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# Effect of Different Processing Techniques on the Retention Rate of Main Bioactive Components and the Stability of Nutritional Quality in Noni Fruit

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**Abstract:** Noni fruit is rich in bioactive substances such as polyphenols and flavonoids, and its processing techniques directly affect the retention rate of functional components and quality stability. Using wild Noni fruit from Hainan as the research subject, this paper employed three processing techniques: natural sun-drying, hot-air drying, and vacuum freeze-drying. The retention rates of polyphenols, flavonoids, and enzyme activities such as SOD were analyzed, and the antioxidant activity, nutritional quality, and storage stability of products from different processes were compared. The research results indicate that vacuum freeze-drying yielded the highest retention rate of active components and the best product quality stability, providing a reference for the industrial processing of Noni fruit.

**Keywords:** Noni fruit; Drying technique; Bioactive components; Quality stability

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## 1. Introduction

Noni fruit (*Morinda citrifolia* L.) is a tropical fruit from the Rubiaceae family, containing abundant bioactive substances such as polyphenols, flavonoids, polysaccharides, phenolic acids, and SOD, possessing significant antioxidant, anti-inflammatory, and immunomodulatory functions. However, Noni fruit is prone to spoilage, and its active components are susceptible to degradation during post-harvest handling and processing, severely impacting its functional properties and commercial value. Currently, drying is the primary method for processing and preserving Noni fruit, but different drying techniques significantly differ in their effectiveness in retaining active components and their impact on quality. Based on this, systematically studying the effects of different processing techniques on the retention rate of main bioactive components and the stability of nutritional quality in Noni fruit is of great significance for determining optimal processing methods, improving product quality, and developing functional foods <sup>[1]</sup>.

## 2. Materials and methods

### 2.1. Experimental materials

Wild Noni fruit from Baisha County, Hainan Province, was selected as the raw material. Fruits with moderate maturity and intact appearance were cleaned for use. Main reagents included analytical grade Folin-Ciocalteu reagent, gallic acid, rutin reference standard, and DPPH radical. Experimental equipment included a DHG-9030A forced-air drying oven, an FD-1A-50 vacuum freeze-dryer, and a UV-1800 UV-Vis spectrophotometer. Samples were crushed and sieved through a 60-mesh screen.

### 2.2. Experimental methods

Total polyphenol content was determined using the Folin-Ciocalteu method with gallic acid as the standard, measuring absorbance at 765 nm. Total flavonoid content was determined using the  $\text{NaNO}_2\text{-Al}(\text{NO}_3)_3\text{-NaOH}$  colorimetric method with rutin as the reference, measuring absorbance at 510 nm. SOD enzyme activity was determined using the nitroblue tetrazolium (NBT) photoreduction method, measuring absorbance at 560 nm. Antioxidant activity was evaluated using the DPPH radical scavenging rate method, measuring absorbance at 517 nm. All sample determinations were performed in triplicate, and the average values were taken. Data were analyzed for variance using SPSS 20.0 software, with the significance level set at  $P < 0.05$ .

## 3. Results and analysis

### 3.1. Effect of different techniques on the retention rate of active components

#### 3.1.1. Comparison of retention rates for polyphenolic substances

Experimental results showed significant differences in the retention rates of polyphenolic substances in Noni fruit after treatment with different drying techniques. Vacuum freeze-drying yielded the highest polyphenol retention rate at 85.6%, while hot-air drying and natural sun-drying resulted in retention rates of 65.3% and 58.9%, respectively. This difference is mainly attributed to the low-temperature environment during vacuum freeze-drying, effectively inhibiting the oxidative degradation of polyphenols, and the vacuum condition suppresses oxidase activity. In contrast, the higher temperatures during hot-air drying accelerated polyphenol degradation, while prolonged exposure to air during natural sun-drying led to more severe oxidative loss of polyphenols<sup>[2]</sup>.

