The Effect of Sugar Content on Key Flavor Compounds in the Fermentation of Cider

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Abstract

The cider fermentation experiment was carried out by adding different concentrations of white sugar and fructose syrup, and the flavor substances were determined by headspace solid phase microextraction gas chromatography-mass spectrometry. The results showed that the flavor substances produced by fermentation were alcohols and aldehydes and ketones.

Keywords

Cider; Flavor Compositions; Sugar.

1. Introduction

Alcoholic fermentation of cider is mainly through the use of Saccharomyces cerevisiae under anaerobic conditions to consume sugars in apple juice through glycolysis to produce alcohol and carbon dioxide. At the same time, it also produces some by-products such as alcohols, lipids, and aldehydes. As the nutrients change during the fermentation process, the living environment of microorganisms also changes constantly, leading to the continuous production of new metabolites [1].

Fructose syrup is an important sweetener in food. It is formed by isomerizing part of glucose in the saccharification liquid obtained by enzymatic saccharification of starch by glucose isomerase into fructose, which is mainly composed of glucose and fructose, so it is called "Fructose syrup" [2]. Fructose syrup contains a large amount of fructose and can play an excellent synergistic effect when used together with other sweeteners, which can greatly improve the taste of food [3], and it has cold and sweet characteristics, easy use of microorganisms, and anti-crystallization properties. Strong and other advantages, so it is widely used in the food and beverage industry [4,5].

At present, the scenes of using fructose syrup in cider are mostly in the blending stage, and there are few reports about the effect of fructose syrup on flavor substances produced during the fermentation of cider. Therefore, this chapter aims to study the effect of adding different amounts of white sugar and fructose syrup to the basic properties of cider during the fermentation process of cider, and to detect and analyze the characteristics of flavor substances in fermented cider with different amounts of sugar.

2. Materials and methods

2.1 Test materials

Apple: purchased in Qixia, Shandong; Saccharomyces cerevisiae: Dibos Saccharomyces cerevisiae La-Ba; Pectinase: 40 u/mg, Beijing Soleibao Technology Co., Ltd.; White sugar and fructose syrup were purchased from Angel Yeast Limited company.

2.2 Test method

2.2.1 The brewing process of cider

Clean and cut the apples into small pieces as soon as possible and soak them in the color protection solution (compound color protection solution contains sulfurous acid 0.04 g/L, ascorbic acid 2 g/L, and L-cysteine 0.7 g/L), soak for 10 minutes, then Squeeze the juice, put 2 L of apple juice into a 3 L triangular flask, add 60 mg/L of pectinase for 12 hours, and then add 40, 80, and 160 g/L of white sugar and fructose syrup respectively , And finally add 0.3 ‰ weight of active dry yeast to ferment.

The soluble solid content in the initial apple juice is 10°Brix; pH=4.2, and the fermentation temperature is controlled at 20°C [6].

2.2.2 Flavor component detection

The flavor composition is determined by a gas-mass spectrometer from PerkinElmer, USA, which is equipped with an EI ion source and a capillary chromatographic column. The analysis conditions are high-purity helium with a purity of ≥99.999% as carrier gas. The starting column temperature of the chromatographic column is 35 ℃. Continue to heat up to 230 ℃, then splitless injection; inlet temperature: 240 ℃; mass spectrometry ion source temperature: 230 ℃; using ion scanning mode (SIM). Use n-pentyl acetate and 2-ethylbutanoic acid as internal standards. Establish a standard working curve by preparing working solutions of target compounds in different concentration ranges.

Put 6 mL of the cider sample in a 20 mL headspace bottle. In order to increase the ionic strength and increase the extraction rate, 3 g of sodium chloride was added, and finally 60 μL of internal standard stock solution was added. Seal after homogenization. Add the extraction head and stir for 15 minutes, preheat at 50 ℃ for 15 minutes, then start the extraction for 45 minutes, and finally inject the sample for analysis.

3. Results and discussion

3.1 Sugar degradation curve analysis of cider under different treatments

The sugar degradation in cider under different treatments is shown in Fig. 1.

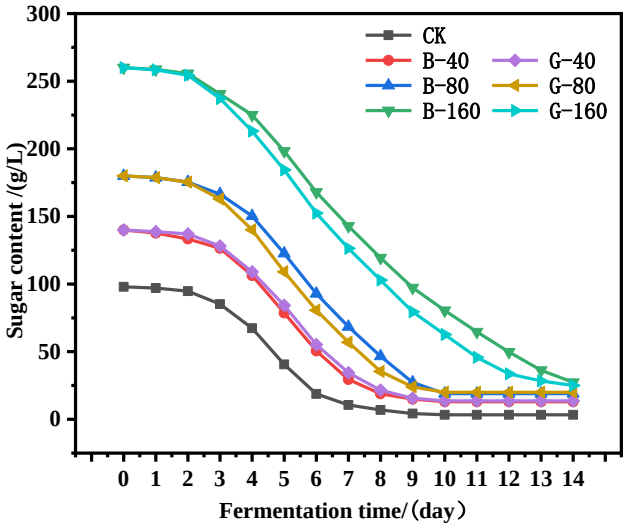

Fig. 1 Comparison of sugar degradation in cider with different treatments

Note: CK: cider without added sugar; B-40: cider with 40 g/L white sugar; B-80: cider with 80 g/L white sugar; B-160: added 160 g/L Cider with white sugar; G-40: cider with 40 g/L fructose syrup; G-80: cider with 80 g/L fructose syrup; G-160: cider with 160 g/L fructose syrup Cider. The following are the same.

