STUDY OF BEER FERMENTATION FROM MIXTURE OF MALT AND SWEET POTATO

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ABSTRACT: Beer is a popular beverage on over the world. In order to decrease the price of beer, finding a suistable adjunct replaced for malt is essential. Sweet potato seems to be satisfied for this need due to its high sugar and starch contents. In this paper, beer fermentation from 60% malt and 40% sweet potato was investigated. Our results showed that yeast growth and diacetyl formation during the primary fermentation in the malt – adjunct wort were slightly lower than those in the 100% malt wort. However, the fermentation time of the two worts was similar. In general, utilization of sweet potato in brewing did not influence negatively to beer fermentation kinetics and sweet potato can be considered as a perspective adjunct in brewing.

1. INTRODUCTION

Adjunct utilization has been a popular phenomenon in brewing. The advantages are as follows: reduction in production cost, amelioration of physio-chemical stability of beer and providing deliberate palate shifts for new product... (Kunz W., 1999). Up to now, there are many researches focussed on the application of different adjuncts in brewing (Lloyd W.J.W., 1986; Pierce J.S., 1987; Le Van Viet Man et al., 2001). Adjuncts can be classified according to their major ingredient: starch-rich and sugar-rich. In asian countries, most breweries have used starch-rich adjuncts such as rice, corn or starch because of their low price (Kunz W., 1999). In Vietnam, rice has been a traditional adjunct in brewing.

Finding new adjuncts has always been an interesting problem in brewing. Our recent research showed that sweet potato with high sugar and starch contents has been considered as a new raw material replaced for malt in brewing (Ton Nu Minh Nguyet et. al., 2003). Up to now, sweet potato has been used only for domestic purpose. The use of sweet potato in brewing industry will bring about economic effectiveness for Vietnam agricultural products.

Adjunct ratio used in brewing varies from company to company and from country to country. Normally, it is in the range of 20-40% (Moll M., 1991; Kalunhans K.A. et al. 1992). In some African and Latin American countries, adjunct ratio used in brewing can reach 50-75% of total raw material mass (Moll M., 1991). In Russia, there was a research in which 90% adjunct and 10% malt were used in mashing (Kalunhans K.A. et al., 1992). In Vietnam, adjunct ratio used in brewing varies from 10 to 40%.

This paper focusses on the primary fermentation of wort prepared from 60% malt and 40% sweet potato. A control sample (wort from 100% malt) is also carried out. The fermentation kinetics in the two worts are examined and compared.

2. MATERIALS AND METHODS

Raw materials

- Malt: malt was supplied by an Australian company (Moisture: 4.5%, extraction yield: 75.4%)

- Sweet potato *(Impomoea batatas L.):* fresh sweet potato (Variety: *Coastal Red*) used in this study was supplied by a Dalat farm (Moisture: 67.4%, glucid: 29.5%, protein: 1.1%, lipid: 0.5%, ash: 0.8% m/m)

- Microbial enzymes: Termamyl 120L with alpha-amylase activity and Neutrase with protease activity (Novo Nordisk Fermented Ltd., Denmark) were used in the 60% malt – 40% sweet potato mashing.

- Hop (granule type) was supplied by an Australian company (Moisture: 12%, alpha-acid content: 12% m/m)

Wort preparation

- Wort from 60% malt and 40% sweet potato was prepared by decoction method. Termamyl 120L (Novo-Nordisk, Denmark) containing alpha-amylase was added (0.2% of adjunct mass) to the sweet potato-mash. Adjunct mashing was carried out at 90°C for 15 minutes and then at 100°C for 15 minutes. Neutrase (Novo-Nordisk, Denmark) containing protease was added (0.2% of brewing raw material mass) to the malt-mash. Malt mashing began at 50°C for 30 minutes. The malt-mash was then mixed with the adjunct-mash. The mashing process was continued at 63°C for 15 minutes and at 72°C for total saccharification (checked by the iodine test). Hop was added to the filtered wort and the mixture was boiled at 100°C for 60 minutes. The wort was filtered again, then sterilized at 121°C for 15 minutes and refregerated to 8°C for the fermentation.

