BERRY AND FRUIT JUICES AS POTENTIAL UNTRADITIONAL ACIDITY REGULATORS IN MASHING

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Abstract

Acids traditionally used for acidification of mash (lactic acid, phosphorus acid) provide optimal medium pH, however, it is theoretically possible to choose such agents that would complete several tasks, ensuring the regulation of pH. Berry and fruit juices (cranberry, black currant, red currant, quince, apple and lemon) containing different organic acids, such as citric acid, malic acid, tartaric acid and fumaric acid, have similar properties, although they can not only acidify mash but also increase the content of extract substances in wort. In berries and fruits juices titratable acidity and pH was measured potentiometrically using pH meter. The highest titratable acidity of berry and fruit juices was in lemon (5.71 mmol L^{-1}) and quinic juice (5.80 mmol L^{-1}). Lemon juice has a lower pH 2.40 and apple juice has the highest pH 4.82. Results of the analysis of mash pH changes showed, that it is possible to reduce pH replacing traditional acidification regulators (lactic acid, phosphoric acid) with berry and fruit juices. The pH was practically in all the mashing stages in the limits of 5.14±0.02 up to 5.19±0.02. The content of wort extract was analyzed using beer analysing system – Anton Paar „Alcolaizer" analysis. Using HPLC the Carbohydrates like glucose and maltose in wort were detected and quantified. The optimal berry and fruit mashing acidification regulators were quince and cranberry juices.

Keywords: acidity regulators, pH, mashing, mash, wort.

Introduction

In brewing, the raw materials that give the beer its specific sensory properties are water, barley malt, hop, and yeast. The most important technological process in producing of wort is the mashing what is the first stage of beer preparing (Heyse, 1995., Kunze, 1998). The factors that affect the output of malt extract are the quality of water, medium pH and temperature. In the process of mashing, it is important to provide the optimal conditions for starch hydrolysis ferments α-amylase and β-amylase activity. The largest α-amylase activity was stated when medium pH was 5.1–5.2. In the mashing process mash pH is higher and optimal pH is obtained by adding traditional acidificators: phosphor acid, lactic acid or gypsum to the mixture (Kunze, 1998; Narziβ, 2004; Меледина et al., 2006). However, these traditional materials can be partially replaced with other products. Berry and fruit juices (cranberry, black currant, red currant, quince, apple and lemon) containing different organic acids, such as citric acid, malic acid, tartaric acid and fumaric acid, have similar properties, although they can not only acidify mash but also increase the content of extract substances in wort.

The aim of the research was to produce the wort using untraditional acidity regulators as fruit and berry juices and to analyse its chemical composition.

Materials and Methods

Acidity regulators

Samples of berry and fruit: (black currant (*Ribes nigrum*), red currant (*Ribes rubrum),* quince (*Cydonia oblonga*), cranberry (*Vaccinium microcarpum*), apple (Antonovka) (*Malus sylvestris*) were collected at Cesis region in Latvia. Lemon juice is obtained from Lemon samples (*Citrus x lemon*) buy in local retail market Maxima. After collection, the berries and fruits were extracted in juice extractor Moulinex A7534K, and pasteurized 80 °C, 1.5 L min^{-1} with Voran PA 90.

Chemical acidity regulator reagents: lactic, phosphoric, fumaric, quinic, malic and citric acids HPLC–grade>99.0% (Fluka, Germany)

An amount of acidity regulators (Fig. 1.) added to experimental mash with initial pH.

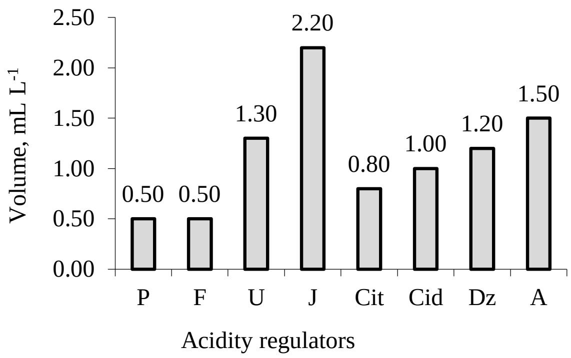

Figure. 1. An amount of added acidity regulators in mash

P – lactic acid, F – phosphoric acid, U – black currants juice, J – red currants juice, Cit – lemon juice, Cid – quinice juice, Dz – cranberries juice, A – apple juice

Raw materials of mashing

Light barley malt (Brupak, England), water (SIA „Griģis un Co") in accordance with the law of LR MK Nr.235/29.04.2003.

