Refinement of the physical and chemical methods for the determination of sugars

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Keywords:

Sugars
Fermentable sugars
Determination
Express-analysis

Article history:

Received 25.12.2012
Received in revised form 20.02.2013
Accepted 22.03.2013

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ABSTRACT

The purpose of the work is the comparison of the main existing methods for the determination of sugars to identify the most accurate and easy-to-use in the brewing industry. Experimentally there are optimal methods for determination of sugars for the use in laboratory and industrial conditions of the brewing industry. The correlated coefficients were determined between the results obtained by different methods for the adequate reflection of the main components of sugar share of wort and beer. The essential practical conclusion of the research is the methods for determination of sugars have a sufficiently high accuracy in the determination of the maltose concentration in wort. These methods are the most suitable for the control of kinetics and regulation of production processes.

Introduction

Beer brewing is a complex biochemical process flow of which depends on many factors. To achieve consistently high quality of the product it is necessary to monitor the main parameters of raw materials and intermediate product at all stages of production. Quantitative and qualitative determination of carbohydrates in the wort is one of the main parameters of cooking wort and beer.

Methods for determination of sugars are divided into physical and chemical. The first one are based on the change in the physical properties of solutions depending on the concentration of the test substances in them (the value of the refraction of light, the rotation of the plane of polarization of light, conductivity, density, optical density, etc.). The second one on the specific properties of these substances to enter into certain chemical reactions. Both the first and the second have some inaccuracies in the study of multicomponent systems, one of which is wort.

The aim of this work is the comparison of some existing methods for the determination of sugars to identify the most accurate and convenient one for use in the brewing industry. As the normative documents are regulated only the content of the extract [SSTU 3888-99].

Material and methods

Model solutions were used as solutions of glucose and maltose in the wort and distilled water. Many methods for the determination of sugars require specialized and expensive equipment. Therefore, the choice we stopped at the most simple methods. For comparison were chosen next methods: refractometric, polarimetric, Bertrand method and iodometric (based on the oxidation of iodine aldoz).

Results and discussions

As a result of the first series of experiments with aqueous solutions of glucose from 1 to 10% in 1% increments have the following results:

- physical methods for determining sugars (refractometric and polarimetric) were the most accurate;
- method of Bertrand had stable error, and showed an average of 3.23 times inflated results concerning index of refractometer;
- the ratio of the results by the method of Bertrand to sample is described by the formula (1):

$$y = 0{,}312x - 0{,}021, \quad (1)$$

where x – sugar content by the method of Bertrand, g/100sm^3;
y – the actual content of glucose g/100sm^3;
the value of the reliability of approximation of this equation $R^2 = 0{,}999$;

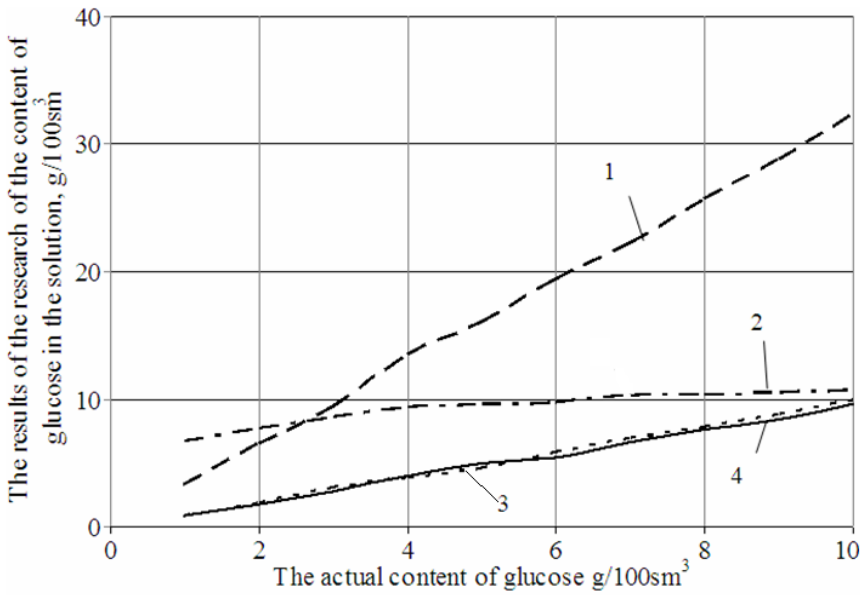

Fig. 1. Comparison of methods for determination of glucose in aqueous solutions: 1 – Bertrand method; 2 – iodometric; 3 – polarimetric; 4 – refractometric

- the least accurate results had iodometric method which although showed a relative increase in the concentration of glucose, but did not have a dependency. This can be explained by the narrow range of working concentrations of this method.

In the second series of experiments the similar samples of glucose were diluted by wort 8.4% of dry substances and the measurement were repeated (Fig. 2). As a result the most linear results were again obtained by physical methods of analysis, however, indexes of polarimeter were larger than indexes of refractometer an average on 9.68. The dependence between these indexes is described by formula (2):

$$y = 0{,}870x - 6{,}708, \quad (2)$$

where x – indexes of polarimeter, %;
y – indexes of refractometer, %.

