Study on the Relationship between Different Components of Jujube and Diabetes Mellitus

Shijun Liu1,2,3,*, Baozhu Ma1,2,3, Zhishu Tang1,2,3, Hui Li1,2,3, Yong Liu1,2,3
1Shaanxi University of Chinese Medicine/Shaanxi Collaborative Innovation Center of Chinese Medicinal Resource Industrialization, Xianyang, Shaanxi, 712083, China
2Shaanxi Research Centre on Discovery & Innovation of New Medicine, Xianyang, Shaanxi, 712083, China
3Shaanxi rheumatism and tumor center of TCM engineering technology research, Xianyang, Shaanxi, 712083, China

*Corresponding author e-mail: l181618@126.com

Abstract. The jujube with the sugar content of 65.12% to 89.58% is a dry ripe fruit of the Rhamnaceae. Diabetes is a metabolic disease characterized by hyperglycemia, and patients should not eat foods that contain too much carbohydrate and sugar. But some sugars in Zizyphus jujuba are beneficial to diabetics. Besides, jujube is rich in nutrition, and a large amount of dietary fiber can help the health of diabetic patients.

1. Introduction
Jujube is a traditional Chinese medicine and food dual-use food, which is popular among the people. At present, the research on jujube is mainly focused on its chemical composition, pharmacological effects[1], and some deep-processed products, such as jujube beverage, jujube wine, jujube powder, jujube dietary fiber biscuits, etc., but the circulation in the real market is not much. And the real circulation of the market is some of the high sugar content of the primary processing products, such as dried jujube, sweetmeats, etc., and deep processing products occupy less than 10%. Because jujube and jujube products contain high sugar content, diabetes patients are far away from jujube. We combed the sugar in the jujube and hoped to produce a diabetic people could eat the sugar-free jujube.

2. Diabetes profile
Diabetes mellitus is a group of chronic diseases characterized by hyperglycemia and is associated with abnormal insulin production and function [2]. According to the International Diabetes Federation data, the total number of diabetics in the world is about 425 million in 2017, China's diabetes is about 134.3 million, accounting for about 3/11 of the world. In addition to drug therapy, diet plays a crucial role in diabetes. The American Diabetes Association has proposed ways to control blood sugar by improving lifestyle, nutrient intake, and dietary fiber supplementation.

3. Relationship between glucose in jujube and diabetes mellitus (Table 1)
Jujube has a high sugar content. Ji Shuang-shuang determined the sugar content of 20 kinds of jujube, such as grey jujube and Jun jujube. The results showed that the total sugar content was between...
65.12% and 89.58%, and the reducing sugar content was between 30.26% and 62.49% [3]. Carbohydrates are divided into polysaccharides, oligosaccharides and monosaccharides.

3.1. Polysaccharides
Polysaccharide is a kind of polymer which is composed of more than ten monosaccharides through glycosidic bond polymerization [4]. The dried jujube polysaccharides are pale yellow and can be divided into water-soluble neutral polysaccharides and acid polysaccharides. They are soluble in water and insoluble in organic solvents. The molecular weights measured by Hung are 67633, 143108, and the molecular weights measured by Yang Yun and others are also different [5]. It may be related to the difference of varieties and separation methods. Lin Qinbao et al. hydrolyzed the jujube polysaccharide by acid and analyzed it by HPLC and glucuronide. The monosaccharides of the neutral polysaccharide were L-arabinose, D-galactose and D-glucose. The monosaccharides of the acidic polysaccharides were L-rhamnose, L-arabinose, D-galactose and D-mannose, D-galacturonic acid [6]. However, the proportion of polysaccharides in different varieties of jujube is also very different, and their biological activities may be different. Yuan Chao et al. intercepted jujube polysaccharide using 10000U ultrafiltration membrane and the pressure of about 0.12Mpa [7]. According to research, jujube polysaccharide has the functions of inhibiting tumor cells, hematopoiesis and antioxidation. Besides, jujube polysaccharide has certain effects on blood sugar. The highest inhibition rates of jujube polysaccharide on the activities of α-amylase and α-glucosidase were 53.35% and 62.25%, respectively, which could delay the release and absorption of monosaccharide and inhibit postprandial hyperglycemia. Luonizha·Wahapu et al. also found that large doses of jujube polysaccharide had hypoglycemic effect on alloxan-induced diabetic mice [8]. Studies on the relationship between jujube polysaccharide and blood glucose are rare, and its hypoglycemic effect is uncertain. At present, the main polysaccharides commonly used in health food are Cordyceps, tremella, Ganoderma lucidum and Lycium barbarum polysaccharides. The development and utilization of jujube polysaccharides is not common.

