Effect of mechanical juice extraction method on the quality of fresh-squeezed apple juice

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Abstract. In order to study the effect of different mechanical juice extraction methods on the quality of fresh-squeezed apple juice, the optimal fresh-squeezed apple juice processing method was selected. The fresh-squeezed apple juice is processed by three kinds of mechanical juice extraction methods: squeezed juice, spiral juicer and broken juice. Five main evaluation indexes of soluble solid content, titratable acid content, value of b*, value of a* and 625nm transmittance of fresh-squeezed apple juice obtained by three mechanical juice extraction methods were determined. Through the analysis and research of the data obtained from the five indicators, the influence of different mechanical juice extraction methods on the quality of fresh-squeezed apple juice was determined, and the mechanical juice extraction method suitable for processing fresh-squeezed apple juice was determined.

1. Introduction

Apple is widely distributed all over the world and is one of the world's major fruits [1]. Apples are rich in minerals and vitamins and have high nutritional value. According to statistics from the Food and Agriculture Organization of the United Nations, China's apple production in 2017 was 41.129 million tons, accounting for 49.79% of the world's apple production. China is the world's largest apple producer [2]. At the same time, China is also the world's largest producer and exporter of concentrated apple juice. With the progress and development of society, consumers' attention to health is increasing. Fresh-squeezed apple juice, which retains apple nutrition to a high degree, and has a good natural flavor, is increasingly popular among consumers. In the United States and Europe, fresh-squeezed apple juice sales account for more than 40% of the apple juice market share [3].

The core process of fresh-squeezed apple juice is juicing, and different methods of juicing directly affect and determine the quality of fresh-squeezed apple juice. At present, the research on the processing methods of fruit and vegetable juices at home and abroad mainly focuses on large industrial juicers such as hydraulic tube juicers and belt juicers, and there are few studies on small household juicers [4]. The research on the influence of processing technology on the quality of fruit and vegetable juice is mainly concentrated on the finished fruit and vegetable juice, and the research on the quality of fresh-squeezed fruit and vegetable juice is less [5]. In recent years, the domestic fresh-squeezed fruit and vegetable juice market has continued to expand, and the sales of household fruit juicers have been increasing. At the same time, various vending fresh-squeezing juice machines have appeared in cities. Studying the effects of different processing techniques on the quality of fresh-squeezed apple juice is of great significance for maintaining the natural nutrient composition and functional properties of fresh-squeezed apple juice.

At present, there is no domestic evaluation standard for fresh-squeezed juice. National Standard GB/T 31121-2014 "Fruit and Vegetable Juices and Beverages" stipulates that raw juices (non-rejuvenated juices), which are made from fruits, are fermentable but unfermented and unconcentrated
juice product made directly by mechanical means. Raw juice (non-reconstituted juice) made by non-heat treatment or pasteurized sterilization can be called fresh juice [6]. Jiyun Nie [7] preliminarily constructed an fresh-squeezed apple juice evaluation system through factor analysis, probability distribution and analytic hierarchy process. Jiankang Deng [8] established a comprehensive evaluation model of apple (substandard fruit) juice quality based on analytic hierarchy process and gray correlation method. Among them, the five main evaluation indexes for fresh-squeezed apple juice quality are: soluble solid content, titratable acid content, value of $b^*$, value of $a^*$, and 625nm transmittance.

This study is mainly aimed at the three kinds of mechanical juice extraction methods of common broken juice, squeezed juice and spiral juice on the market. According to the five main evaluation indexes affecting the quality of fresh-squeezed apple juice, the effects of the above three mechanical juice extraction methods on the quality of apple fresh juice were studied. By comparing the experimental results and data, the advantages and disadvantages of different mechanical juice extraction methods are analyzed, which provides a scientific basis for the selection of apple mechanical juice extraction methods.

