CHANGES OF PH IN BEER DURING MANUFACTURE PROCESS

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Abstract

The possibility to use cranberry juice for acidification of water in the process of beer making instead of traditionally used acidifiers is researched in this work. The output of malt extract received from cranberry juice with acidity regulator is 21.84%. Physicochemical parameters of mash and beer have been defined. The developed method is recommendable for beer production at small enterprises and in home environment.
Key words: malt, beer, pH, cranberries.

Introduction

Beer is usually prepared from water, barley malt, hop, and yeast. The solution of drink received in the result of multiform chemical and fermentative processes is complicated – it contains about 400 various substances (Heyse, 1995). Therefore, even negligible indentions from traditional production technologies affect some specific chemical or biochemical processes and result in alteration of beer quality, making it better or worse (Narziβ, 1995).

One of the most important processes in beer fermentation is the process of mash recovery. Mash raw material – malt - is currently a standard quality commercial product and many of beer manufacturers prefer to choose any kind of malt from the wide range of offered products instead of getting it themselves.

On the first stage of malt getting – the process of mashing – the factors that affect the output of malt extract are the quality of water, medium pH and temperature, as in this period the biochemical processes carry on (Varnam, Sutherland, 1994). In the process of mashing, it is important to provide the optimal conditions for starch hydrolysis enzymes α-amylase and β-amylase activity. The largest α-amylase activity was stated when medium pH was 6.0-5.8, but β-amylase - 5.4–5.6. Because of that this process is commonly carried out when the mash pH is between 5.4 and 5.8 (Kunze, 1998).

Normally, mash medium pH is higher and an optimal pH is obtained by adding phosphoric, lactic acids or gypsum or *Lactobacillus delbrueckii* to the mixture. The option of specific additive is defined by the quality of used water. In most cases, medium pH regulator is lactic acid which reacts with calcium hydrogen-carbonate and forms calcium lactate which substantially affects activity of enzymes (Меледина, 2003).

The purpose of this research is to find out the possibility to substitute phosphoric acid for other organic acids which are in berry and fruit juices.

Materials and Methods

In the experiment, the malt and ready beer acquired in laboratory conditions.

Three series of experiments were accomplished changing the water pH and acidificators was:

- raw water mixed with malt,
- water acidulated with cranberry juice mixed with malt,
- water acidulated with phosphoric acid mixed with malt.

Materials:

1. Light malt.
2. 'Līvu' source water: Ca^{2+} - 50-75 mg L^{-1}, Mg^{2+} - 10- 25 mg L^{-1}, SO_4^{2-} - 5-20 mg L^{-1}, Cl^- - 5-15 mg L^{-1}, Fe^{2+} - 0.01-0.05 mg L^{-1}.
3. Beer yeast.
4. Phosphoric acid.
5. Cranberries.

Methods:

Physicochemical indications of ready beer – output of malt extract, content of ethanol and density - were been defined by beer analyzing system 'Anton Paar beer Alcolyzer Plus' analyzer, but color, bitter substances and VDC - with spectrophotometer 'Jenway' UV/VIS 6400/6405.

Content of wort extract analyzed with beer analyzing system 'Anton Paar beer Alcolyzer Plus' analyzer.

The mash and wort samples were analyzed potentiometrically at the Department of Chemistry of the Faculty of Food Tehnology, LLU, by employing the WTW pH meter (pH 538) with electrode (Sen Tix 97T), using the AOAC 945.10 method.

Mashing conditions are standardized (Figure 1):

Results and Discussion

In the first case, by mixing non-acidulated water with malt, the medium pH decreased for 1.3 units. In further stages, pH changes were insignificant (Figure 2): at the end of the process, the mash pH was 6.02, so the medium acidity (pH 5.4–5.8) necessary for optimal activity of amylase was not achieved. The output of extract matters relatively was the lowest (Table 1).

