

Research Progress on Nutritional Quality Evaluation of Huangguan Pear

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Abstract The fruit of Huangguan pear is deeply loved by consumers because of its rich nutrition and rich flavor. The quality evaluation system of Huangguan pear is composed of many quality types. In this study, the types and functions of nutritional quality indexes of Huangguan pear were summarized, such as vitamin C, soluble solids, soluble sugar and titratable acid, and the factors affecting the nutritional quality of Huangguan pear including genetic factors, environmental factors and agricultural management measures were overviewed, aiming to provide reference for establishing a comprehensive quality evaluation system of Huangguan pear and then promoting the high-quality development of Huangguan pear industry.

Key words Huangguan pear; Nutritional quality; Genetic factors; Environmental factors; Agricultural management

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Huangguan pear is a kind of Rosaceae plant in Rosales. Its fruit is oval or nearly spherical in shape, with a small core, white flesh, delicate texture, few stone cells, and less residue. The fruit not only has a round and regular shape, but also tastes crisp and juicy, and sweet and sour. Huangguan pear has the advantages of early fruiting, early yielding, and strong disease resistance^[1]. The fruit is rich in vitamin C, lycopene and other nutrients, which can improve human immunity, improve blood lipid and inhibit cardiovascular diseases. It is a natural prescription for anti-oxidation. The fruit of Huangguan pear is deeply loved by consumers because of its unique flavor and rich nutrients, and its consumption has increased year by year^[2], but the flavor quality of Huangguan pear has gradually declined^[3]. Improving the flavor quality and nutritional value of Huangguan pear has become the main task of Huangguan pear breeding, and it is also an urgent need for the development of Huangguan pear industry in China^[4]. Carrying out quality evaluation of Huangguan pear fruit is the basis of promoting the improvement of Huangguan pear quality, which not only meets the needs of people's longing for a better life, but also is an important measure for the high-quality development of Huangguan pear industry, rural revitalization and

improvement of people's life and health.

Main nutrients and flavor substances of Huangguan pear fruit

Vitamin C

Vitamin C is a water-soluble vitamin, which widely exists in fruits and vegetables such as Huangguan pears and watermelons, and has a strong antioxidant effect, and its content is in direct proportion to the antioxidant activity^[5]. Vitamin C can inhibit the production of oxygen free radicals, thus regulating the production of inflammatory factors, inhibiting the infiltration of inflammatory mediators, improving microcirculation to inhibit inflammatory reaction, and taking vitamin C moderately can improve the micro-inflammatory state in patients^[6]. Meanwhile, it can promote the absorption of iron, treat anemia and regulate the metabolism of fat, lipid and cholesterol.

According to the genetic law and map of vitamin C content in Huangguan pears, Huangguan pears with high vitamin C content can meet the demand of human beings for the quality of Huangguan pears, and also has an important influence on the quality of Huangguan pear fruit. Studies have shown that the difference of vitamin C content in the same type of Huangguan pear is mainly caused by additive genes, and the effect is significant.

Soluble solids

Soluble solids mainly refer to soluble sugars and other soluble substances. Soluble sugars include monosaccharides, disaccharides and polysaccharides. The soluble solids in Huangguan pears mainly include soluble sugar, titratable acid, vitamin C and other soluble nutrients, which are an important factor affecting the flavor and taste of Huangguan pear fruit. Soluble solids can also maintain the structure and water balance of Huangguan pears, and delay the decay and deterioration of Huangguan pear fruit, thus making it

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more resistant to storage and having better commodity properties.

In recent years, there have been many studies on soluble solids in Huangguan pears. The research shows that the gene of Huangguan pear can be changed by hybridization or biotechnology, so as to improve its soluble solid content. Meanwhile, it is found that soluble solids belong to nuclear inheritance controlled by polygenes and have high heritability^[7].

Soluble sugars

Soluble sugars are a class of sugar substances that can be dissolved in water, including monosaccharides, disaccharides and some oligosaccharides. Huangguan pear fruit mainly contains soluble sugars such as glucose, fructose and sucrose. Soluble sugars significantly affect the taste and flavor of Huangguan pear fruit. Soluble sugars are important nutrients and flavor substances in Huangguan pear fruit, which has high solubility and good fluidity and participates in many biochemical reactions in organisms. Proper intake of soluble sugars is necessary for human health. They can provide energy and help maintain normal functioning of the body. In addition, soluble sugars also interact with other nutrients, and their content changes with external environment and other factors, thus determining the comprehensive quality of Huangguan pear fruit.

The results showed that the soluble sugar content of Huangguan pear is controlled by polygenes. Under the same light intensity, the soluble sugar content of Huangguan pear fruit with less water content is also lower. Under the same water content, the soluble sugar content of Huangguan pear fruit decreases with the decrease of light intensity^[8]. Therefore, in the development stage of Huangguan pear, the soluble sugar content of fruit can be improved to adapt to the low temperature stress environment.

Titrate acids

Titrate acids are one of the important components of plant quality and an important factor affecting fruit flavor quality. Titrate acids also have the functions of promoting digestion and increasing the absorption of iron. For fresh food species, generally speaking, high sugar and medium acid mean strong flavor and excellent quality. For processed varieties, high sugar and high acid are required. Therefore, the quantitative study of titrate acids is of great significance to the high quality breeding of fruits and vegetables.

