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INFLUENCE OF DEVELOPMENT OF CHENJI DIOSCOREA OPPOSITA THUNB. CV. TIEGUN SERIES PRODUCTS ON ECONOMIC DEVELOPMENT IN SHANDONG PROVINCE

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ABSTRACT

In recent years, Dioscorea opposita shares a bigger market as people pay more and more attention to health. Dioscorea opposita Thunb. cv. Tiegun is deeply favored by people as it has high edible value, medicinal value and nutritional value. Relatively concentrated harvest season of Dioscorea opposita Thunb. cv. Tiegun and its thin skin are not conducive to the preservation and long-distance transport. Meanwhile, local yam industry is in extensive form and few enterprises perform deep processing, which lead to limited utilization of yam resources. Therefore, Chenji Dioscorea opposita Thunb. cv. Tiegun should be further processed to improve its additional value, so as to bring certain economic benefits to the Chenji area and increase the economic income of local farmers. Taking Chenji Dioscorea opposita Thunb. cv. Tiegun as an example, this study explored its starch enzymolysis as well as the stability of yam series products, providing a scientific basis for better developing henji Dioscorea opposita Thunb. cv. Tiegun juice. In addition, this work also analyzed the influences of development of Chenji Dioscorea opposita Thunb. cv. Tiegun series products on economic development in Shandong province.

1. Introduction

Chinese yam is mainly used for tonifying spleen and kidney, nourishing stomach, profiting lung and arresting seminal emission (Sheng-sheng et al., 2013; Chui-Jie et al., 2013). Medical researches indicate that Chinese yam containing a variety of nutrients such as fat, carbohydrate, protein and vitamin also has multi-trace elements and more than ten kinds of amino acids which can not only strengthen spleen and benefit kidney (Liu et al., 2013), but also reduce blood fat, resist aging and regulate the immune. Hence, Chinese yam has been deeply favored by people in recent years. Nowadays, increasing importance has been attached to health. Scholars in China and overseas have done relevant researches on Chinese yam and yam series products and tried to improve the utilization rate of yam.

For example, Koo et al. *(*2014) attempted to transform the state from current rough machining to finish machining for medical use or consumption and truly reflected its nutritional value and regulating effect. Kondo and Fujita (2012) signified that Chinese yam is a functional food for health care and beauty. Regular consumption of Chinese yam can ward off disease and promoting longevity. Functional health food - yam fruit series mainly includes chocolate fruit yam and yam jelly (Kondo and Fujita, 2012). Qu et al. *(*2014), after briefly analyzing nutrition and health functions of Chinese yam and lactic acid bacteria fermented food, introduced processing process, operating points and matters of lactic acid bacteria fermented yam beverage, yam beverage and yam yoghourt in detail, which provided a reference for the development of yam series beverage. Taking Chenji yam in Shandong province as an example, this study discussed effects of Chenji Dioscorea opposita Thunb. cv. Tiegun on starch enzymolysis under different volumes of addition, times and temperatures, providing a scientific foundation for the development of yam series products. Besides, this research also simply analyzed the influence of yam on economic development in Shandong province.

2. Materials and methods

2.1.Materials

Dioscorea opposita Thunb. cv. Tiegun, phenol, sodium sulfite, sodium hydroxide, citric acid, xylitol, sodium carboxymethylcellulose and medium-temperature α - amylase were used in this experiment.

2.2. Main instruments

Thermostatic water bath, food processer, electronic scales, refrigerated centrifuge and ultraviolet spectrophotometer were applied.

2.3.Experimental methods

2.3.1 Technological process

Chinese yam was made into final goods through a series of treatments, for instance, skin peeling, slicing, soaking, drying, grinding, precooking, beating, gelatinization, centrifugal separation, enzymolysis, allocation, homogenizing, degassing and sterilization.