3.2. Oligosaccharides
Oligosaccharides refer to a class of compounds of 2-9 monosaccharides linked by glycosidic bonds to form linear or branched chains, but some literature will contain two sugar residues of polymers called disaccharides, not included in the category of oligosaccharides [4]. Oligosaccharides are classified into ordinary oligosaccharides and functional oligosaccharides. Ordinary oligosaccharides can be digested and absorbed by the body. Generally which are used only as sweeteners and not suitable for consumption for diabetics. Functional oligosaccharides are a kind of oligosaccharides with special physiological functions. Their monosaccharides are difficult to be digested in the human gastrointestinal system because of their special binding position. They are directly into the large intestine and preferentially utilized by bifidobacteria to promote the proliferation of bifidobacteria and improve intestinal function. It has low caloric value, anti-caries, anti-tumor, prevention and treatment of diabetes, prevention of constipation and diarrhea and other physiological effects [9]. Diabetic patients can not only eat functional oligosaccharides at ease, but also help their health. The oligosaccharides of jujube are arabinose, rhamnose, ribose, mannose, galactose and glucose [10]. The average molecular weight of oligosaccharides was 3951 Da by HPLC. It was found that oligosaccharides in jujube were pyran oligosaccharides by IR analysis[11]. The oligosaccharides of jujube were intercepted using 500U nanofiltration membrane and pressure at about 0.54MPa by Yuan Chao et al. [9]. The research and development of oligosaccharides in China is relatively late. At present, the main oligosaccharides are isomaltose, fructooligosaccharides and soybean oligosaccharides. The research on jujube oligosaccharides is still in its infancy, and the structure, content and function of oligosaccharides need further study.
3.3. Monosaccharides
Monosaccharides are the most basic units of sugar components in polysaccharides and natural products. They are generally polyhydroxy aldehydes or polyhydroxy ketones containing 3-7 carbon atoms. The main monosaccharide in jujube is glucose and fructose, the ratio is about 1:1.2 [10]. Glucose is an indispensable nutrient metabolized in the body. The heat released by its oxidation is an important source of energy for human life activities. However, diabetics eat as little or no glucose as possible. Fructose is the sweetest sugar in monosaccharides, and its metabolism is not dependent on insulin, blood sugar is not easy to rise after eating. According to many clinical studies, such as Wang Qinbo [12], Feng Hui [13], Wang Jun [14], it has been proved that injection of fructose injection and oral administration of a certain amount of fructose have no significant effect on insulin levels in diabetic patients. Fructose is more suitable for diabetics.

| Jujube          | Polysaccharides, Hypoglycemic effect is uncertain | Glucose                                                                 |
|-----------------|-------------------------------------------------|-------------------------------------------------------------------------|
| Glucide         | Oligosaccharides                                | Ordinary oligosaccharides                                               |
|                 |                                                  | Not suitable for diabetics (To remove)                                  |
|                 | Oligosaccharides                                | Functional oligosaccharides                                             |
|                 |                                                  | Suitable for diabetics                                                 |
|                 | Monosaccharides                                 | Glucose                                                                 |
|                 |                                                  | Not suitable for diabetics (To remove)                                  |
|                 | Monosaccharides                                 | Fructose                                                                |
|                 |                                                  | Suitable for diabetics                                                 |
| Dietary fiber   | Insoluble dietary fiber                          |                                                                         |
|                 |                                                  | Suitable for diabetics                                                 |
|                 | Soluble dietary fiber                            |                                                                         |
| Other           | Triterpene acids, saponins, alkaloids, flavonoids, glycosides, nucleosides, etc. | Suitable for diabetics                                                 |

4. Relationship between dietary fiber and diabetes in jujube (Table 1)
In recent years, the role of dietary fiber in diabetes has attracted wide attention. According to research, the rising incidence of diabetes is related to the lack of dietary fiber. Dietary fiber is considered as the "seventh nutrient". It generally refers to the polysaccharide food components that is not easily digested by digestive enzymes and divided into soluble dietary fiber and insoluble dietary fiber. Jujube is rich in dietary fiber (with content of 1.9%) and the dietary fiber quality of all fruits is the best and higher than other fruits. Dietary fiber prevents and treats diabetes mellitus by blocking glucose absorption, increasing insulin sensitivity, decreasing glucose release rate, and producing satiety [15] [16]. Because of the high dietary fiber content, jujube is very suitable for diabetics.