For regulation of medium acidity, the phosphoric acid, which reacts with hydrogen-carbonates existing in water, was used. However, in this case, a continuous increasing

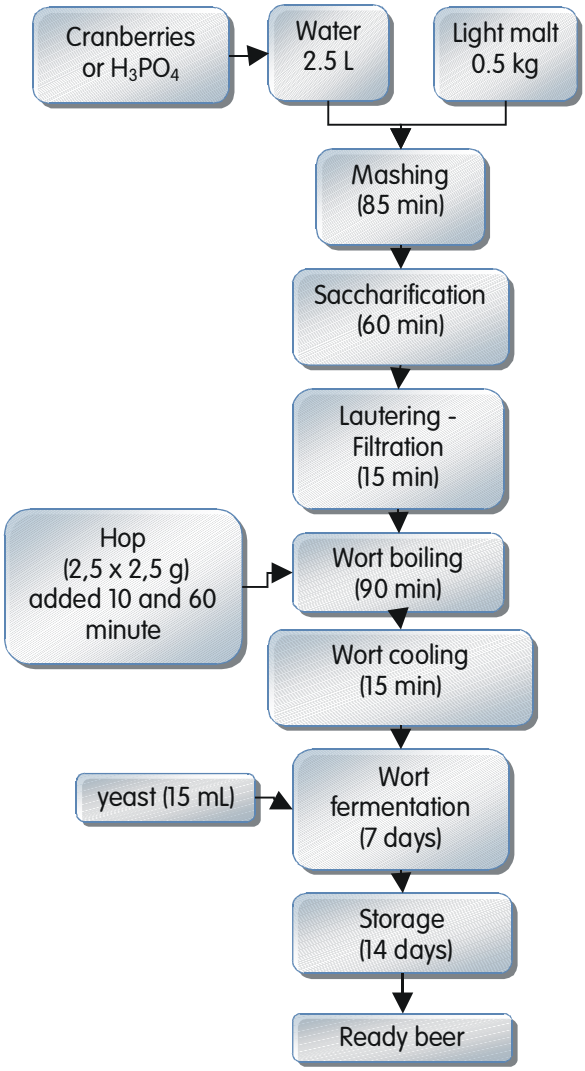

Figure 1. The scheme of the technological process of beer production.

of mash pH was observed. It may be explained by cooperation of phosphoric acid and phosphate with malt extract matters, for instance, amino acids, phosphates, and others. The results of our experiment show that using phosphoric acid as a regulator of acidity, it should be periodically added during the whole process of mashing, which is technologically troublesome.

Beeries and fruits content different organic acids, so them be a possible acidulate leaven agent. For this presumption was testet cranberries. Well-known that 100g cranberries containt 1g citric acid, 1g malic acid and 1g quinine acid (Ruciņš, 2000).

Mixing water, acidulated with cranberry juice (pH 5.64), with malt, the medium pH at all mashing stages was changing very insignificantly and it may be practically considered as constant. In reaction with citric acid, malic acid and quinine acid existing in cranberries, calcium and magnesium hydrogen-carbonates of water were divided this creating salts of relevant organic acids. The practically constant mash pH could confirm that these salts do nor react with extract components. The high output of extract (21.8%) show that it's became absolute saccarification. Cranberry juice as acid regulator is not technological for malt mashing in industrial conditions. However, producing beer in small food production enterprises, e.g., objects of country tourism or in home environment, neither lactic nor phosphoric acids are available. In such production conditions, fruit or berry juice may be used as leaven acidity regulator, such as cranberry, currant, lemon, etc.

To decrease the pH of 200 mL of water which initial pH is 7.0–7.6 up to 5.6, 2.3-2.5 mL of cranberry juice should be added.