2.3.2.Operational requirements

Chinese yam was skinned and sliced into cuboids with the length and thickness of 10 and 2.5 cm respectively, and the width could be set according to the yam itself (Pathak et al., 2015). After that, the yam was soaked into preservative (benzoic acid) for 3.5 h, in order to bleach it. It was baked for 12 h until dry and then ground into flavor powder. The skinned yam was precooked in boiling water (100±1°C) for 6 min. Then, the precooked yam was beaten with water (1: 6) and grounded into yam serous fluid. Considering the fined serous fluid containing organization fiber which would affect the taste, the serous fluid was centrifuged at 3500 r/min for 8 min and the obtained yam serous fluid was processed with enzymolysis. Medium-temperature a - amylase in 1.2 mg/mL was added into the yam serous fluid and stirred for 6 min and then heated at a constant temperature of 95 °C for 20 min after 23-enzymolysis at 65 °C. 0.18% of citric acid and 0.12% of carboxy methylated cellulose (CMC)-Na were added into the ground raw material and taken as a suspending agent, and an appropriate amount of white sugar and organic acid could also be added to make flavoring beverage (Mamede et al., 2015). The prepared raw material was homogenized once at 72 °C under over 18 mPa pressure. Additionally, the yam product was sterilized at 125 °C for 10 min under high pressure and then canned, which was a finished beverage.

2.4. Experiment content

Except the water, starch has the highest content (20%) in Chinese yam tuber. The insoluble starch restrains the application of Chinese yam. Especially in production and storage processes of beverage, the character of Chinese yam is not stable. But enzymolysis technology based on amylase can solve the problem; it can not only improve the taste, but also stabilize Chinese yam fluid (Mastrantonio et al., 2014). Medium-temperature enzymolysis technology based on a-amylase is characterized by mild condition, high efficacy and few side reactions. Hence we processed Chinese yam starch with enzymolysis using medium-temeprature enzymolysis technology based on a-amylase (enzyme activity: 6000 U/g). The enzymatic hydrolysate includes glucose, maltose, maltotriose and a-limit dexitrin. Reducing sugar obtained from enzymolysis of starch can change the color of 3, 5-dinitrosalicylic acid into brownish red. The optimal enzymolysis technical parameters for medium-temperature a-amylase can be confirmed using response surface experiment and taking the content of reducing sugar obtained from enzymolysis.

2.4.1. Detection of the content of reducing sugar with dinitrosalicylic acid (DNS)

DNS method refers to the generation process of 3 - amino - 5 - nitro salicylic acid based on the redox reaction of DNS and reducing sugar. The product is brownish red in boiled water; the color depth is in a proportional relation with the content of reducing sugar; the content of reducing sugar is detected using colorimetric method (Gao et al., 2010; Montouto-Graña et al., 2012). The depth of color is correlated to the number of free reducing group instead of the category of reducing sugar. Hence the method is suitable to be used in multiple reducing sugar systems generated in polysaccharide enzymolysis.

2.4.2. Preparation of reagenst

Glucose standard solution: 100 mg of glucose was dried at 80 °C. After the dissolution in flask, the solution was moved into a 100mL volumetric flask. Then it was diluted into 100mL with distilled water.

3, 5 - dinitrosalicylic acid reagent: 3.15 g of DNS and 131mL of NaOH solution (2mol/L) was added into a 250mL hot solution containing 92.5 g of potassium sodium tartrate. Then 2.5 g of phenol and 2.5 g of sodium sulfite were added. After stirring and cooling, it was dissolved into 500mL with drilled water. Finally it was stored in a brown bottle.

2.4.3. Glucose standard curve

0mL, 0.2mL, 0.4mL, 0.6mL, 0.8mL, 1.0 mL and 1.2 mL of glucose standard solution (1 mg/ml) were added into 25mL test tubes respectively (Cheuk-Chun et al., 2007). Then the solutions were added with drilled water until the volume became 2.0mL. Then 2mL of DNS reagent was added. After 5-min boiling water bath and cooling with ice water, the solution was added with drilled water until the volume became 25 mL. Absorbance was detected at the wavelength of 540 nm. Standard curve was drawn, taking the content of glucose as the horizontal coordinate and the absorbance as the vertical coordinate (Figure 1). R is 0.99917, suggesting an obvious linear correlation.