It can be seen from the figure that the glycolysis rate of the fermentation broth with added white sugar is slower than that of the fermentation broth with added fructose syrup, and the greater the amount of sugar added, the more obvious the tendency is that yeast has a stronger utilization effect on fructose syrup than white sugar. On the third day after fermentation, the total sugar concentration all began to decline rapidly, and the total sugar in the fermentation broth was almost completely consumed in the CK group after 7 days of fermentation. B-40 and G-40, B-80 and G-80, B-160 and G-160 were almost completely consumed in the fermentation broth at 8, 9, and 14 days, respectively.

3.2 Analysis of flavor substances in cider under different treatments

Flavor substance is a direct factor in the sensory evaluation of fruit wine, and it is also an important indicator of wine quality evaluation. Most of the flavor substances in fruit wine are produced by the saccharomyces cerevisiae consuming nutrients such as sugar during the fermentation process [7]. Using headspace solid phase microextraction gas chromatography-mass spectrometry technology to analyze the flavor content of cider under different fermentation conditions, as shown in Table 1. It can be concluded from the table that alcohols and aldehydes accounted for most of the flavor substances in this study.

Table 1. The content of flavor substances in cider fermentation with different treatments

flavor compositions(mg/L)	CK	B-40	B-80	B-160	G-40	G-80	G-160
Methanol	21.70	19.13	20.36	19.69	18.08	19.21	20.66
N-propanol	29.62	37.80	34.50	42.16	36.52	35.65	43.21
Isobutanol	21.66	28.88	33.76	46.50	28.45	31.15	39.83
Isoamyl alcohol	58.17	74.42	86.24	114.81	75.81	84.08	112.13
N-hexanol	2.44	1.76	0.66	1.55	0.76	2.55	0.93
2,3-Butanediol	20.81	33.91	70.85	98.56	34.62	72.58	97.56
1, 2- propylene glycol	1.43	1.92	10.69	18.84	10.16	10.75	20.79
β-Phenylethanol	10.66	16.04	0.52	0.53	15.54	0.74	0.86
Acetaldehyde	84.14	87.85	116.63	149.76	105.67	117.65	163.73
Propionaldehyde	0.54	0.66	0.61	0.53	0.59	0.54	0.55
Acetal	4.76	7.32	10.20	13.92	9.06	7.56	13.72
3-hydroxy-2-butanone	8.91	42.89	154.11	448.83	44.26	204.12	346.77
Ethyl acetate	6.86	12.51	15.92	20.24	11.95	14.57	18.40
Ethyl Decanoate	0.89	1.32	1.56	2.75	1.03	1.23	3.44
Ethyl phenylacetate	0.53	0.57	0.84	1.61	0.42	0.75	1.33
Phenethyl acetate	0.67	0.91	0.54	1.83	1.05	1.25	2.02

It can be seen from the table that the addition of white sugar and fructose syrup increases the content of isoamyl alcohol, 2,3-butanediol and 3-hydroxy-2-butanone, especially the content of 3-hydroxy-2-butanone. The content increased nearly a thousand times; but the content of methanol, n-propanol, and propionaldehyde did not change significantly with the increase in the amount of added sugar. Isoamyl alcohol and 2,3-butanediol are the highest alcohol aromas in cider in this study. It is reported that yeast fermentation will form many alcohols, also called fusel alcohols, which are mainly composed of C_3-C_5 linear alcohols, branched chain alcohols and phenyl alcohols, which are produced by the decarboxylation and deamination of amino acids and the catabolism of sugars [8].

Esters are one of the most important flavor substances in cider. Very few of them are formed during the growth of the apple itself, but most of them are produced by the esterification reaction during the fermentation of the cider and the secondary metabolism of yeast. Of [9]. In this study, ethyl acetate is the highest content of ester aroma. According to reports, ethyl acetate is a fermentable compound, and it is an important aroma component of many varieties. The acetate and ethyl esters formed by the acyl-CoA produced by yeast during the fermentation process provide the fruit wine with a unique fruit and plant aroma [10].

4. Conclusion

In this paper, the experiment of cider fermentation by adding different concentrations of white sugar and fructose syrup shows that the utilization effect of Saccharomyces cerevisiae on fructose syrup is better than that of white sugar. The flavor substances produced by fermentation are mainly alcohols and aldehydes and ketones. The addition of white sugar and fructose syrup increases the content of isoamyl alcohol, 2,3-butanediol and 3-hydroxy-2-butanone. Especially the content of 3-hydroxy-2-butanone increased nearly a thousand times; but the content of methanol, n-propanol, and propionaldehyde did not change significantly with the increase in the amount of added sugar.

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