The Selection and Development of High-efficiency Jerusalem Artichoke

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Abstract: This paper analyzes the sugar components of different Jerusalem artichoke (Helianthus tuberosus L.) tubers and their leaves. The results showed that the total sugar content of Jerusalem artichoke tuber accounted for more than 70% of dry weight. The content of inulin reached 77.5% on average, and the highest is “Binyu no.1” tuber. The content of inulin in the stem leaf was more than 11.73%, reaching an average of 12.93%. And the effect of inulin was then tested by functional test on constipation model mice. ICR male mice were randomly divided into blank control group, model control group, positive control group, low dose inulin group, medium dose inulin group and high dose inulin group. After 7 or 15 days of continuous inulin infusion, we observe the small intestine movement, initial stool time and amount of black stool. The results showed that inulin had a significant effect on constipation in mice. Finally, we analyse 27 varieties of Jerusalem artichoke by experiments, and select 6 varieties with high efficacy.

1. Introduction

Early studies have found that chronic constipation is related to water deficiency, decreased intestinal smooth muscle tone, slow intestinal peristalsis and disturbance of defecation muscle group. And in recent years, it has been found that intestinal flora imbalance plays an important role in the pathogenesis of chronic constipation. The colonic mucosa was disordered in the patients with refractory constipation, showing a decrease in diversity of colonic mucosa. However, as prebiotics, inulin can effectively improve the symptoms of constipation and reduce the incidence of constipation. These results suggest that inulin itself has the effect of relaxing bowel to relieve constipation. There are 36,000 species of plants known to contain inulin in nature. The inulin content of Jerusalem artichoke is between 64.81% and 77.54%, and it is the plant with the highest inulin content.

Jerusalem artichoke is a perennial herb of the genus helianthus. It is wild and adaptable, which has low requirements on natural conditions such as climate and soil. The tubers of Jerusalem artichoke are rich in inulin, which can be used to produce ethanol. Jerusalem artichoke has strong adaptability, such as cold tolerance and drought resistance. The tuber contains a large amount of inulin and fructose, which is the raw material of sugar and syrup. Stems and leaves can be used as feed for rabbits, pigs, sheep, donkeys, horses, etc., which can be used directly for green feed in summer or for dry feed after being crushed in autumn. So, if we want to develop the Jerusalem artichoke industry, we must make full use of its tubers and leaves. So, we must master the difference between the tubers and leaves of different varieties, and then choose the right varieties in different directions.

In this study, through the analysis and comparison of six kinds of Jerusalem artichoke, this study revealed the varieties with high inulin nutrition composition. Then, the application of the high-efficiency variety was verified for animal function, which provided theoretical support for the comprehensive utilization and industrialization development of Jerusalem artichoke.

2. Test 1: Effect of inulin on relaxing bowel

In recent years, with the change of living rhythm, diet structure, behavior and living habits of modern people, as well as the influence of mental and psychological factors, the incidence of

constipation has been on the rise. The incidence of constipation in population is 3% ~ 20%, which seriously affects people's quality of life. The effect of inulin on constipation mice was tested as follows, which was used as a basis for developing health food with inulin as efficacy material.

2.1 Test materials and methods

2.1.1 Test materials

Inulin is provided by Zhengsheng nutrition technology (Beijing) co. LTD. ICR male mice were provided by the animal experiment center of China Medical University.

2.1.2 The test methods

A total of 120 ICR male mice were randomly divided into 6 groups, namely blank control group, model control group, positive control group, low dose inulin group, medium dose inulin group and high dose inulin group. There were 20 mice in each group and 10 mice in one group were fed for 7 and 15 days respectively. Each group was given basic feed. The blank control group and model control group were given normal saline of equal volume every day. Each dose group was given 0.2ml /10 g of mice subjects per day, and the mice were given continuous gavage for 7 or 15 days. The recommended amount of inulin is 10 g/d, which is prepared into an aqueous solution before perfusion.

2.1.3 Modeling and measurement indexes

Given the drugs for 7 or 15 days, the mice in each group fasted for 16 hours. The blank control group was given lavage distilled water, the model control group, the positive control group and each dose group were given lavage (10 mg/kg). After half an hour, the positive control group was given the positive drug. The ink was given to each dose group. In the blank control group and the model control group, lavage ink was administered with a dosage of 0.2ml /10 g. The mice were raised in a single cage and fed and drank normally. The recommended amount of inulin is 10 g/d. The medium dose inulin group is 20 g/d and the high dose inulin group is 30 g/d. The time of first black stool drainage, the number of black stool pellets and weight of each mouse were recorded within 6 h after lavage instillation.

2.2 Results and analysis

2.2.1 The test results

Table 1 shows the effect of the 7-day test on defecation in mice. Table 4 shows the effect of 15-day test on defecation in mice.