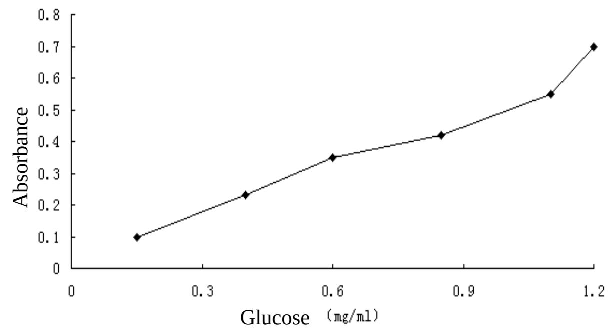

Figure 1. Glucose standard curve

2.4.4. Determination of samples

An amount of 0.2 mL of sample was put in a plugged test tube (25 mL) and distilled water was added to 2.0 mL. DNS reagent (2 mL) was added into boiling water bath for 5 min and the absorbance was then measured at the wavelength of 540 nm. The quantity of glucose (mg/mL) was figured out according to standard curve and reducing sugar content in the sample was calculated.

3. Results and discussions

3.1 Confirmation of temperature, time and concentration in alkali peeling

Yam was skinned with sodium hydroxide solution (7%, 8%, 9%) at 65 °C, 75 °C and 85 °C respectively. The optimal peeling condition was confirmed taking edible rate and peeling situation as indexes (Table 1). As shown in Table 1, higher alkali liquor concentration and temperature showed shorter peeling time. With the increase of alkali liquor concentration, edible rate was lower.

Table 1. Influences of temperature, time and concentration in skin peeling with sodium hydroxide solution

Number	Length of yam (cm)	Temperature (°C)	Time (min)	Concentration of sodium hydroxide solution (%)	Edible rate (%)	Peeling situation
1	6	65	13	7	85.74	With rhizome
2	6	75	11	7	84.12	With rhizome
3	6	85	5	7	87.96	Complete
4	6	65	11	8	85.12	With rhizome
5	6	75	7	8	79.23	Complete
6	6	85	5	8	90.12	Complete
7	6	65	7	9	86.12	Complete
8	6	75	5	9	85.23	Complete
9	6	85	3	9	83.65	Complete

Yam was completely skinned with the concentration of 8% at 75 °C taking 6.5 min, with the edible rate of 79.23%; at 85 °C, yam was completely skinned taking 4.5 min, with the edible rate of 90.12%. Peeling time was shorter and the edible rate decreased when the concentration was 9%. To reduce the loss of nutrients in yam and increase of corrosion to equipment when the temperature was too high, the optimal peeling condition was considered as concentration 8%, temperature 75 and 7 min.

3.2. Confirmation of the optimal proportion of Dioscorea opposita Thunb. cv. Tiegun and water

Material-water ratio of yam directly affected nutrition, flavor and taste of yam juice. Setting material-water ratio as 1:4, 1:6 and 1:8, enzymatic hydrolysate was determined and results are shown in Table 2.

Table 2. Influence of material-water ratio on yam quality

Material-water ratio	Structural state and taste
1:4	Dirty solution, uniform structural stat, mild taste
1:6	Dirty solution, uniform structural stat, moderate taste
1:8	Dirty solution, uniform structural stat, light taste

It could be seen from Table 2 that the comprehensive index was better when the solution ratio was 1:6; color and taste were better when the material-water ratio was 1:6.

3.3. Confirmation of enzymolysis parameters

3.3.1. Influence of enzyme volume of addition on starch hydrolysis effect

Accurately weighted yam and water were beaten (1:6) and 0.4, 0.6, 0.8, 1.0, 1.2 mg/mL of moderate-temperature a-amylase was added respectively (Figure 2).

