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Orthogonal experimental study on Steam explosion treatment technology of areca nut

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Abstract. Improving quality of areca nut is a critical problem for manufacturers. A steam experimental explosion device has been developed. An areca nut processing technology was optimized by using the orthogonal experiment method. In which, the processing parameters including pressure, processing time and temperature, were taken by three factors. Each factor selected three levels and nine groups of orthogonal experiments were carried out. The volume expansion rate of the sample was taken as evaluation standard; the best treatment scheme is obtained through optimization. The experimental results showed that the equipment shortened soaking time of normal process, orthogonal experiment reduced the number of experiments, and orthogonal experiment accelerated the application speed. Products will meet the use requirements of customers.

Keywords: Betel nut processing; Orthogonal experiment; Steam explosion; Processing efficiency.

1. Introduction

Areca nut is dry and mature seed of Areca catechu of a palm plant. It has been recorded as early as the Han and Jin Dynasties in China. It has medicinal effects such as eliminating stagnated food to destroy intestinal worms, Promoting qi, stopping malaria, expelling intestinal and parasites[1, 2]. Areca Catechu has a history in India going back to 1300 BC[3]. As an edible product, the custom dates back to Malaysia and Thailand 4000 years ago. The history of areca nut consumption is recorded in Nan Yi Yi Wu Zhi written by Yang Fu of the Eastern Han Dynasty[4]. areca nut also appears in literary works[5], as well as in the name of relevant associations, institutions and geographical names[6, 7].

In recent years, areca nut, as a kind of commercial crops, has been widely planted in southern China, such as Hainan, Guangdong and Fujian provinces[8]. Researchers have studied areca nut technologies of increasing production, value addition and storage etc. [9-11]. As one of major medicines in the south of China, Many technicians are also developing its medicinal value [12-14].

In addition, areca nut shell contains high quality natural fibers, which can be used to manufacture composites, textiles and other applications.

In recent years, areca nut has become a popular leisure food. According to statistics, About 10 % of the world ' s population chew areca nuts[18,19], although there is evidence that chewing betel nut is associated with oral cancer and throat cancer[21–24]. The number of people eating areca nut is only less than tobacco, alcohol and caffeine. 20 ~ 40 % of people chews betel nut in South Asia. Southeast Asia and the Pacific islands are mainly distributed as shown in Figure 1, which may be related to local habits and beliefs[22, 25]. In China, areca nuts have also become a business card for leisure in Hunan. Processing methods, ingredients and tastes of areca nuts are different from those in Southeast Asia. Areca nut is loved by consumers in the south and north of China because of their unique characteristics. As processing and production base for edible areca nuts, Xiangtan has become representative of characteristic industries, known as 'areca nut city'. According to statistics, the output value in 2018 exceeds 30 billion Yuan.

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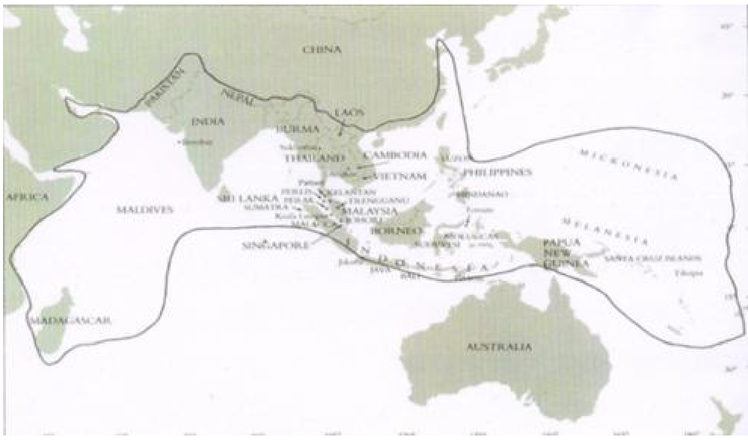

Fig1. Distribution of chewing areca customs in Southeast Asia

Xiangtan has a history of processing edible areca nuts for more than 400 years. The processing technology has also changed from simple “lime areca nuts” to “characteristic areca nuts” such as sesame, osmanthus, mint, cream, and wolfberry, which are combined with traditional and modern technologies. With the progress of processing technology, it has better taste and is easy to chew.

Usually, the main processing flow of betel nut is:

Dry,areca,nut—cleaning—concoction—polishing—drying—cutting,fruit—Point,halowaters—treatment of WT—secundiflora—vacuum packing—grading—packing—finished product

Dried betel nut is made into products by cleaning, processing and other processing techniques showed above. However, due to betel nut fruit texture be hard, the taste of brine is not easy to enter the flesh (or processing cycle becomes longer) and long-term chewing is easy to cause tooth deformation. In order to soften the betel nut and taste well, the betel nut must be cooked and soaked for a long time to make its juice enter the inside of flesh. However, the production cycle is too long and the energy consumption is very high too. The water contained in the prepared betel nut is not high, otherwise the quality guarantee period will be too short. In order to solve this problem, a steam explosion process is added after the cleaning process of the traditional betel nut processing process, and a set of equipment is developed by our team, which can make the betel nut loose in texture, greatly shorten the processing time, greatly improve the production efficiency, and the condiment is easier to penetrate into the inside of the pulp, so that the taste of the eater is better.