5. Conclusion
Although diabetic patients eat a lot, but the food range is narrow, fast excretion, than normal people need more nutrition. Jujube contains abundant nutrients such as protein, carbohydrates, organic acids, vitamins, trace elements and amino acids. It also contains polysaccharides, functional oligosaccharides, fructose, dietary fiber and other substances, which are beneficial to diabetes. Therefore, as long as the deep development of jujube processing and eliminating the disadvantageous glucose, ordinary oligosaccharides and other components of diabetes, I believe that jujube will be sought after by diabetics.

Acknowledgments
This work was supported by Shaanxi Project (Grant no. 2015KTCL03-14, 15JF001, ZYMS025, 2018TD-005, 2018SF-285); Shaanxi Education Finance (1213)171; and College Students' Innovative Entrepreneurial Training Programme (Grant no. 201710716010), Key Disciplines of Pharmaceutical Engineering of TCM of Shaanxi Administration of TCM (2017).
References

[1] Liu SJ, Tang ZS, Cui CL, et al. Advances in studies on chemical constituents of Ziziphus jujuba[J]. J.Yunnan Univ Trad Chin Med. 2015, 38 (3): 96-100.

[2] Kang JH, Guan T, Ning G, et al. Diabetes research in China: current status and future challenges [J]. Translational Medicine Research (Electronic Edition), 2012, 2(3): 1-24.

[3] Ji SS. Studies on the Functional Sugar from Chinese Jujube[D]. Baoding: Agricultural University of Hebei, 2012.

[4] Tu PF. Natural sugar chemistry[M]. Beijing: Chemical Industry Press, 2013.

[5] Hung CL, Hsu BY, Chang SH, et al. Antiproliferation of melanoma cells by polysaccharide isolated from Zizyphus jujube [J]. Nutrition, 2012, 48 (1): 98-105.

[6] Lin QB, Gao DW, Yu SJ, et al. Study on monosaccharide composition of polysaccharides from Chinese red dates by HPLC [J]. Journal of Zhengzhou Grain College, 1998, 19(3): 57-60, 82.

[7] Yuan C, Fan SH, Lin QB, et al. Separation of functional component of jujube dates by ultrafiltration and nanofiltration membranes [J]. Food science and technology, 2012, 37(2): 102-107.

[8] Luoyizha·W, Luo X, Xie F, et al. Influence of jujube polysaccharide on blood glucose and serum insulin of mice [J]. Science and technology of food industry, 2012, 33 (22): 369-371, 374.

[9] Yuan C. Study on the Extraction and Separation of Oligosaccharides from Jujube Date [D]. Taiyuan: Shanxi University, 2012.

[10] Lin QB, Jiang MF, Yang C. GC-MS Determination of Monosaccharide Composition of Oligosaccharides from Fruits of Chinese Jujube (Ziziphus jujuba Mill var. muzao) [J]. Food Science, 2009, 30 (16): 210-212.

[11] Jiang MF, Lin QB. Separation, Purification and Structural Analysis of Oligosaccharide from Jujube Dates [J]. Food Science, 2008, 29(8): 376-378.

[12] Wang QB. Effect of Fructose Injection on blood glucose fluctuation in diabetic patients [J]. Strait Pharmaceutical Journal, 2012, 24 (5): 208-209.

[13] Feng H. Effects of Fructose Injection on insulin, serum uric acid and blood glucose in elderly patients with type 2 diabetes mellitus [J]. Health care guide, 2016, (21): 346-346.

[14] Wang J, Guo SQ, Zhang YL, et al. Clinical study on glucose limit of oral glucose, fructose and maltose in patients with type 2 diabetes mellitus [J]. Journal of Chinese Physician, 2012, 14 (7): 938-940.

[15] Lu HK, Wang Q, Ou AB, et al. Function and application of the dietary fiber [J]. Guangdong Agricultural Sciences, 2007 (4): 67-70.

[16] Yao WH, Yin ZR. Study on Ziziphus Jujube [J]. Academic Periodical of Farm Products Processing, 2006 (2): 28-30.