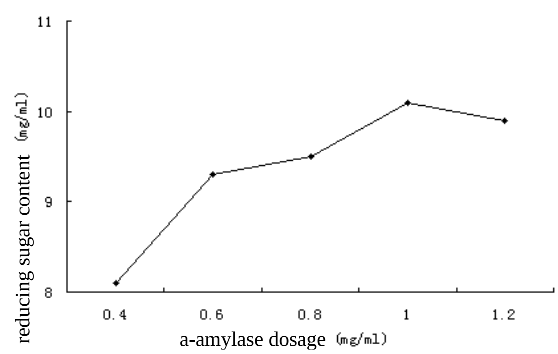

Figure 2. Influence of a-amylase dosage on starch hydrolysis

As shown in Figure 2, reducing sugar content increased with the increase of amylase dosage when volume of addition of moderate-temperature a-amylase was small. However, when amylase dosage reached to over 1.0 mg/mL, we found that reducing sugar content changed slowly as amylase dosage increased. This explained that the reaction rate speeded up with the increase of amylase dosage and the effect of amylase was the best when amylase was completely combined with the substrate (Nithiyanantham et al., 2012; Engelen et al., 2003). Amylase failed to be completely combined with the substrate in the case of more molecular content and amylase effect was unable to be displayed. Therefore, the best dosage of amylase was 1.0 mg/mL.

In the experiment, we found that reducing sugar content increased obviously with the increase of amylase dosage and it changed slightly when amylase dosage increased to more than 1.0 mg/mL.

3.3.2.Influence of temperature on starch enzymolysis

Accurately weighted yam and water were beaten (1:6). Starch amylase was added for enzymolysis for 30 h at 45, 55, 65, 75 and 85 °C respectively, with the dosage of 1.0 mg/mL (Figure 3).

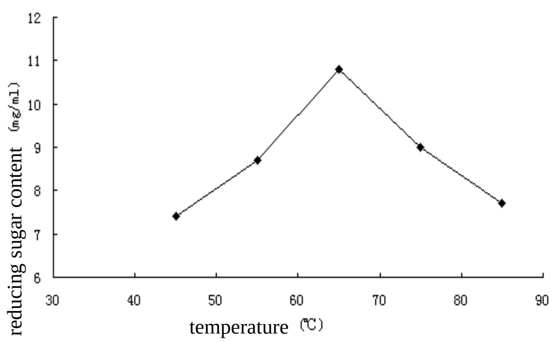

Figure 3. Influence of temperature on starch enzymolysis

It could be known from Figure 3 that reducing sugar content increased fast at 45 ~ 65 °C while it decreased gradually at 65 ~ 85 °C (Kimberly and Neuberger, 2011), which suggested that starch amylase had good activity at an appropriate temperature and higher or lower temperature was not beneficial to the enzyme activity. Therefore, the temperature was set as 65 °C in this study.

3.3.3. Influence of time on starch enzymolysis

Accurately weighted yam and water were beaten (1:6). Starch amylase was added for enzymolysis at 65 °C for 15, 20, 25, 30 and 35 min respectively, with the dosage of 1.0 mg/mL (Figure 4).

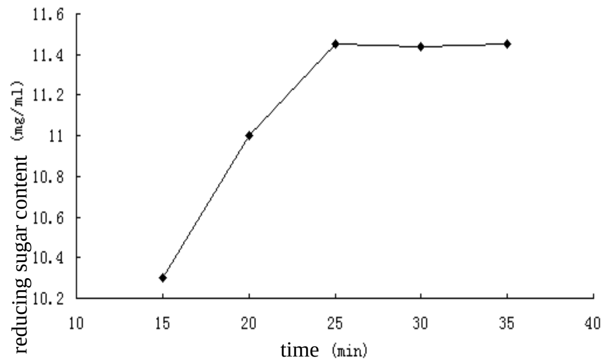

Figure 4. Influence of time on starch enzymolysis

As shown in Figure 4, reducing sugar content increased gradually within 25 min while it tended to be stable after 25 min, indicating that enzymolysis was incompletely performed on amylase in a short time while the degree of starch enzymolysis did not increase in a too long enzymolysis time. Hence, the enzymolysis time was set as 25 min.

3.4. Single factor experiment on stabilizer

Protein and other precipitates in Dioscorea opposita Thunb. cv. Tiegun juice would affect the quality, appearance and taste of products as well as destroy the stability of products, thus shortening the shelf life of products (Rodriguez-Aguilera et al., 2011; Coloma et al., 2014). To date, centrifugal observation, standing observation, viscosity density test, microscopic examination, electrophoresis detection and dynamic spectrum analysis are mainly used to confirm the stability of products. This study combining centrifugal observation with spectrophotometer detection detected and determined the stability taking the ratio of absorbance before and after centrifugation.