2. Materials and Methods

2.1. Materials and reagents
Fuji apple, the origin of Yantai, Shandong, has a complete appearance, no mechanical damage, and is stored in a 4 °C cold storage. Sodium hydroxide, Damao Chemical Reagent Factory. ascorbic acid, phenolphthalein, Sinopharm Chemical Reagent Co., Ltd.

2.2. Equipment and instruments
Squeezing juicer, SZ-18 Baijie stainless steel manual juicer, Deqing Baijie Electric Co., Ltd.. spiral juicer, Shuangmeijian Juicer, Linyi Shuangjian Food Machinery Co., Ltd.. Broken juicer, TL-780B green baby broken wall nutrition conditioning machine, Foshan Shunde District Good Life Electronic Technology Co., Ltd.. HT119ATC refractometer, WGZ-200BS desktop turbidity meter, Shenzhen Yuanhengtong Technology Co., Ltd.. WSC-2B portable precision color difference Instrument, Shanghai Yidian Physical Optical Instrument Co., Ltd.. V-5000 spectrophotometer, Shanghai Yuanxi Instrument Co., Ltd.. YP20002 electronic balance, FA2004B electronic balance Shanghai Youke Instrument Co., Ltd.. LXJ-IIB low speed large capacity multi-tube centrifugation Machine, Shanghai Anting Scientific Instrument Factory.

2.3. Experimental method
Take the experimental apple, wash it with ultrapure water, peeling and denucleating, and divide the pulp into rectangular pieces of no more than 1cm³. The apples were juiced after the splitting using a squeeze juicer, a spiral juicer and a broken juicer. The weight of the pulp and the weight of the obtained juice were recorded, and the juice yields of the three juice extraction methods were obtained (Table 1). Add ascorbic acid to the fresh-squeezed apple juice (addition amount 0.2g/kg). Put the juice into the centrifuge, centrifuge at 4500 rpm for 10 minutes. Filter 8 layers of gauze. Seal the filtered juice into a refrigerator at 5 °C stand-by.

The fresh-squeezed apple juice was sampled by three different juice extraction methods, and the soluble solid content was determined by HT119ATC refractometer. The titratable acid content was determined by the indicator titration method [9]. The value of $b^*$ and value of $a^*$ was measured by WSC-2B portable precision colorimeter. The 625nm transmittance (T625) was measured using a V-5000 spectrophotometer. Three times for each experiment, the results were averaged (Table 2).

| Table 1. Juice rate |
|-------------------|
| Broken juice | Squeeze juice | Spiral juice |
| Average weight of pulp | 385.5g | 423.26g | 269.39g |
| Average juice weight | 113.38g | 162.59g | 126.73g |
| Juice rate | 29.4% | 38.4% | 47.0% |
3. Result analysis
The soluble solids in fresh-squeezed apple juice are mainly soluble sugars. The higher the soluble solids value, the higher the sugar content in fresh-squeezed apple juice. The titratable acid content in fresh-squeezed apple juice (calculated as malic acid), the higher the value indicates the higher malic acid content. The sweetness in the juice is related to the content of soluble solids and titratable acid. When the value of $a^*$ is positive, the value of $a^*$ is larger, the color is redder. When the value of $a^*$ is negative, the absolute value of the value of $a^*$ is larger, the color is greener. When the value of $b^*$ is positive, the value of $b^*$ is larger, the color is yellower. When the value of $b^*$ is negative, the absolute value of the value of $b^*$ is larger, the color is bluer. The color of the apple juice affects its value of $a^*$ and value of $b^*$. The greater the transmittance at 625nm, the better the light transmittance, which is an important indicator reflecting the quality of apple turbid juice.