- Wort from 100% malt was prepared by infusion method. Hydrolysis was carried out at 50, 63 and 72°C. Then the preparation procedure of the 100% malt wort was similar to that of the malt-sweet potato wort.

Fermentation

- A flocculant strain of *Saccharomyces cerevisiae* species from Micro-organism collection of Food Microbiology Laboratory, Department of Food Technology, Ho Chi Minh City University of Technology was used. Inoculum was prepared by three succesive stages: 1) in 10mL wort at 22-24°C; 2) in 100mL wort at 16-18°C and 3) in 1L wort at 12-14°C. For each stage, 11°Pt sterile wort was used. The inoculating rate was 20 million viable cells per mL.

- Fermentation was carried out at 8°C in a 2L fermenter. Before taking a sample, the medium was magnetically agitated for homogeneity. The fermentation was considered as completed when the reduction in specific gravity was less than 0.3°Pt during 24 succesive hours.

Analytical methods

- Specific gravity was determined by densimeter method, expressed in Plato degree (°Pt)

- Reducing sugar and free amino nitrogen were quantified by spectrophotometric method, using 3,5 DiNitroSalycilic and ninhydrin reagents respectively (Analytica EBC, 1987; Helrich K. 1992)

- For ethanol quantification, the sample was distilled. Ethanol content was then determined by picnometric method (Helrich K. 1992).

- For diacetyl quantification, the sample was distilled by a Parnas still (steam distillation). Diacetyl content was then determined by spectrophotometric method (Analytica EBC, 1987).

- Yeast cell concentration was determined by haemocytometry, using a Thoma counting chamber. Methylene blue test was used for yeast viability evaluation (Analytica EBC, 1987).

3. RESULTS AND DISCUSSION

3.1. Analysis of the media

Some physio-chemical characteristics of the media are given in table 1.

Table 1. Some physio-chemical characteristics of the media

Characteristic	Wort from 60% malt, 40% sweet potato and microbial enzymes (amylase & protease)	Wort from 100% malt (without microbial enzyme use)
Specific gravity (°Pt)	11.0	11.0
Reducing sugars (g/L)	94.6	96.0
Free amino nitrogen (mg/L)	246.3	254.0
pH	5.53	5.50

Our recent research showed that the use of sweet potato in brewing decreased the sugar and free amino nitrogen concentrations in the obtained wort (Ton Nu Minh Nguyet et al., 2003). In this paper, microbial enzymes (Termamyl 120L with alpha-amylase acitivity and Neutrase with protease activity) were used in the malt-sweet potato mashing. In the 100% malt mashing, no exogenous enzyme was used. From table 1, it can be seen that the reducing sugar and free amino nitrogen contents of the wort from 100% malt were slightly higher than those of the wort from malt-adjunct mixture. However, the differences were insignificant (1.5% and 3.0% for reducing sugar and free amino nitrogen contents respectively). In wort, sugar is the carbone source and free amino nitrogen - nitrogen source for yeast growth. It can be confirmed that utilization of microbial enzymes made the contents of the two principal substrates in worts become equivalent.

3.2. Yeast growth

The kinetics of yeast growth in the two worts are presented in figure 1. It was shown that the times of adaptation phase of yeast in the two media were similar (16-18h). Then yeast reproduction began. The growth rate of yeast in the wort from 100% malt was slightly higher than that in the wort from 60% malt and 40% sweet potato. In addition, the maximal concentration of yeast cells in the 100% malt wort was 11.5% higher than that in the malt-adjunct wort.

Some growth factors and microelements are essential for micro-organism reproduction (Kunz W., 1999). Some authors affirmed that in the medium containing sufficiently carbone and nitrogen substrates, certain vitamines and microelements became growth limiting factor for yeast. Malt wort is traditionally considered an ideal medium for yeast budding due to high contents of sugar, assimilable nitrogen, vitamines and mineral compounds (Moll M., 1991). It seems that utilization of sweet potato in brewing changed the qualitative and quantitative composition of growth factors and microelements in the medium. This affected to yeast growth during the fermentation. The same phenomenon was also observed in malt – rice brewing. Utilization of rice with high ratio reduced the concentrations of some vitamines and microelements in the obtained wort (Le Van Viet Man et. al., 2001).