Table 1 Effects of inulin on first stool time and quantity of black stool (7 days)

Group	Number of sample	First defecation time /min	Number of black stool(6h)	Weight of black stool(6h)
blank control group	10	74.28±26.31	16.50±1.60**	6±0.136 2**
model control group	10	120.13±27.44**	11.75±3.37	0.235 1±0.078 4
positive control group	10	45.38±16.71***	15.75±2.87*	0.370 7±0.087 3*
low dose inulin group	10	34.48±15.37***	20.38±3.623**	0.331 9±0.056 9**
medium dose inulin group	10	19.33±5.77***	25.58±5.85***	0.461 9±0.132 1**
high dose inulin group	10	15.05±22.01***	29.78±9.06***	0.533 8±0.082 8**

Note: * the significant difference was P<0.05; ** means the difference is extremely significant P<0.01; *** means the difference height is significant P<0.001.

Table 2 Effects of inulin on first stool time and quantity of black stool (15 days)

Group	Number of sample	First defecation time /min	Number of black stool(6h)	Weight of black stool(6h)
blank control group	10	92.53±7.50*	18.13±2.90**	0.443 6±0.124 2**
model control group	10	130.50±20.21	8.450±1.67	0.231 5±0.087 4
positive control group	10	84.13±11.06**	13.50±1.07**	0.362 4±0.094 5**
low dose inulin group	10	57.33±13.59**	12.30±2.07**	0.378 2±0.135 6**
medium dose inulin group	10	40.50±13.15**	16.53±4.66**	0.457 1±0.127 5**
high dose inulin group	10	30.63±15.94**	18.28±3.02**	0.471 8±0.093 6**

Note: * the significant difference was $P<0.05$; ** means the difference is extremely significant $P<0.01$.

2.2.2 The test analysis

When the first defecation time of mice was taken as the indicator, the difference between the model group and the blank control group was extremely significant ($P<0.01$), indicating that the modeling was successful. The results of each index indicated that the positive control group and each dose group had a shortening effect on the first stool time, or an increase effect which lavage high dose of inulin on the amount of defecation. The first fecal time of mice was taken as the indicator. In the 7d experiment, the first defecation time of all dose groups was significantly shorter than that of the positive drug, which was statistically significant ($P<0.05$). In the 15d experiment, all the dose groups were shorter than the positive group and which was statistically significance ($P<0.05$).

Number of black stool (6h) was taken as the index. In the 7 day experiment, low dose inulin group, medium dose inulin group and high dose inulin group was significantly stronger than that in the positive group ($P<0.05$). And with the increase of dose, the effect was more significant. In the 15 day experiment, low dose inulin group, medium dose inulin group and high dose inulin group was significantly stronger than that in the positive group ($P<0.01$). And with the increase of dose, the effect was more significant. So, inulin dose has a significant effect on nourishing enteral laxative.

3. Test 2: Selection of high inulin varieties

3.1 Test materials and methods

3.1.1 Test materials

27 kinds of Jerusalem artichoke tuber harvest, wash with ultra-pure water and dry naturally. The tubers and stems leaves were crushed and screened with 0.25mm sieve for sealing preservation. Finally, the nutrient composition of the powder was determined. The test reagents include anhydrous ethanol, sulfuric acid, formaldehyde, sodium hydroxide potassium sodium tartrate, copper sulfate, anhydrous glucose, potassium sulfate, methylene blue, methyl red, etc. The Analytical Reagent are all made in China.

3.1.2 Test method

Reducing sugars were determined by the capacity method of GB/T 5009.7-2008. The total sugar is transformed into reducing sugar after hydrolysis by hot sulfuric acid, and then determined by film reagent capacity method. Inulin is a non-reducing polysaccharide. The content of inulin is determined by total sugar minus reducing sugar.

3.2 Results and analysis

3.2.1 The test results

The nutritional components of different Jerusalem artichoke tuber were shown in table 3, and the stems leaves were shown in table4.

3.2.2 The test analysis

Inulin has the function of relaxing bowel, and is an important raw crop extracted from relaxing bowel medicine. Therefore, the higher the content, the better. The varieties suitable for medicine are listed in table 4. Crops with high total sugar content and protein content of 6%~10% are important industrial raw materials, especially as raw materials for alcohol. The varieties suitable for industrial raw materials selection are shown in table 5. Protein content and ash content are important indexes to evaluate the nutritional value of feed crops. The indexes of good feed are protein content of 9%~18% and ash content of 5%~6%. The varieties suitable for feed selection are shown in table 6.

