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EFFECT OF DIFFERENT TREATMENT METHODS ON *HYPERICUM MONOGYNUM* NUTRIENT COMPOSITION

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Abstract

A *Hypericum monogynum* (*H. monogynum*) variety was chosen and exposed to six pretreatment methods: vacuum drying, natural air drying, hot air drying, sugar solution, acid solution, and salt solution to understand its physical and chemical properties and nutrient content. After drying and avoiding light for two months, the samples were tested and analyzed for their nutrients, including their moisture content, soluble sugar content, soluble protein content, total flavonoid content, carotenoid content, ascorbic acid (vitamin C) content, and the contents of nine mineral elements, including N, P, K, Ca, Mg, S, Zn, Cu, and Fe. It was found that the nutrient content of *H. monogynum* was affected by the different treatment methods. Among them, the content of soluble sugar, soluble protein, L-ascorbic acid, metal elements, nitrogen (N), and phosphorus (P) was significantly higher for the vacuum dried samples than for the other treatment methods. Vacuum drying may be utilized as an ideal method for retaining *H. monogynum* nutrients. The natural and hot air-drying treatments were cheaper and simpler to operate, and what's more, they were second only to vacuum drying in terms of improving soluble sugar and soluble protein concentrations. Although the carotenoid concentration of *H. monogynum* in the acid solution treatment was substantially higher than for the other treatments, it impeded the total flavonoid accumulation. The sulfur (S) content was much higher for the sugar solution treatment than for the other treatments. By analyzing the variations in the nutrient composition of *H. monogynum* for these different treatments, this study provides a scientific reference for *H. monogynum* research.

Key words: *H. monogynum*, Nutrients, Minerals, Vacuum drying.

Introduction

Hypericum monogynum is a *Garcinia* family plant known as Begonia, Forsythia, and others. The entire plant is smooth and glabrous with numerous branches, and its twigs are often symmetrical and reddish-brown. It has numerous stamens, slender as silk, golden yellow, and lustrous, and its flowers are shaped like peach blossoms. *H. monogynum* has over 500 species worldwide, roughly 50 of which are in China. They are found in Anhui, Zhejiang, Shandong, Chongqing, and other Chinese provinces. Frequently seen on hillsides, roadsides, and around bushes, it is used as a decorative shrub. In China, *H. monogynum* has been introduced and planted to green the country in East, North, and South China, as well as other regions (Li *et al*., 2022). In foreign countries, it has been widely used in gardens, squares, roads, and urban green spaces. While conventional flower treatment methods like natural air and hot air drying are straightforward and convenient, they have flaws. Natural air drying is not efficient and has a long drying cycle, which can lead to mildew and bacterial contamination. It is influenced by many factors, such as geographical location and climate. Hot air drying has certain limitations for some plant samples, which can result in their discoloration and inactivation, among other things. The temperature and drying time affect the drying efficiency (Önal *et al*., 2019), but excessively high temperatures inactivate active plant chemicals, such as flavonoids, polyphenols, and other substances. It is showed that different drying methods produce great differences in the measured nutrient content of jujubes (Wang *et al*., 2012). On the basis of vacuum freeze-drying technology, the proportion of liquid preparations for flower drying was optimized, and an ideal rose preservation method was obtained (Qiu *et al*., 2020). Vacuum freezing can be traced back to the 1970s, when researchers first successfully used liquid nitrogen to preserve plant cells. With this technology's recent innovation and progress, ultra-low temperature treatment has been applied in many industries. The concept is that the free water inside plant cells is no longer "free," which hinders a series of typical plant physiological functions and related metabolic activities; the entire plant body becomes stagnant. The plant's physiological activity and related metabolism are restored when it is returned to an environment with a normal temperature; the plant's activity and morphogenetic potential remain unchanged without genetic variation.

