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RELATIONSHIP BETWEEN TOTAL POLYPHENOLS AND COLOUR VALUES OF WORT AND BEER

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ABSTRACT:
We researched the values of total polyphenols and colour of wort and beer, produced out of different reactional mixtures of malt and supplement cereals, in different conditions of wort boiling. Composition of the reaction cereals mixture significantly impacts the content of total polyphenols and colour of wort and beer. Colour values of the worts produced out of the reaction mixtures malt with a part of supplement cereals get increased with polyphenol content increase. Overpressure wort boiling impacts: more intensive extraction of polyphenols out of hops, polyphenol oxidation and coloured compounds formation (melanoidine), what results in increased colour value in the worts and beers produced by the mentioned procedure.
KEYWORDS:
total polyphenols, colour, wort boiling, beer

1. INTRODUCTION

Phenol compounds come into wort and beer from the raw materials used in production (hops, barley malt, and supplement cereals. Their content depends on the conditions of the wort boiling. Depending on the structure and size of molecules, phenol compounds impact: colour, taste, foam and chemical-physical stability of beer. They can be found in cereal chaff and aleuronic layer. In hops polyphenols are located exclusively in surface leaflets and cones. Those are: dimers, trimers and higher polymers of catechins, epicatechins and galocatechins. Polyphenols of hops are, in contrast to polyphenols of cereals, condensed in higher degree and more reactive[2]. In the beer production process, interaction of proteins and polyphenols appear, when the main bond in protein-polyphenol complexes, is of hydrophobic character. Hydrogen bonds only help in the complex strengthening. That way created complexes act negatively on the colloidal stability of the beer[9]. However, these compounds have a positive impact on health. There are indications that polyphenols act: anticancerously, antibacterially, antithrombotically, antioxidatively, immunomodulatorily, antiinflammatorily and as regulators of blood pressure and blood glucose[13, 3,11].

Wort and beer colour depends either on the cereals kind used in wort production, as well as on the production conditions. Namely, the substances that impact the wort and beer colour, beside polyphenols, are melanoidines – coloured compounds which are resulted from interaction of aminoacids and fermentable

carbohydrates. We researched the values of total polyphenols and colour of wort and beer, produced out of different reactional mixtures of malt and supplement cereals, in different conditions of wort boiling.

2. METHODOLOGY

Researches were performed on the following cereals: barley (Nova Gradiska, Hrvatska), barley wort (Nova Gradiska, Hrvatska), splitted corn grains (Mlin Ljubace, Tuzla), rice (Monferatto, Italija). Beside the cited cereals, in order to produce wort and beer we used: water (drinking water – Tuzla's water supply firm «Vodovod»), hops (Zalec, Ljubljana), commercial enzymes Termamyl 120 and Ceremix 2X L (Novo Nordisk, Switzerland), yeast – Sacharomyces cerevisiae (D.D. Pivara , Tuzla). Prepared samples of the reaction mixtures were of the following composition: 80% wort, 20% raw barley (Wort I); 70% wort and 30% splitted corn grains (Wort II); 70% wort, 15% raw barley and 15% splitted corn grains (Wort III); 70% wort, 20% splitted corn grains and 10% rice (Wort IV); and 100% wort (Wort V).

The process of husking of the reaction mixture of barley malt with supplement cereals (samples I,II,III, and IV) was performed by decoction process. Husking of the barley wort was performed by decoction process, with no enzyme addition.

In the further procedure, worts were divided into two parts and treated by hops (1,2 g/L of extract): one part of the wort was exposed to boiling for 60 minutes at STP, and the other part for 60 minutes under the temperature of 104–108°C , at overpressure of 1 bar (1,013 x 10^5 Pa) – OP (overpressure boiling). In the produced worts and beers, colour and content of total polyphenols were determined. Phenol compounds in basic pH react with Fe (III) ions, when brown-coloured complex is produced. Intensity of staining is measured by spectrometry at wave length of 600 nm. Colour of the prepared extract solutions is determined by spectrometry at wave length of 430 nm[5].

3. FINAL RESULTS

The research results (Table 1.) show that the highest content of total polyphenols is present in the Wort I, then in Wort III, Wort IV and Wort II. The colour values of worts produced from reaction mixtures with the portion of substitute cereals get increased with the increase of polyphenol content (Table 2). However, the highest value of the colour has the wort produced out of the pure malt, though its polyphenols content value is not the highest one. That is probably a result of melanoidins presence, which are produced in the malting process, so their concentration in the wort is higher than in anmalting cereals. Polyphenol and colour values in the researched beers are in harmony with their values in the worts (Table 3, Table 4) (the sign STP refers to the boiling at standard temperature and pressure conditions, then OP is the mark for overpressure boiling).