The titratable acidity and pH

The titratable acidity and pH was measured potentiometrically using pH meter – WTW inoLab® pH 720.

Wort extract

Content of wort extract was analysed using beer analysing system - Anton Paar „Alcolaizer analysis".

Carbohydrates

The Carbohydrates was determined by HPLC using Shimadzu LC20 Prominence chromatographer. Determination parameters: Refractive Index Detection RID-10A; Column: Alltech NH_2, 4.6x250mm, 5μm; Temperature of the column: +30 °C; Mobile phase: A – acetonitrile and water (70:30); Isocratical regime; Capacity of the injection sample; 10 μL; Rate of the flow: 1.3 mL min^{-1}; Total time of the analysis: up to 20 minutes.

Technological process of mashing and obtaining wort (Fig.2.)

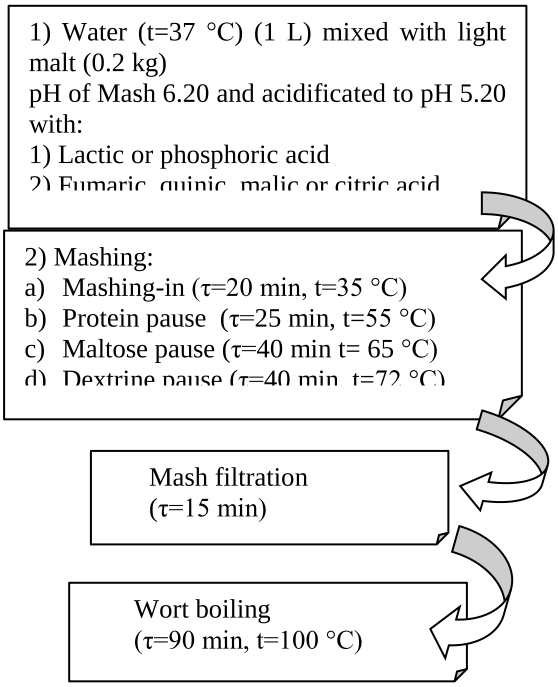

Figure. 2. Technological process of preparation mash and wort

Mathematical data processing

Data obtained were analysed using statistical software Minitab 15 for Windows.

Results and Discussion

The titratable acidity and pH of berry and fruit juices.

The pH in the samples is characterized in Figure 3.

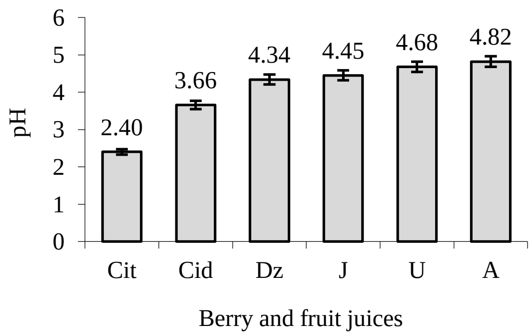

Figure. 3. The pH of berry and fruit juices

U–black currants juice, J–red currants juice, Cit–lemon juice, Cid–quinice juice, Dz–cranberries juice, A–apple juice

It should be concluded from the data presented in Figure 3, that from the berry and fruit juices the lemon juice has a lower pH 2.40 and apple juice has the highest pH 4.82.

The total titratable acidity of berry and fruit juices are showed in Figure 4.

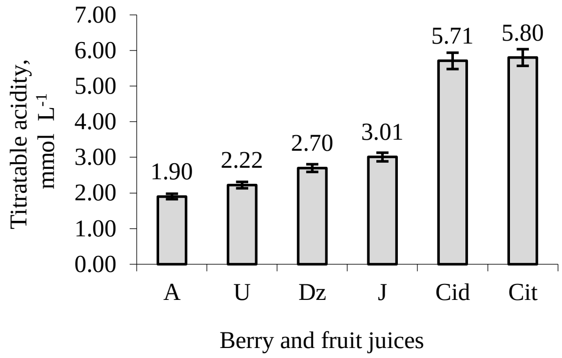

Figure 4. The titretable acidity of berry and fruit juices

U – black currants juice, J – red currants juice, Cit – lemon juice, Cid – quinice juice, Dz – cranberries juice, A – apple juice

The highest titratable acidity of berry and fruit juices was in lemon (5.71 mmol L^{-1}) and quinic juice (5.80 mmol L^{-1}).