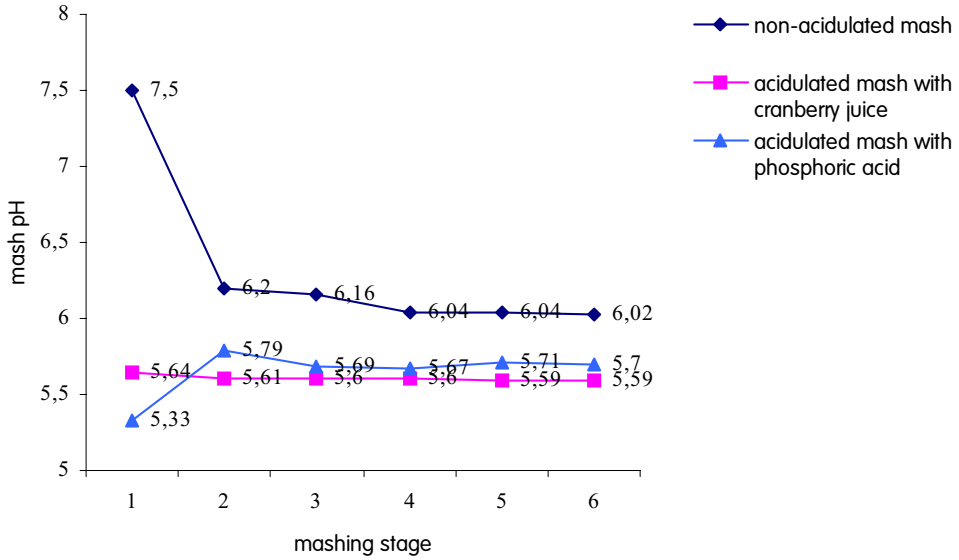

Figure 2. Water and mash pH: for water (1), mixing in (2), albumen pause (3), maltose pause (4), 1st sugaring (5), 2nd sugaring (6).

Derivation beer in a labaratory show variety results. Mash acidulated with phosphoric acid shows in a ready beer the neare results as is in brewery produced beer. Ready beer from mash acidulated with cranberry juice shows very highe original extract, strange color and highe density. This beer color schows, that it's derivate darke beer, but beer was producing from ligh malt. Cranberry juice is influence on beer color in masching process, like dark malt, and it can add in strong beer.

Vicinal diketon (diacetyl, 2.3-pentanedione) content of beer from non – acidulated mash is very highe 1.07 mg L^{-1}. The diacetil flavor threshold is 0.05 – 0.10 mg L^{-1}, and 2.3-pentanedione near 1.0 mg L^{-1}, this mean that beer from non – acidulated mash is appreciable flavor in a buttery and honey like aroma (Fix, 1993).

Conclusions

1. In malt mashing processes water acidulated traditional agents can changed with cranberries juice.

Table 1

Physicochemical indicators of the beer production process

Indicators	Mash		
	Acidulated with cranberry juice	Non-acidulated	Acidulated with phosphoric acid
Mash strained pH	5.59 ± 0.02	6.02 ± 0.02	5.71 ± 0.02
Wort after boiling pH	5.44 ± 0.02	6.02 ± 0.02	5.50 ± 0.02
Wort after main fermentation pH	4.15 ± 0.02	3.92 ± 0.02	4.35 ± 0.02
Original extract, % Plato	21.84 ± 0.03	14.27 ± 0.03	12.47 ± 0.03
Alcohol, %	8.88 ± 0.01	3.77 ± 0.01	5.21 ± 0.01
Color, EBC	18.3 ± 0.1	13.2 ± 0.1	6.0 ± 0.1
Bitterness, BU	23.1 ± 1	20.4 ± 1	20.5 ± 1
VDC*, mg L^{-1}	0.32 ± 0.01	1.07 ± 0.01	0.34 ± 0.01
Density, g/cm^3	1.02304±0.00001	1.02737±0.00001	1.00873±0.00001

Vicinal diketon content

2. Mixing water acidulated with cranberry juice (pH 5.64) with malt, medium pH at all mashing stages is changing very insignificantly and it may be practically considered as constant.

3. With acidity regulator cranberry juice is acquired 21.84% malt extract, which is valuated a high.

4. Acidulated method with cranberries is recommendable for small food production enterprises and home environment.

References

1. Fix G. (1993) Diacetyl: Formation, reduction and control. Brew. Tecn. 1(2), pp. 3-12.
2. Heyse K.U. (1995) Handbuch der Brauerei – Praxis (Handbook of brewery – praxis). Hans Carl, Nürnberg, 547 pp. (in German).
3. Kunze W. (1998) Tehnologie brauer und mälzer (Brewery and malt technology), VLB, Berlin, 910 pp. (in German).
4. Narziβ L. (1995) Abriβ der Bierbrauerei (Description of brewery), Ferdinant Enke Verlag, Stuttgart, 397 pp. (in German).
5. Ruciņš M. (2000) Bioloģiski aktīvo savienojumu kombinēšana ogu un augļu pārstrādes produktos (Combination of biological active components in processing products of berries and fruits). LLU PTF zinātniski paraktiskā konference '21.g.g. Kopā ar zinātni un praksi'. Referāti, Jelgava, pp. 51-54. (in Latvian).
6. Varnam A.M., Sutherland J.P. (1994) Beverages, tehnology, chemistry and microbiology, Chapman&Hall, London, 464 pp.
7. Меледина Т.В. (2003) Сырье и вспомогателъные материалы в пивоварении (Raw materials and helpmate materially in brewery). Профессия, Санкт-петербург 304 с. (in Russian).