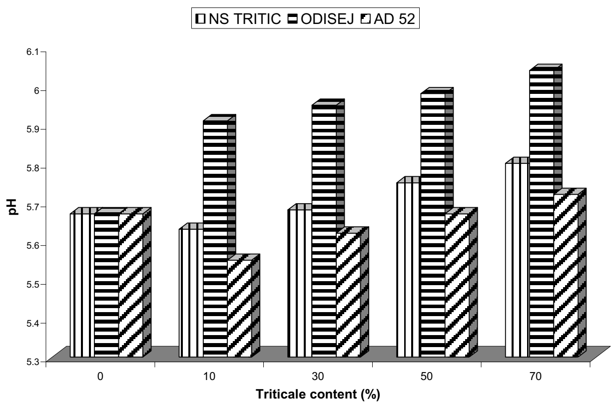


**Fig. 3.** pH values of the obtained worts

The increase in malt share from triticale resulted in a uniform pH increase for all triticale varieties. The highest wort pH values were obtained with malt produced from triticale variety „ODISEJ".

Comparison of wort colour obtained from the different varieties and shares of triticale in grist is presented in Figure 4.

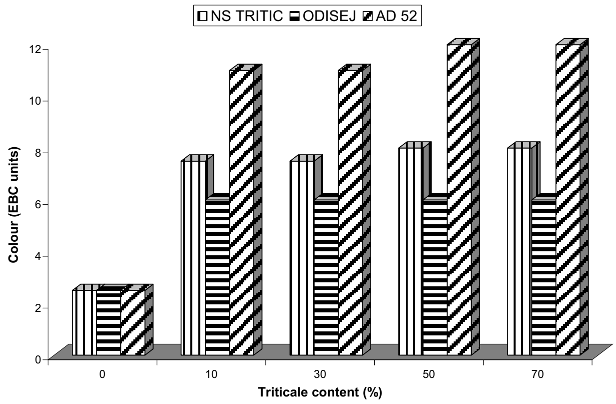


**Fig. 4.** Colour of the obtained worts

Replacement of barley malt with triticale malt 10–70% had no influence on wort colour for triticale variety „ODISEJ". The increase of malt share from triticale resulted in uniform wort colour increase for „NS TRITIC"and „AD 52" triticale varieties.

Comparison of wort apparent attenuation obtained from the different varieties and shares of triticale in grist is presented in Figure 5.

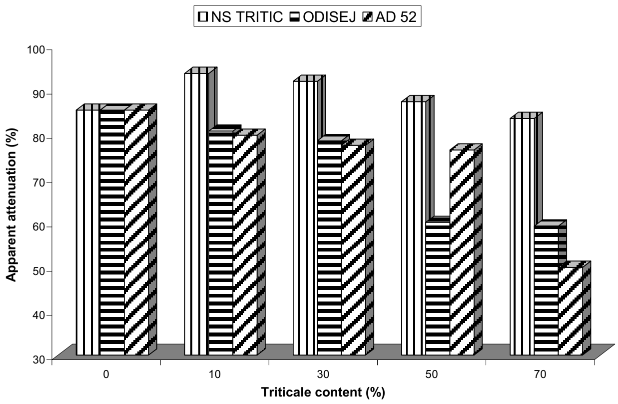


**Fig. 5.** Apparent attenuation of the obtained worts

The increase in malt share from triticale resulted in a uniform apparent attenuation decrease for all triticale varieties. The highest wort apparent attenuation was obtained with the triticale variety „NS TRITIC".

## CONCLUSIONS

Regarding extract content. all investigated malted triticale varieties could be used as the substitute for malted barley up to 70%. Saccharification was under 10 minutes for all malted triticale varieties, which indicates good activity of amylolytic enzymes. With increase in the content of all malted triticale varieties in the grist, wort viscosity showed also an increase.

The obtained results indicate that the application of triticale gave worts that had good analytical quality parameters.

## REFERENCES


1. Lowe D., Ulmer, H., van Sinderen, D. and E. Arendt: Application of Biological Acidification to Improve the Quality and Processability of Wort Produced from 50% Raw Barley. J. Inst. Brew. **110**, 2 (2004) 133-140.
2. Glatthar, J., Heinisch, J. and T. Senn: The Use of Unmalted Triticale in Brewing and its Effect on Wort and Beer Quality. J. Am. Soc. Brew. Chem. **61,** 4 (2003) 182-190.
3. Glatthar, J., Heinisch, J. and T. Senn: A Study on the Suitability of Unmalted Triticale as a Brewing Adjunct. J. Am. Soc. Brew. Chem. **60**, 4 (2002) 181-187.
4. Pomeranz, Y., Burkhart, B. and L. Moon: Triticale in Malting and Brewing. American Society of Brewing Chemists, Annual Meeting, Detroit, 10-14 May 1970, Proceedings, pp. 40-46.
5. Gupta, N., Singh, T. and G. Bains: Malting of Triticale: Effect of Variety, Steeping Moisture, Germintation and Gibberellic Acid. Brew. Dig. **60**, (1985) 24-30.
6. Holmes, M.: Triticale for Malting and Brewing in: Triticale Topics. International Triticale Newsletter. International Triticale Association (1989) pp. 9-18.
7. Varughese, G., Pfeiffer, W. and R. Pea: Triticale – A Successful Alternative Crop (Part 2). Cereal Foods World, **41**, 6&7 (1996) 635-645.
8. Schuster, K., Weinfurtner, F. und L. Narziss: Die Technologie der Malzbereitung. Die Bierbrauerei. Band I, Ferdinand Enke Verlag, Stuttgart (1999) pp. 402-441.
9. European Brewery Convention, Analytica – EBC: 3. Barley, 4. Malt, EBC Analysis Committee, Verlag Hans Carl, Getärnke-Fachverlag, Nürnberg (1998).
10. MEBAK-Methodensammlung der Mitteleuropäischen Brautechnischen Analysenkommission: Band I, 2. Gerste, 4. Malz, 3. Auflage, Neubearbeitet und Ergänzt, Selbstverlag der MEBAK, Freising-Weihenstephan (1997) pp. 133-289.
11. Kunze, W.: Technologie Brauer und Malzer, VLB Berlin, Verlagsabteilung, Berlin (1994) pp. 171-174.


## ПРИМЕНА СЛАДА ТРИТИКАЛЕА КАО ЗАМЕНА ЗА ЈЕЧМЕНИ СЛАД У ПРОИЗВОДЊИ СЛАДОВИНЕ

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Циљ рада је био истраживање производње сладовине за пиво применом слада тритикалеа као делимичне замене за јечмени слад у усипку. За производњу сладо-

вине урађене су три серије експеримената у којима је слад произведен од три различите сорте тритикалеа, са експерименталних поља на Римским Шанчевима (Србија), жетве 2006. године, употребљен као замена јечменом сладу у усипку. Експерименти су изведени на лабораторијском нивоу применом инфузионог поступка за производњу сладовине.

Добијени резултати су показали да су применом слада тритикалеа добијене сладовине добрих аналитичких показатеља.

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