3.1. Broken juice
According to the data in Table 1 and Table 2, it can be seen that the broken juice method has the lowest juice yield. The soluble solid content of the fresh-squeezed apple juice obtained is lower than that of the spiral juicer, which is higher than the squeezed juicer. The titratable acid content (calculated as malic acid) and the light transmittance at 625nm are lower than the squeezed juice extraction method, which is higher than the spiral juice extraction method. The sweetness of the obtained juice is between the other two juice extraction methods. The value of $b^*$ is slightly larger than the squeezed juice method, much smaller than the spiral juice extraction method. The value of $a^*$ is the smallest. The resulting juice color is the worst. The main juicer of the broken juice is the rotating blade (Fig. 1). During the work, the apple pulp is cut by the high-speed rotation of the rotating blade, and the larger fruit is cut into finely divided apple pulp, which increases the contact area between the apple pulp and the air and oxidative browning speed [10]. The apple juice is obtained by mixing the apple pulp with the apple juice (Fig. 2), which needs further separation by high speed centrifugation, and is not suitable for processing fresh-squeezed apple juice.

Table 2. Five main evaluation indicators

|                      | Broken juice | Squeeze juice | Spiral juice |
|----------------------|--------------|---------------|--------------|
| Soluble solids       | 13.0         | 12.5          | 16.0         |
| Titrate acid         | 1.7152       | 2.0904        | 1.5812       |
| value of $b^*$       | 2.32         | 2.28          | 4.49         |
| value of $a^*$       | 0.82         | 1.86          | 1.22         |
| 625nm transmittance  | 34.1         | 81.1          | 23.9         |

Figure 1. Rotating blade.  Figure 2. Apple pulp.
3.2. Squeeze juice
According to the data in Table 1 and Table 2, it can be seen that the juice extraction rate of the squeezed juice method is higher than that of the broken juice, which is lower than that of the spiral juice. The separation of the pulp and the juice during the work does not require high-speed centrifugation. The obtained fresh-squeezed apple juice has the lowest soluble solid content. The titratable acid content (calculated as malic acid) and transmittance at 625nm are the highest. The juice is relatively acidic. The value of b* is the smallest and the value of a* is the largest, so the resulting juice has the best color. The main juice extraction mechanism of the squeezed juice is a conical upper cover and a juice net (Fig. 3). The flesh is placed between the conical top cover and the juice net. When juicing, the conical top cover and the juice net are close to each other to squeeze the apple pulp in the middle. Only one action is required to complete, and the juice speed and efficiency are high. Due to the quickest juice extraction process, the juice has the least oxidative browning and the juice color is the best.

3.3. Spiral juice
According to the data in Tables 1 and 2, the spiral juice extraction method has the highest juice yield. During the working process, the pulp and juice can be automatically separated without high-speed centrifugation. The obtained fresh-squeezed apple juice has the highest soluble solid content. The titratable acid content (calculated as malic acid) and transmittance at 625nm are the lowest. The juice is relatively sweet. The value of b* is the largest and the value of a* is between the broken juice and the squeezed juice, so the color of the juice obtained is between the other two juice extraction methods. Since the spiral juicer structure is the screw rod (Fig. 4), the pitch on the screw is decreasing, the pressing force is increasing when juicing, and the pulp is squeezed layer by layer, and the juice yield is the highest. However, the juice extraction process increases the contact time and area of the juice with the air, resulting in a higher degree of oxidative browning of the freshly squeezed apple juice than the squeeze juicer, but lower than the crushed juicer.
4. Conclusion
It can be seen from the above experimental results that different mechanical juice extraction methods will have a greater impact on the quality of fresh-squeezed apple juice. In terms of the quality of the juice and the juice yield, the broken juice has the worst effect, and the pulp obtained after the juice extraction needs further separation, so it is not suitable for the fresh juice processing of apples. The quality of the fresh-squeezed apple juice obtained by the squeeze juicer is optimal without considering the juice rate. The juice yield of the fresh-squeezed apple juice using the spiral juicer is the best regardless of the quality of the juice. If the juice rate and juice quality are combined, the best overall performance is the squeeze juicer, which takes into account both the quality and the juice yield. It is the most suitable mechanical method for fresh-squeezed apple juice production.

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