Changes of pH in mashing process and evaluation of extract substance content

It is possible to reduce pH mash during mashing using cranberry, black currant, red currant, quince, apple, lemon fruit and berry juices up to pH 5.20±0.02. The changes of mash pH by fruit and berry juices are slight and vary between 5.19±0.02 and 5.14±0.02, thus providing amylase activity of α- and β-enzymes and optimal conditions for starch hydrolysis (Kunze, 1998, Montanari et al., 2005).

The content of measured extract substances in wort obtained during the experiments using traditional and untraditional acidity regulators is displayed in Fig. 5.

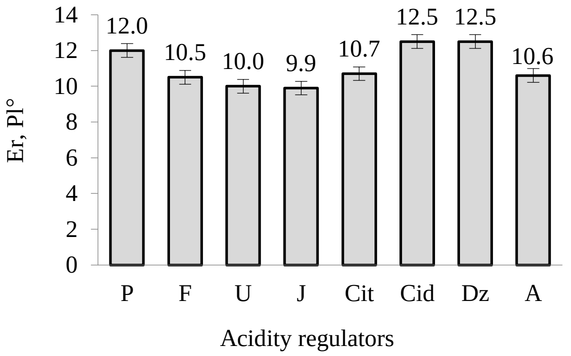

Figure. 5. The content of extract substances in wort (Er), using various acidity regulators

U–black currants juice, J–red currants juice, Cit–lemon juice, Ci–quinice juice, Dz–cranberries juice, A–apple juice

Optimal results of extract substances are gained using cranberry (12.5 Pl°) and quince (12.5 Pl°) juices, the lowest results – using red currant 9.9 (Pl°) and black currant juices. The obtained results using traditional acidity regulators, lactic acid and phosphorus acid, are 12.0 Pl° and 10.5 Pl° (Fig. 5.). Comparing quinic and cranberries juices to the traditional acidity regulators lactic acid, the quinic and cranberries juice's acquisition of extract substances is more efficient by 0.5 Pl°. Using lemon, apple, black currant and red currant juices for acidification of mash there were fewer amounts (by 14.4–23.2%) of extract substances extracted comparing to cranberry and quince juices.

Content of carbohydrates in the wort

Starch in malt hydrolyses to dextrin in mashing process where enzymes α- and β-amylases are active, thus forming maltose and glucose. The amount of maltose and glucose in wort depends on mashing conditions and certain organic acid used for acidification. Measured content of carbohydrates is displayed in Table 1 and 2.

Table 1

Content of carbohydrates in the wort, %

Carbohydrate	**Acidity regulators**			
	P	**F**	**U**	**J**
	(n=5) $\bar{x}_i$ ±SD%	(n=5) $\bar{x}_i$ ±SD%	(n=5) $\bar{x}_i$ ±SD%	(n=5) $\bar{x}_i$ ±SD%
Fructose	–	–	0.13±0.05	0.11±0.05
Glucose	1.36±0.03	1.17±0.03	1.08±0.03	0.91±0.03
Sucrose	0.40±0.06	0.34±0.06	0.32±0.06	0.26±0.06
Maltose	7.38±0.05	6.30±0.05	5.83±0.05	4.91±0.05

P – lactic acid, F – phosphoric acid, U – black currants juice, J – currants juice

Table 2

Content of carbohydrates in the wort, %

Carbohydrate	**Acidity regulators**			
	Cit	**Cid**	**Dz**	**A**
	(n=5) $\bar{x}_i$ ±SD%	(n=5) $\bar{x}_i$ ±SD%	(n=5) $\bar{x}_i$ ±SD%	(n=5) $\bar{x}_i$ ±SD%
Fructose	0.08±0.05	0.07±0.05	0.07±0.05	0.11±0.05
Glucose	1.19±0.03	1.35±0.03	1.37±0.03	1.00±0.03
Sucrose	0.34±0.06	0.39±0.06	0.37±0.06	0.54±0.06
Maltose	6.50±0.05	7.42±0.05	7.44±0.05	7.46±0.05

Cit–lemon juice, Cid–quinic juice, Dz–cranberries juice, A–apple juice

As the amount of extract substances is different when using various acidity regulators in mashing process (Fig. 5), the concentration of maltose and glucose also differ significantly (Table 1 and 2). There was also a little amount of fructose (0.07–0.13%) and sucrose (0.26–0.54%) found in wort (Table 1 and 2). There was no fructose found in wort extracted using lactic and phosphorus acids, because the fructose come from juices.

Acidity regulators – black currant, red currant, lemon, quince and cranberry juices – themselves contain fructose and glucose (Table 3).