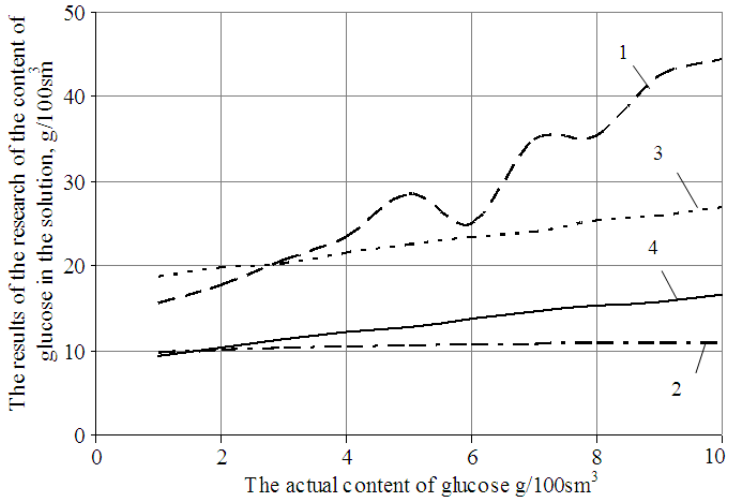

Fig. 2. Comparison of methods for determination of glucose in wort:
1 – Bertrand method; 2 – iodometric; 3 – polarimetric; 4 – refractometric

The value of the reliability of approximation of this equation $R^2 = 0{,}992$.

By the method of Bertrand we have got jumping on indexes with every change of dilution which can be explained by the influence of substance of wort on the chemistry of this method. Iodometric method had no reliable results again and showed changes in the concentration of 1-st to the last sample only 1.22 g/100sm3.

The third series of experiments was conducted on aqueous solutions of maltose with the same concentrations (Fig. 3). As a result, we are seeing a high accuracy of all methods except method Bertrand, whose results are higher than the actual average of 1.18 times. The dependence of the data obtained by the method of Bertrand to the actual sample maltose expressed by (3):

$$y = 0{,}847x, \quad (3)$$

where x – amount of sugars by Bertrand, g/100sm^3;
y – actual content of maltose, g/100sm^3.

The value of the reliability of approximation $R^2 = 0{,}997$.

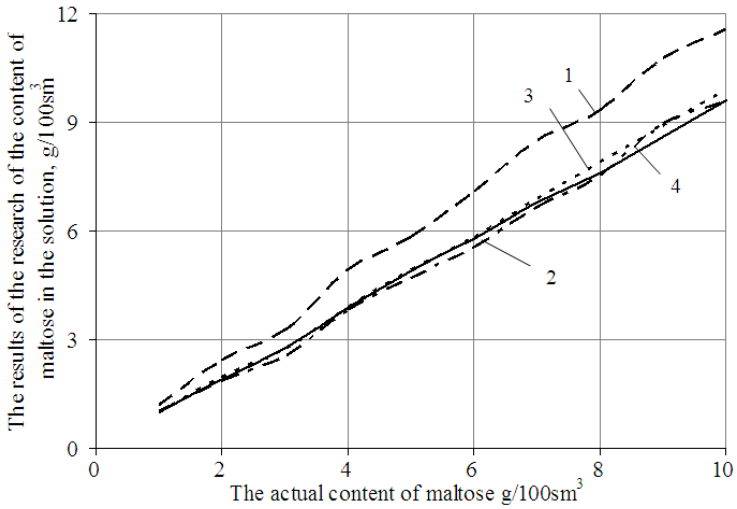

Fig. 3. Comparison of methods for determination of maltose in aqueous solutions:
1 – Bertrand method; 2 – iodometric; 3 – polarimetric; 4 – refractometric

The fourth series of experiments was carried out with solutions of maltose in wort 11% of dry substances (Fig. 4). These results have high correlation. Deviations from the average values f ± 1,35-1,6. Modified breeding slightly impacted on the results of iodometric method. Physical methods had some inaccuracy because of insufficient transparency wort that was complicating removal of indexes.

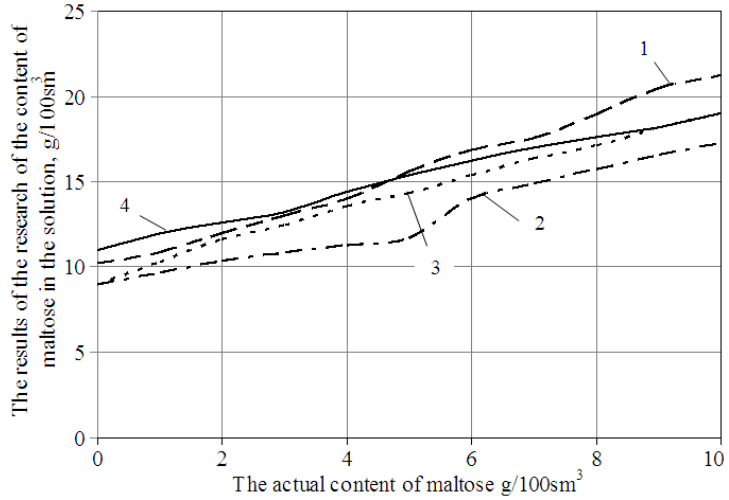

Fig. 4. Comparison of methods for determination of maltose in wort:
1 – Bertrand method; 2 – iodometric; 3 – polarimetric; 4 – refractometric

Conclusions

As a result of these studies physical methods (refractometric and polarimetric) have high accuracy in measuring the concentration of aqueous solutions of glucose, also method of

Bertrand which resulted in actual concentration is calculated by the formula y = 0,312x – 0,021.

Determination of glucose in the wort showed high accuracy only physical methods. On chemical methods greatly affect substances that make up the wort.

As a result of studies of aqueous solutions of maltose observed high accuracy of all methods except the method of Bertrand. Actual concentration dependence of the results obtained by the method of Bertrand described by the formula y = 0,847x.

All methods for determining sugars showed sufficient accuracy in determining the concentration of maltose in the wort and are allowed to control the dynamics of the processes.

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