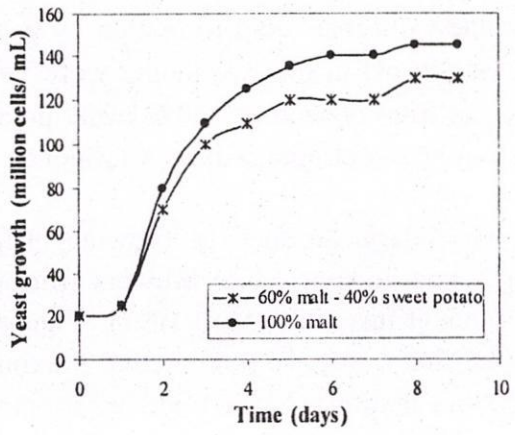

Figure 1: Kinetics of yeast growth

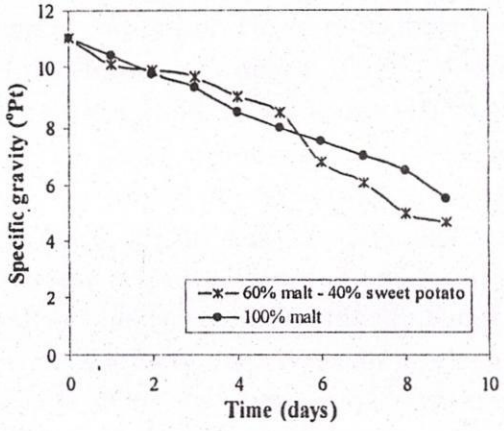

Figure 2: Change of wort specific gravity during the primary fermentation

3. 3. Substrate utilization

The kinetics of wort specific gravity are visualized in figure 2.

In the first 5 days, the reduction of specific gravity in the 100% wort was more rapid than that in the malt-sweet potato wort. This observation in figure 2 was very logical to the obtained results in figure 1. The higher the substrate content metabolized by yeast, the higher the growth rate and the higher the yeast cell concentration in the medium. Nevertheless, from the 5^{th} day, substrate assimilation rate in the malt-adjunct medium became higher than that in the malt medium. Therefore, at the end of the primary fermentation, the concentration of residual substrates in the green beer from 60% malt and 40% sweet potato was slightly lower than that in the control sample. This improved the biological stability of the final product from malt-adjunct mixture.

3. 4. Metabolite formation

Ethanol is the principal product in alcoholic fermentation. The obtained results showed that the ethanol concentrations in the two media at the end of the primary fermentation were nearly similar (3.2% and 3.3% v/v).

In brewing, secondary products of alcoholic fermentation play an important role in flavour formation for beer. The kinetics of pH and diacetyl are given in figures 3 and 4.