The obtained data (Table 3) show that the content of fructose in black current (4.29%), red current (3.95%) and apple (3.60%) juices is the largest comparing to lemon (1.62%), quince (1.51%) and cranberry (1.64%) juices. The amount of glucose is also bigger in black currant and red currant juices (3.80–3.66%), however the glucose amount in apple juice is the least (0.50%). Black currant and red currant juices contain 52–58% more glucose and 35–38% more fructose that lemon, quince and cranberry juices. The total content of glucose and fructose is arranged as follows: black currant (8.09%) > red currant (7.64%) > apple (4.10%) > cranberry (3.93%) > lemons (3.82%) > quince (3.51%).

Table 3

The content of glucose and fructose in berry and fruit juices, %

Berry and fruit juices	**Fructose**	**Glucose**	**Total content of glucose and fructose**
Black currants	4.29±0.21	3.80±0.19	8.09±0.20
Red currants	3.95±0.19	3.69±0.18	7.64±0.18
Apples	3.60±0.18	0.50±0.02	4.10±0.10
Cranberries	1.64±0.08	2.29±0.11	3.93±0.09
Lemons	1.62±0.08	2.20±0.11	3.84±0.09
Quince	1.51±0.07	2.00±0.10	3.51±0.08

Summarizing the results, the biggest amount of glucose and fructose is found in black currant and red currant juices, but the least – in quince juice.

Fumaric, quinic, malic and citric acids like acidity regulators

Due to the fact that berry and fruit juices differ because of various qualitative and quantitative content of acids, the following hypothesis has appeared: high outcomes of extract substances are connected with the concentration of malic acid and quinic acid in berry and fruit juices. Dominant acid in black currant, red currant and lemon juices is citric acid. Cranberry and quince juices contain not only citric acid, but also malic acid, quinic acid, but quince also contains fumaric acid. In order to verify the hypothesis that dominant organic acids that significantly affect the outcome of extract substances are malic acid and quinic acid, separate addition of these acids, citric acid and fumaric acid in mashing process was performed (Fig. 6). The obtained data displayed that added organic acids affect the content of glucose and maltose in wort to a great extent. The highest amount of glucose and maltose was extracted using quinic acid and malic acid as acidification agents, where the total amount of carbohydrates was 9.9±0.04% and 9.5±0.04%.

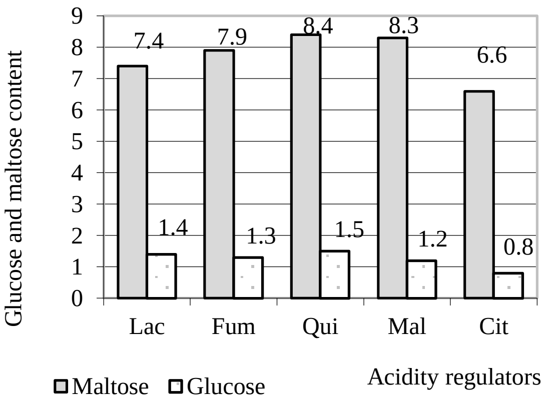

Fig. 6.The content of glucose and maltose in wort

Lac–Lactic acid, Fum-fumaric acid, Qui–quinice acid, Mal–malic acid, Cit–citric acid

Slightly smaller content of carbohydrates was measured when acidifying mash with fumaric acid (9.2±0.04%). Comparing quinic acid, malic acid and citric acid as acidity regulators together with regulation of pH these acids also affect the content of glucose and maltose, using citric acid 26.7% smaller amount of total carbohydrates content is extracted. Thus, experiments helped to find out that using lemon, apple, black currant and red currant juices for mash acidification it is possible to extract less amount of extract substances than by using cranberry and quince juices, as the dominant acid in lemon, black currant and red currant juices is citric acid.

Conclusions

The lemon juice has a lower pH 2.40 and apple juice has the highest pH 4.82. The highest titratable acidity of berry and fruit juices was in lemon (5.71 mmol L^{-1}) and quinic juice (5.80 mmol L^{-1}). The changes of mash pH by fruit and berry juices are slight and vary between 5.19±0.02 and 5.14±0.02. Optimal results of extract substances are gained using cranberry (12.5 Pl°) and quince (12.5 Pl°) juices, the lowest results – using red currant 9.9 (Pl°) and black currant juices. The highest amount of glucose and maltose was extracted using tartaric acid and malic acid as acidity regulators, where the total amount of carbohydrates was 9.5±0.04%. Slightly smaller content of carbohydrates was measured when acidifying mash with fumaric acid (9.2±0.04%). The optimal berry and fruit mashing acidification regulators were quince and cranberry juices.

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