Table 1. Total polyphenols values in the worts

Wort boiling	Total polyphenols (mg/L)				
	Wort I	Wort II	Wort III	Wort IV	Wort V
STP	226,01	165,28	171,70	169,15	182,76
OP	234,94	177,66	202,88	185,55	226,46

Table 2. Colour values in the worts

Wort boiling	Colour (EBC)				
	Wort I	Wort II	Wort III	Wort IV	Wort V
STP	9,6	8,7	9,3	9,2	11,4
OP	13,1	12,1	12,9	12,8	13,2

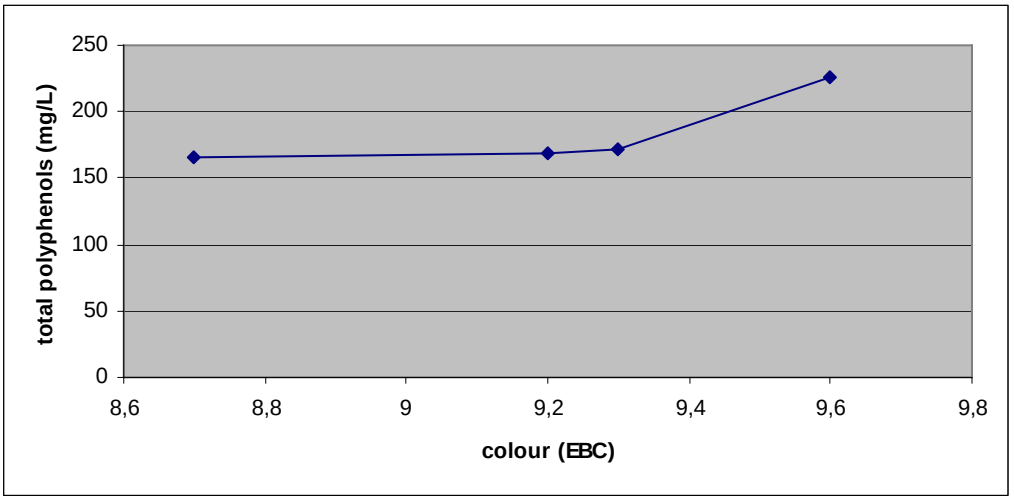

FIGURE 1. Correlation between colour and total polyphenols in the worts (STP) with supplement cereals

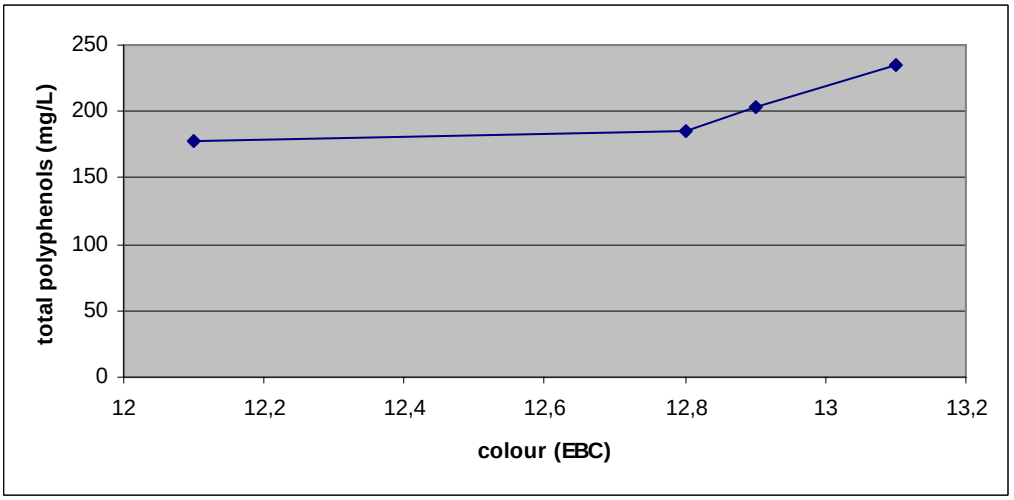

FIGURE 2. Correlation between colour and total polyphenols in the worts (OP) with supplement cereals