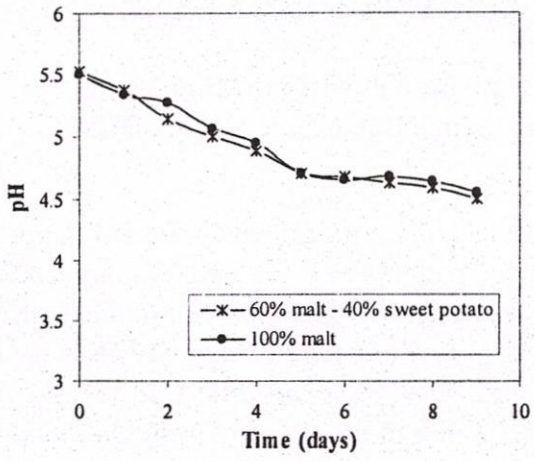

Figure 3: pH evolution during the fermentation

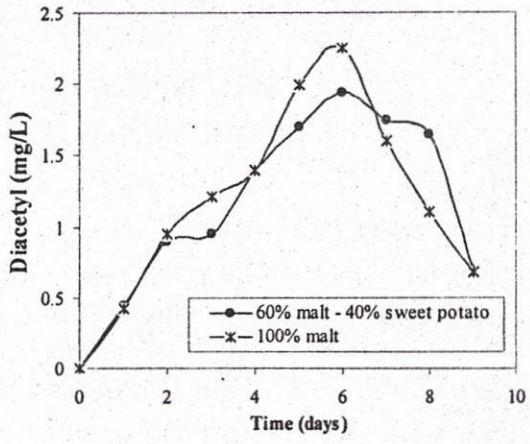

Figure 4: Diacetyl formation during the fermentation

Reduction in pH during the fermentation is due to organic acid formation by yeast (Kunz W., 1999). Figure 3 showed that the evolutions of pH in the two media were very similar. The pH of the green beer from 100% malt and from 60% malt - 40% sweet potato were 4.55 and 4.50 respectively. Therefore, utilization of sweet potato did not influence to pH of the product.

Diacetyl is one of the most important secondary product in brewing. High concentration of diacetyl gives an unpleasant butter flavour in beer. Many brewers affirmed that diacetyl content in beer should be less than 0.1ppm (Kunz 1999, Moll 1991). Figure 4 showed that diacetyl formation was carried out in the first 6 days in both media. Maximal diacetyl concentration in the 100% malt wort was higher than that in the malt-sweet potato wort. In fact, diacetyl formation is related to valine biosynthesis of nitrogen metabolism (Kunz 1999). The higher the yeast growth rate and the yeast biomass content, the higher the diacetyl content in the fermenting medium.

From the 6^{th} day, diacetyl was reduced and diacetyl contents in the two green beers were similar. According to many authors, during the following maturation, diacetyl concentration in green beer continues decreasing (Moll M., 1991; Kalunhans K.A. et al., 1992; Kunz W., 1999).

In summary, diacetyl formation in the 60% malt – 40% sweet potato wort was less intensive than that in the 100% malt wort. Therefore, utilization of sweet potato in brewing did not affect negatively to the diacetyl content in the green beer and the final product.

4. CONCLUSION

Utilization of sweet potato in brewing reduced slightly the yeast growth and biomass concentration in the fermenting wort. Diacetyl formation in the 60% malt – 40% sweet potato wort was less intensive than that in the 100% malt wort. The fermentation time of the two worts was quite similar.

In general, utilization of sweet potato in brewing did not influence negatively to beer fermentation kinetics. Therefore, sweet potato can be considered as a perspective adjunct in brewing.

KHẢO SÁT QUÁ TRÌNH LÊN MEN BIA TỪ HỖN HỢP NGUYÊN LIỆU MALT VÀ KHOAI LANG

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TÓM TẮT: Bia là một thức uống phổ biến trên thế giới. Để làm giảm giá thành sản phẩm, việc tìm kiếm thêm các nguồn thế liệu thích hợp có thể thay thế malt đại mạch để đưa vào sản xuất là một nhu cầu bức thiết. Khoai lang dường như thỏa mãn các tiêu chí của thế liệu trong sản xuất bia do khoai chứa nhiều đường và tinh bột. Nghiên cứu này khảo sát quá trình lên men bia từ hỗn hợp nguyên liệu 60% malt và 40% khoai lang. Các kết quả thực nghiệm cho thấy sự sinh trưởng của nấm men và sự hình thành diacetyl trong quá trình lên men chính trên dịch nha có sử dụng thế liệu hơi thấp hơn so với trên dịch nha từ 100% malt đại mạch. Tuy nhiên, thời gian lên men của hai dịch nha là như nhau. Việc sử dụng thế liệu

khoai lang đã không ảnh hưởng xấu đến động học quá trình lên men và khoai lang có thể được xem là một loại thế liệu triển vọng trong sản xuất bia.

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