On the basis of preliminary experiment and data reference, the two factors mostly affecting the stability of yam juice were selected, i.e., CMC-Na and xanthan gum.

They were processed with single factor experiment according to the ratio of 0.02 %, 0.04 %, 0.06 %, 0.08 % and 0.10%.

3.4.1.Influence of differently concentrated CMC-Na on the stability of yam juice

The influence of differently concentrated CMC-Na on the stability of yam juice is shown in Table 3.

Table 3. Influence of differently concentrated CMC-Na on the stability of yam juice

Test number	Concentration (%)	Stability coefficient
1	0.02	86.49
2	0.04	88.23
3	0.06	87.16
4	0.08	87.12
5	0.10	86.89

As shown in Table 3, the ratio of absorbance increased gradually with the increase of CMC-Na dosage when other conditions were the same and the peak was 0.04%. After 0.04%, the ratio showed a downward trend. Hence, the appropriate dosage of CMC-Na was around 0.04% by comprehensive consideration.

3.4.2.Influence of differently concentrated xanthan gum on the stability of yam juice

Table 4. Influence of differently concentrated xanthan gum on the stability of yam juice

Test number	Concentration (%)	Stability coefficient
1	0.02	85.13
2	0.04	86.31
3	0.06	86.51
4	0.08	84.23
5	0.10	83.12

It could be known from Table 4 that the ratio of absorbance increased gradually with the increase of xanthan gum dosage when other conditions were the same and the peak was 0.06%. After 0.06%, the ratio showed a downward trend. Hence, the appropriate dosage of xanthan gum was around 0.06% by comprehensive consideration.

Chinese yam, as a kind of medicine as well as food, can not only be made into health food, but also has medicinal value on treatment of diseases (Bhatia et al., 2014). The Chenji yam studied in this paper is a product of geographical indication, with its protective range within the administrative region of Chenji town, Dingtao county, Shandong province, including 26 administrative villages which covers a total area of 83.9 square kilometers. It has been favored for thousands of years for its sweet and soft taste (Blackwell, 2003; Huhn, 2002) as well as medicine and health care practical value by local people.

Due to various advantages of yam, the sales volume of yam products is high nationwide, which to some extent has led to the economic development of Shandong province and has made some contribution for coordinated regional economic development in Shandong Province. Coordinated development of regional economy (Durbec and Disant, 2015; Xiong et al., 2008) refers to the state and process of realization of the interdependence, mutual adaptation and mutual promotion among regions under a fully open premise. It consists of coordination between economic growth rate, economic development quality and economic aggregate as well as coordination between industrial type and quantity inside and outside the region, which is beneficial for the coordination of economic layout of economic development in developed regions and development of the underdeveloped regions (Xia et al., 2011) as well as the coordination between interest relation, exchange relation, exchange relation and status relation among regions.

Through the experiment, we found that the polyphenol oxidase contained in Dioscorea opposita Thunb. cv. Tiegun during the production process could easily cause enzymatic browning and affect color and luster of products. Thus, pretreatment are usually performed on yam so as to lower the enzymatic activity to inhibit enzymatic browning.

Usually, boiling water pre-cooking method is applied to realize enzyme inactivation in raw materials, cause starch dextrinization, increase juice yield and achieve a bactericidal effect. Since Dioscorea opposita Thunb. cv. Tiegun has hard texture, moisture cannot reach the inside part of yam with short precooking time and thus the enzyme deactivation effect will be unsatisfactory. However, with overlong precooking time, pulping effect can be influenced because the yam texture becomes too soft. Taking the above situation into consideration, the precooking time of yam is selected as 5 min.

4. Conclusions

The enzymolysis of yam starches was carried out with α-amylase and optimal enzymatic hydrolysis parameters were determined with response surface analysis as follows: dosage of enzyme: 1.0mg/mL; time: 25 min; temperature: 65 °C.

The compound stabilizer combination of yam juice was as follows: CMC-Na 0.04%; xanthan gum: 0.06%. Also, the development of Chenji Dioscorea opposita Thunb. cv. Tiegun series products have positive effects on economic development of Shandong province, especially on coordinated development of regional economy. However, due to limitations on conditions, there are some deficiencies on the results and analysis of this study, which will be improved in future studies.

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