Table 3. Colour values in the beers

Wort boiling	Boja (EBC)				
	Beer I	Beer II	Beer III	Beer IV	Beer V
ATP	9,58	6,49	8	6,77	10,57
OP	11,8	9,52	11,10	9,80	12,20

Table 4. Total polyphenols values in the beers

Wort boiling	Ukupni polifenoli (mg/L)				
	Beer I	Beer II	Beer III	Beer IV	Beer V
ATP	153,43	78,22	125,29	95,46	137,89
OP	191,87	123,15	145,51	127,27	198,77

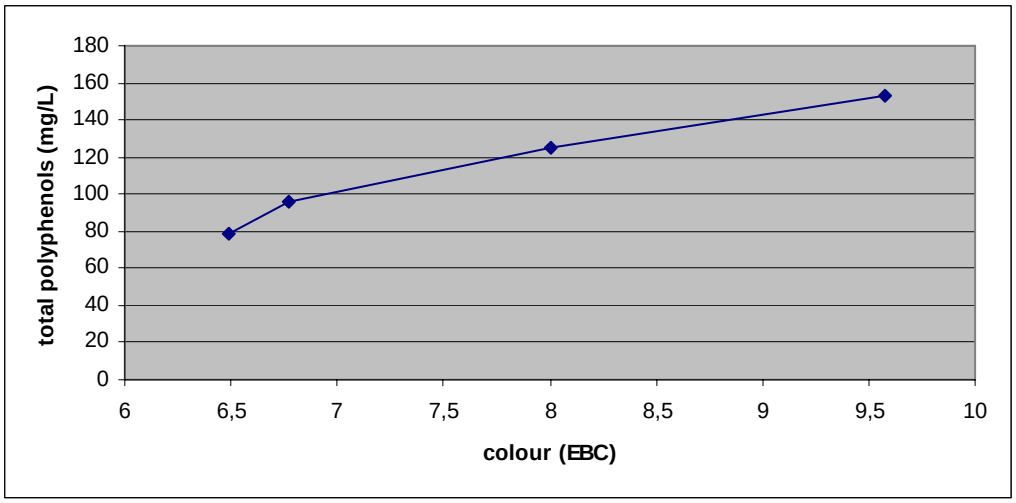

FIGURE 3. Correlation between colour and total polyphenols in beers (STP) with supplement cereals

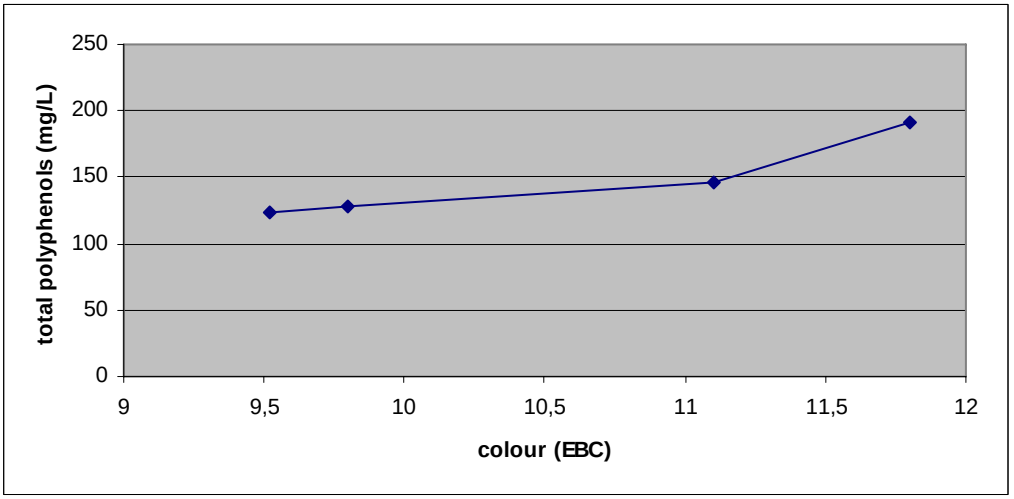

FIGURE 4. Correlation between colour and total polyphenols in beers (OP) with supplement cereals

Importance of polyphenols content in wort and beer is different. Here we have two extremely different claims: need for lower polyphenols concentration that provide colloidal stability, or increased concentration because of their antioxidative properties and taste stability[6].

It is known that higher temperatures impact the content of: polyphenols, bitter substances and colour of fermentable extract[8]. Essential differences in the researched parameters are the results of the composition of reaction cereals mixture, as well as the thermal digestion conditions.