Table 3 Results of tuber nutrition analysis (g/100g)

NO.	Varieties	Seed location	Ash	Protein	Fat	Total sugar	Reducing sugar	Inulin
1	TY3B3:H29	Tanghai city	6.1	11.1	0.9	8.6	7.2	1.4
2	LNDD	Liaoning city	5.3	9.38	1.3	10.3	7.3	3
3	ZKY1	CAS	5.5	10.6	1.3	8.1	6.6	1.5
4	NY2	Nanjing agricultural university	6.7	10.2	2.1	9.2	7.4	1.8
5	ZKY1	CAS	6.2	10.6	0.8	8.9	6.9	2
6	JY4	Jilin academy of agricultural sciences'	6.4	11	1	8.83	8.1	0.73
7	QY2	Qinhaungdao city	6.4	10.6	1	9.6	7.8	1.8
8	NY2	Nanjing agricultural university	6.2	10.6	1	8.9	7.9	1
9	DQ24	Heilongjiang academy of agricultural sciences'	6.3	10.2	0.6	9.1	6.9	2.2
10	BJ	Beijing city	6.9	11.4	0.9	8.8	6.3	2.5
11	DQ4	Heilongjiang academy of agricultural sciences'	5.2	7.5	1.2	9.7	8.2	1.5
12	LY8	Langfang academy of agricultural sciences'	7.1	11.6	10.3	9.3	7.3	2
13	Binyu 1	Hebei academy of agricultural sciences'	5.9	9.8	0.8	9.5	6.9	2.6
14	HBHS	Hengshui city	5.7	11.4	0.9	9.6	7.4	2.2
15	DQ4	Daqing city	6.2	9.86	0.6	10.4	8.1	2.3
16	HLY5	Heilongjiang academy of agricultural sciences'	6.3	11.5	1	13.4	10	3.4
17	HBBD	Baoding city	6.2	10.6	0.6	12	7.8	4.2
18	JSSQ	Jiangsu province	6.5	8.64	0.7	15	12.1	2.9
19	LNZY	Liaoning province	6.6	14.5	0.8	10	7.2	2.8
20	HHY	Huanghua city	6.1	10.3	0.6	8.8	7	1.8
21	JY1	Jilin academy of agricultural sciences'	6.5	10.9	1.2	8.3	6.7	1.6
22	QHY3	Qinghai academy of agricultural sciences'	5.6	9.92	0.6	9.6	7.2	2.4
23	DQ11	Heilongjiang academy of agricultural sciences	5.4	11.8	1.1	9.7	8.1	1.6
24	JY3	Jilin academy of agricultural sciences	5.8	10	1.5	9	7.5	1.5
25	MY1	Inner Mongolia academy of agricultural sciences	7	11.6	0.8	8.4	6.8	1.6
26	QY1	Hebei city	5.8	10.2	0.6	6.19	5.3	0.89
27	LNCY	Liaoning city	6.3	13.6	0.9	9.9	8.1	1.8

Table 4 Selection of breed feed

NO	Varieties	Inulin
1	LNDD	3
2	BJ	2.5
3	Binyu 1	2.6
4	HLY5	3.4
5	HBBD	4.2
6	JSSQ	2.9
7	LNZY	2.8

Table 5 Selection of industrial materials

NO	Varieties	Protein	Total sugar
1	LNDD	9.38	10.3
2	DQ4	7.5	9.7
3	Binyu 1	9.8	9.5
4	DQ4	9.86	10.4
5	JSSQ	8.64	15
6	QHY3	9.92	9.6
7	JY3	10	9

Table 6 Selection of breed feed

NO	Varieties	Ash	Protein
1	ZKY1	5.5	10.6
2	Binyu 1	5.9	9.8
3	HBHS	5.7	11.4
4	QHY3	5.6	9.92
5	DQ11	5.4	11.8
6	JY3	5.8	10
7	QY1	5.8	10.2

Statistical results of the three functions are shown in figure 1.

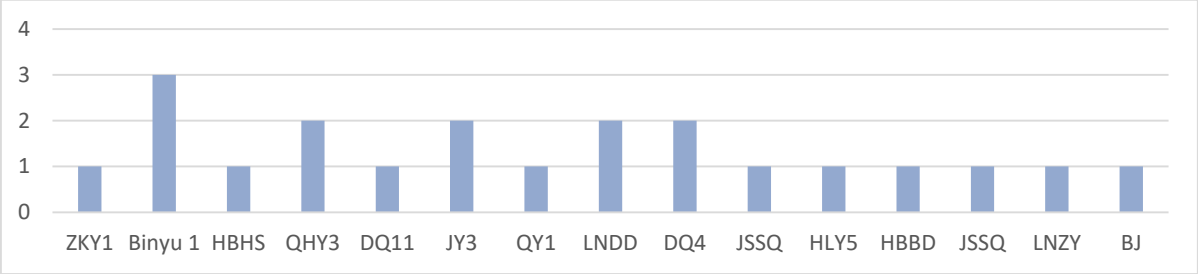

Figure 1 Statistical results of the three functions

4. Conclusions

According to test 1, inulin has a significant effect on constipation test mice, and it can be proved that inulin has a significant effect on human relaxing bowel. Many studies show that Jerusalem artichoke is the most abundant plant among plants known to contain inulin.

Therefore, 27 varieties of Jerusalem artichoke were analyzed for their nutritional composition. Hope to be able to choose the variety of Jerusalem artichoke which is relaxing bowel, and have the characteristic of high effect. Among them, Binyu 1, QHY3, JY3 and QY1 have high efficacy.

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