2. Materials and methods

2.1 Materials and equipment

The experimental materials were selected from several high-quality betel nuts produced in Hainan. The equipment used is a newly developed steam explosion tank device for betel nut products, as shown in Figure 1, mainly including: heating tank, working tank, vacuum pump, rapid pressure relief device, etc. The SEM for fiber microscopic analysis was JSM6490LV.

2.2 Experimental methods

2.2.1 Basic principle of steam explosion

Filling → Pumping → High pressure steam → Rapid pressure relief

The purpose of vacuum is to reduce the pressure in the tank. When filling the steam, the high temperature and high pressure steam can quickly fill the tank and minimize heating cold air to reduce thermal potential. Injected high temperature and high pressure steam penetrates into the betel nut quickly and water in sarcocarp increasing rapidly. The water in the betel nut boil because of

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pressure in the tank releasing rapidly subsequently. The rapid reduction of pressure also induces the fibers in the betel nut are separated from others. Texture of betel nut becomes soft too.

2.3 Orthogonal experimental scheme

The temperature, pressure and holding time of process parameters were taken as the research objects, the orthogonal experiment scheme was designed at three-factor level. Each factor is tested at three levels. According to the design conditions of the equipment, the highest design pressure of 2.6 bar is selected for the highest pressure level.

3. Results and analysis

Three factors level design orthogonal experiment scheme, scheme and experimental results as shown in table 1.

Table 1. Orthogonal experiment plan

No.	factors			results
	Temperature(℃)	Pressure maintain (S)	pressure (bar)	
1	110	120	2.3	2.3
2	110	150	2.6	2.9
3	110	180	2.0	2.4
4	120	120	2.6	3.1
5	120	150	2.0	2.8
6	120	180	2.3	3.2
7	130	120	2.0	2.9
8	130	150	2.3	3.2
9	130	180	2.6	3.3

Before the experiment, the betel nuts in each basket were placed in a stainless steel mesh basket, and the volume was about 2 / 3 of the basket volume. The height of the test betel nuts in basket was the same, and the height of the betel nuts was recorded. The upper part of the fruit was smoothed with a tool. Then the basket was covered with a cover. The baskets with nuts were put into steam explosion tank and tested according to the design scheme. When test was end, the basket was taken out. The height of betel nuts after cooling was measured and recorded in table 1. Seen from table 1, The experimental results showed that the holding time is 180 s and the temperature is 130 °C, the expansion of areca nut is the most obvious, which increases by 3.3 cm in the basket when the steam pressure is 2.3 bar.

Betel nut surface before treatment was brown yellow (Figure 2).The surface of brown epidermis was removed after treatment. The surface became white and full (Figure 3).

The betel nuts treated in Scheme 9 and untreated betel nuts were cut from the middle along the long axis respectively to observe the fiber differences in the cross section. Natural air drying after cutting continued for five days, and then samples were dried at 120 °C for 5 h in a ventilated oven. Gold-plated layer was carried out at the cross section before morphology test. Then the micro-surface morphology of the cross section was analyzed on a JSM6490LV scanning electron microscope. The specific working parameters were as follows: voltage of 200 kV, working distance of 10 mm, and beam current of 50. The scan results are shown in Figure 4.

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Fig 2. Raw areca nuts

Fig 3. Processed areca nuts

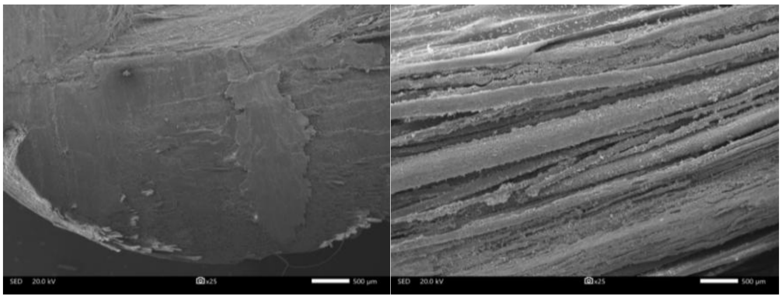

Fig 4. micrograph of areca nut (a) non-treatment with steam explosion (b) treated with steam explosion

It can be seen from Figure 4a that the betel nut fruit without steam explosion tank treatment was dense, no fiber tissue was found in the surface layer. In Figure 4b, the betel nut fiber treated by steam explosion tank was obviously separated from each other. The gap between fibers was obvious. There is obvious tearing between fibers, which shows that the texture has obvious loose after treatment.

4. Conclusions

The experimental results showed that: (1) The surface of areca nuts treated by steam explosion was white and the volume was expanded; (2) The internal tissue of betel nut is fluffy, and there is a large gap between fibers, which is not as dense as the original fruits; (3) Soft texture, more conducive to chewing, eating taste better.

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