The titrate acids of Huangguan pear fruit mainly include citric acid, malic acid and so on, and citric acid accounts for 40%–90% of the total acid content. The content and types of titrate acids have an important influence on the flavor and quality of Huangguan pear fruit. Specifically, Huangguan pears with appropriate soluble sugar and titrate acid content have better flavor, and generally speaking, Huangguan pears with sweet and sour taste and rich flavor can be favored by consumers. The influence of titrate acid content on the flavor of Huangguan pear accounts for about 49% of the total influencing factors, while soluble sugars play a secondary role, accounting for 25% of the total influencing factors^[9].

Influencing Factors of Nutrition and Flavor Quality of Huangguan Pear Fruit

Hereditary factors

Genetic factors have a significant impact on the nutrition and flavor quality of Huangguan pear. Different varieties of Huangguan pear have different kinds and contents of nutrients, such as soluble sugars, titrate acids and vitamin C. Some varieties of Huangguan pear have been selected and improved by biotechnology, which can enhance their flavor characteristics and nutritional value. For example, some studies have edited the sgRNA on the promoter sequence of the lycopene regulatory gene *SISGR1* in Huangguan pear, so that the promoter element sequence is mutated, which leads to functional changes, which further lead to the improvement of lycopene content in Huangguan pears^[10], making the variety bright in color and having significant health benefits, such as anti-cancer and anti-oxidation. Through genome analysis, a series of related gene loci affecting the volatile flavor substances of Huangguan pear have been found. After silencing the expression of *LYC-B* gene, the types of volatile substances in Huangguan pears increased significantly, which improved the flavor of Huangguan pear fruit. In addition, different varieties of Huangguan pear have different genomes in plant metabolic pathways, which will affect the synthesis of some flavor substances, such as volatile compounds, thus changing the aroma and taste of Huangguan pears.

Environmental factors

Environmental conditions play an important role in the growth of Huangguan pear. Climatic factors such as temperature, humidity and light directly affect the photosynthesis and growth rate of Huangguan pear, thus affecting the accumulation of its nutritional components, leading to differences in nutritional quality and flavor. For example, suitable light conditions can promote the synthesis of carotenoids and vitamin C in Huangguan pears, and red light can significantly increase the content of volatile substances in Huangguan pear fruit^[11]. However, too-high temperature may lead to the decrease of sugar and acidity in the fruit, which in turn will affect the flavor. In addition, soil properties such as pH value and nutrient contents will also affect the nutritional quality of Huangguan pear fruit. For example, soil with high organic matter content can improve the nutritional contents of Huangguan pear fruit, while poor soil reduces the nutritional value of the fruit.

Agricultural management measures

Agricultural management measures also have an important impact on the nutrition and flavor quality of Huangguan pear fruit. Fertilization methods, irrigation management and harvest time will all affect the growth and final quality of Huangguan pear. Reasonable fertilization strategy can promote the healthy growth of Huangguan pear and improve the nutritional components in the fruit. For example, the reasonable proportion of main nutrients such as nitrogen, phosphorus and potassium is helpful to improving the sugar and vitamin contents of Huangguan pear fruit. The use of organic fertilizer can not only improve soil structure, but also increase the microbial activity in the soil, thus improving the nutritional quality

of Huangguan pear fruit. The application of bio-organic fertilizer and humic acid fertilizer can increase the content of vitamin C and soluble sugar in Huangguan pear fruit and improve the quality of Huangguan pear fruit^[12].

Irrigation management needs to be adjusted according to different growth stages to maintain appropriate water supply, so as to promote fruit expansion and nutrient accumulation. Unreasonable irrigation may lead to fruit cracking or excessive moisture, thus affecting the flavor. Studies have shown that the application of 60% of normal irrigation amount can improve the commercialization of Huangguan pear fruit. Meanwhile, the soluble sugar content is significantly increased, and the ratio of sugar to acid is more appropriate, and the types of volatile substances are significantly increased. Consequently, the flavor and nutritional quality of Huangguan pear fruit are optimized^[13].

The harvest time of crops varies with their species and growth cycle, and it is possible in all seasons. The harvest time of Huangguan pear is usually concentrated in summer, especially from June to August, and its harvest time and quality are deeply influenced by many factors. The harvest time of Huangguan pear is usually between 45 and 90 d after planting, and the specific time varies with varieties and growth environment.

Research shows that harvest time significantly affects the quality of Huangguan pear fruit, and the contents of soluble solids and vitamin C are greatly affected by different harvest time. Among them, soluble solid content increases first and then decreases with the delay of harvest time^[14].

Prospects

The production of Huangguan pear in China is close to the market demand, and consumers prefer to buy Huangguan pears with good nutritional quality and strong flavor. Quality traits determine the quality of crop products. Therefore, conducting multidimensional nutritional quality evaluation of Huangguan pear fruit and identifying advantageous varieties are the basis for promoting the breeding of high-quality Huangguan pear. Meanwhile, the contents of various nutrients in Huangguan pear fruit can be significantly affected by scientifically regulating the environmental factors such as temperature, light, and other external conditions in the growth process of Huangguan pear, so as to cultivate high-quality Huangguan pear and provide guidance for actual agricultural production. With the continuous progress of molecular breeding, gene technology and biotechnology, related genes and loci involved in quality regulation and nutrient accumulation in Huangguan pear fruit have been continuously revealed, thus

clarifying the internal regulation mechanism of Huangguan pear quality, which is of great significance to the breeding and production practice of high-quality Huangguan pear.

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