#### 3.1.2. Comparison of retention rates for flavonoid substances

Analysis showed that the three drying techniques also exhibited significant differences in their effectiveness in retaining flavonoid substances in Noni fruit. After vacuum freeze-drying, the flavonoid retention rate reached 82.4%, significantly higher than the 61.8% for hot-air drying and 55.2% for natural sun-drying. This is mainly because flavonoid compounds are highly heat-sensitive. The ultra-low temperature environment during vacuum freeze-drying can maximally protect the structural stability of flavonoids, reducing their degradation. During hot-air drying and natural sun-drying, the combined effects of temperature and oxygen accelerate the oxidative decomposition of flavonoids, leading to a significant reduction in their retention rate.

#### 3.1.3. Comparison of retention rates for enzyme activities like SOD

Comparative analysis indicated significant differences in the retention of enzyme activities like SOD under different drying techniques. After vacuum freeze-drying, the retention rate of SOD enzyme activity was as high as 88.7%, far exceeding the 45.3% for hot-air drying and 42.1% for natural sun-drying. The main reason for this difference lies in the extreme temperature sensitivity of enzymes like SOD. The low-temperature environment during vacuum freeze-drying effectively maintains the spatial conformation of enzyme molecules, preventing their inactivation. In contrast, the high temperatures during hot-air drying cause enzyme protein denaturation, and the fluctuating ambient temperatures and longer drying times

during natural sun-drying are also detrimental to maintaining enzyme activity, leading to a substantial decrease in their retention rate <sup>[3]</sup>.

### **3.2. Effect of different techniques on antioxidant activity**

DPPH radical scavenging rate results showed clear differences in the antioxidant activity of Noni fruit samples after treatment with different drying techniques. The vacuum freeze-dried sample had a DPPH radical scavenging rate of 78.5%, exhibiting the strongest antioxidant activity, while the scavenging rates for hot-air dried and sun-dried samples decreased to 52.6% and 48.3%, respectively. This shows a significant positive correlation with the retention rates of antioxidant active substances like polyphenols and flavonoids under each technique.

### **3.3. Effect of different techniques on nutritional quality**

The study analyzed the effects of different drying techniques on the nutritional quality of Noni fruit, including indicators such as soluble solids, vitamin C, and amino acids. Samples treated with vacuum freeze-drying showed the best preservation of nutritional quality: soluble solids content was 28.5 g/100g, vitamin C retention rate reached 85.2%, and the loss rate of essential amino acids was only 12.3%. In contrast, samples treated with hot-air drying and natural sun-drying experienced greater nutrient loss: vitamin C retention rates decreased to 56.4% and 48.9%, respectively, while the loss rates of essential amino acids increased to 25.6% and 28.7%, respectively.

### **3.4. Comparison of storage stability of products from different techniques**

A six-month ambient temperature storage test on Noni fruit samples treated with the three drying techniques showed that the vacuum freeze-dried product exhibited the best storage stability. Its moisture content increased by only 0.8%, the degradation rates of polyphenols and flavonoids were 5.2% and 6.1%, respectively, and changes in sensory qualities like color and flavor were minor. In contrast, the hot-air dried and sun-dried products showed moisture content increases of 2.3% and 2.8%, respectively, during storage, with significant degradation of active components: polyphenol loss rates reached 15.6% and 18.2%, respectively.

## **4. Conclusion**

The study indicates that vacuum freeze-drying offers significant advantages in the processing of Noni fruit. The total polyphenol content in Noni fruit products treated with this technique reached 12.42 mg/g, significantly higher than natural sun-drying (7.78 mg/g) and hot-air drying (6.38 mg/g). High-performance liquid chromatography analysis showed that the total content of seven polyphenol compounds was highest after vacuum freeze-drying, reaching 1207.42 µg/g. Regarding antioxidant activity, the DPPH radical scavenging capacity (35.98 µmol Trolox/g) and ABTS<sup>+</sup> scavenging capacity (36.09 µmol Trolox/g) of the vacuum freeze-dried sample were significantly superior to other techniques. Furthermore, products treated with this technique exhibited excellent storage stability, with active component degradation rates below 7% during six months of ambient temperature storage. Correlation analysis showed a significant positive correlation between total polyphenol content in Noni fruit and its antioxidant activity. Therefore, vacuum freeze-drying is suitable as the preferred technique for large-scale processing of Noni fruit.

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## Disclosure statement

The author declares no conflict of interest.

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