H. monogynum contains flavonoids, ascorbic acid, non-essential amino acids, carotenes, phloroglucinols, and amino acids and is commonly used as a raw material for pharmaceutical production. It is often used for anti-virus, anti-depression, and anti-cancer treatments and can also be used to treat gastritis, diarrhea, hepatitis, rheumatism, and other diseases (Guo *et al*., 2019). *H. monogynum* samples were exposed to six pretreatment methods: vacuum drying, natural air drying, hot air drying, sugar solution, acid solution, and salt solution. This work compares the changes in the content of their various nutrient components to provide a reference for *H. monogynum* nutrient component research.

Materials and Methods

The *H. monogynum* samples used in this experiment were all picked at the Longhu Campus of the Anhui University of Science and Technology, Bengbu City, Anhui Province. Figure 1 shows how to wrap the container with plastic and store it in a cool, dark place for two months. (a) The vacuum drying treatment involved vacuum cooling for 8 hours with a freeze dryer. (b) The natural air-drying treatment involved drying it inside at 25°C, then air drying it naturally. (c) The hot air-drying treatment involved drying the sample for 8+8 hours in an electric hot air blast drying oven at a temperature of 50°C. (d) The sugar solution treatment involved combining a 100g fresh sample with 50g sucrose and dissolving the mixture in 20ml pure water. (e) The acid solution treatment involved mixing a fresh 100g sample with 3g citric acid, and (f) the salt solution treatment involved mixing a fresh 100 g sample with 400 g of NaCl.

The moisture content of the samples was determined by the method described by Kibinza *et al*., (2006). Briefly, the ratio of the sampling mass before and after drying to a constant weight was calculated to measure the moisture content. The samples' content of soluble sugar, soluble protein, carotenoids, total flavonoids, ascorbic acid, and phosphorus (P) elements were measured as described by Wei *et al*., (2014); Isoe *et al*., (2006); Peng *et al*., (2005); Kim *et al*., (2012); Selimović *et al*., (2011); and Pang *et al*., (2003). The calculation of the mineral elements was carried out by the Inductively Coupled Plasma Mass Spectrometry (ICP-MS) method (Liu *et al*., 2014). The concentration of sulfur (S) in the samples was determined by using the Iodine Standard Solution Titration Method (Oliveira *et al*., 2009). The Kjeldahl method was used to determine the total nitrogen content of the sample (Lü *et al*., 2004).

Statistics analysis

Microsoft Excel 10.0 was used to process the data, and SPSS software, for significant difference analysis.

Results and Analysis

Effect of the different treatments on the nutrient content of *H. monogynum*: Figure 2 shows the nutritional composition of *H. monogynum*. Water, soluble sugar, and soluble protein are involved in plant growth, regulating substance absorption, transport, synthesis, and metabolism. They also comprise the essential nutrients for plant growth (Wu *et al*., 2021). Carotenoids are an essential component of plant pigments, providing a physiological basis for plant photosynthesis. Ascorbic acid (vitamin C) is a vital antioxidant in plants, an important substance for maintaining cell activity, and is required for normal plant growth.

Effect of the different treatments on the moisture content of *H. monogynum*: One of the most critical elements for plant growth and development is water. The balance of free and bound water guarantees the stability of plant life activities. The moisture content of *H. monogynum* did not differ significantly between the vacuum and drying treatments, but there were substantial differences between the other treatments. The moisture content of samples from the different treatments was sugar solution > acid solution > salt solution > natural air drying > hot air drying > vacuum drying. The moisture content of *H. monogynum* was lower from the vacuum and hot air drying but higher from the solution treatments.