Higher polyphenols values in all the worts treated by overpressure boiling are the result of more intensive extraction of all the compounds obtained out of cereals and hops on higher temperatures. Increased colour value in the worts treated by overpressure wort boiling points to the forming of higher concentrations of the side products (melanoidines), which are desirable in the dark beer, in contrast to the light coloured beer. In this paper overpressure wort boiling was performed under laboratory conditions (closed vessels in autoclave), where probably stronger thermic wort load appeared. That problem might be avoided in industrial plant. This problem is overcome by modern thermal digestion systems with external boiler, which enable

extract circulation. In the course of thermal digestion of fermentable extract, protein and protein-polyphenol complexes are separated, and then deposited. Protein coagulation appearance in this phase results in transparent extract, what is important for colloidal stability of beers[12].

Analysis of the total polyphenol concentration in the tested beers showed some differences, which are, as in worts, a result of wort boiling conditions. Polyphenol concentrations in beers produced from worts obtained by overpressure wort boiling are in the optimal value limits , while these values are lower in the beers produced out of worts treated at STP. Lower polyphenol content has a significant impact on antioxidative beer capacity [1].

Recent technological achievements enable production of beer with high polyphenol concentration, with no negative impact on colloidal stability[10].

Our research showed that colour values in beers produced out of the worts treated by OP are higher than the colour values in beers produced by STP wort boiling, what is a result of the cited compounds formation. Anyway, most of the beers (except the beer obtained out of reaction mixture wtih rice and splitted corn grains) have colour values in the range of the limits (7-12 EBC). The highest colour value, in our researches, has Beer V, then follow Beer I, Beer III, Ibeer V, and Beer II).

Other researches either show that beers produced out of the reaction mixtures of worts with splitted corn grains and rice, have lower colour values, which are the result of the white colour of these cereals grains, of the polyphenol content, as well as of other coloured compounds[7].

Higher percentage of the barley wort in reaction mixture with supplement cereals, impacts the increase of the beer colour values[4].

4. THE CONCLUSIONS

Composition of the reaction cereals mixture significantly impacts the content of total polyphenols and colour of wort and beer. Colour values of the worts produced out of the reaction mixtures malt with a part of supplement cereals get increased with polyphenol content increase. Overpressure wort boiling impacts: more intensive extraction of polyphenols out of hops, polyphenol oxidation and coloured compounds formation (melanoidine), what results in increased colour value in the worts and beers produced by the mentioned procedure.

REFERENCES

1. Andersen M L, Outtrup H, Skibsted L H. Potential Antioxidants in beer assessed by ESR spin trapping. J Agric Food Chem, 48: 3106-3111, 2000.
2. Kunze W. Technology Brewing and Malting. Berlin, Grmany, p 25,1999.
3. Leopoldini M, Marino T, Russo N, Toscano M. Antioxidant properties of phenolic compounds: H-atom versus electron transfer mechanism. J Phys Chem, 108: 4916-4922, 2004.
4. Maric V. Slad - faktor boje arome i okusa piva. Svijet piva, 10: 6-11, 1996.
5. MEBAK-Brautechnische Analysenmethoden, 1997.
6. Narziss L, Meidaner H, Eichhorn P. Invesigations into the Flavour Stability of beer. Monatschr Brauwiss, 52: 49-57, 1999.
7. O Rourke T. Adjuncts and their use in the brewing process. Brew Guardian, 128: 32-36, 1999.

8. O Rourke T. Wort boiling. Brauwelt International, 2: 166, 1996.
9. Rehmanji M, Mola A, Narajanan K S, Ianniello R M. Polyclar (PVPP) for improving shelf life in laboratory treated lagers. MBAATQ, 35, 1998.
10. Stippler K, Wasmuht K, Meidaner H, Englmann J. A new wort boiling system. Part I: first results of pilot trials. Brauwelt, 139: 185-187, 1999.
11. Van Acker S A, Van den Berg D J, Tromp M N, Griffioen D H, Van Bennekom W P, Van der Vijgh W J, Bast A. Structural aspects of antioxidant activity of flavonoids. Free Radic Biol Med, 20: 331-342, 1996.
12. Wasmuht K, Stippler K. Kochsysteme und schaume. Brauwelt, 13/14: 513-516, 2000.
13. Zielinski H, Kozlovska H. Antioxidant activity and total phenolics in selected cereal grains and their different morphological fractions. J Agric Food Chem, 48: 2008-2016, 2000.