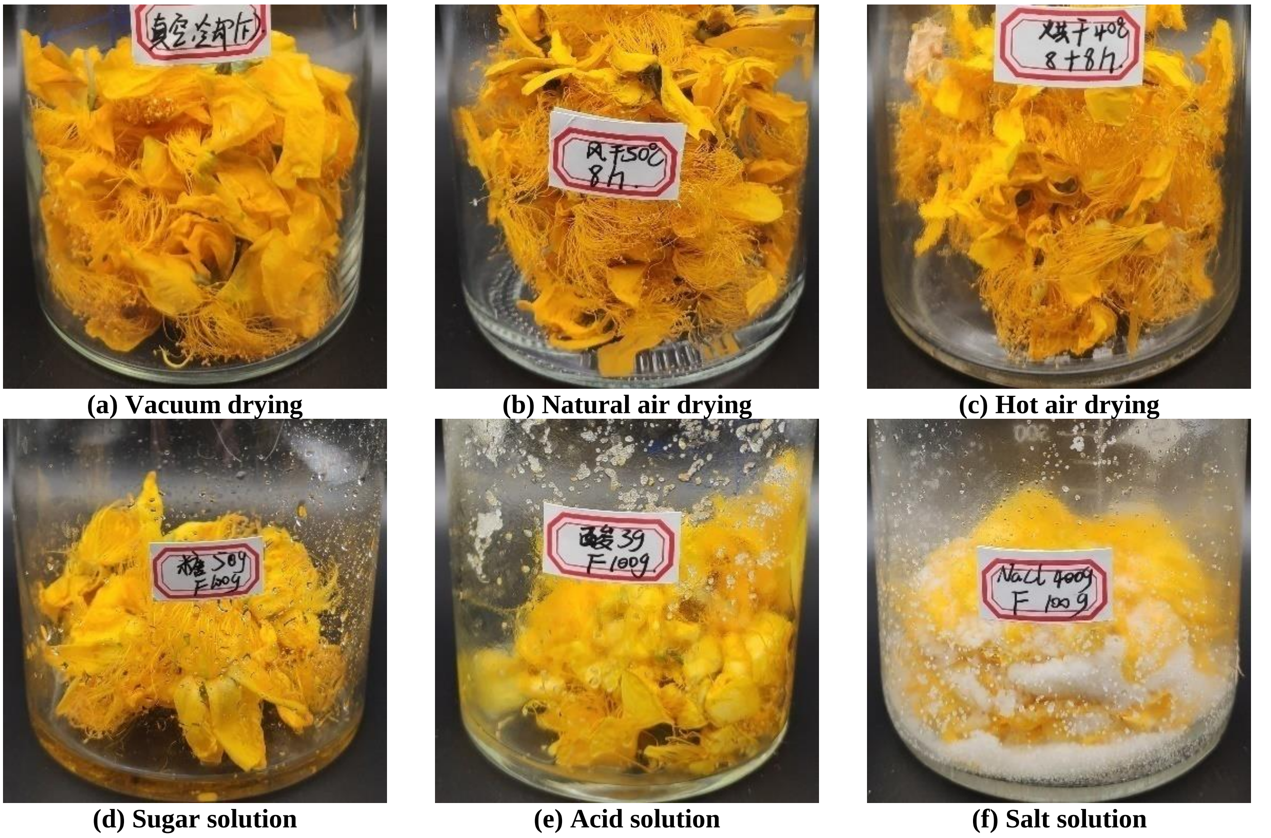
Effect of the different treatments on the soluble sugar content of *H. monogynum*: Glucose, fructose, maltose, sucrose, and other soluble sugars are the primary energy sources for plant physiological metabolism. The soluble sugar content of *H. monogynum* did not differ significantly across the three treatment techniques of sugar solution, acid solution, and salt solution treatment. However, there were substantial differences among the other methods. The soluble sugar content of *H. monogynum* under different treatments was vacuum drying > natural air drying > hot air drying > acid solution > sugar solution > salt solution. The soluble sugar content of *H. monogynum* was higher from vacuum drying and lower for the solution treatments.

Effect of the different treatments on the soluble protein content of *H. monogynum*: Soluble protein is an essential osmotic regulator and nutrition for plants; it protects cells and cell membranes. The soluble protein of *H. monogynum* did not differ significantly between natural air drying, hot air drying, sugar solution, and salt solution treatments. However, there were substantial differences among the other treatments. The soluble protein content of *H. monogynum* from different treatments was vacuum drying > natural air drying > hot air drying > sugar solution > salt solution > acid solution. The soluble protein content was higher from vacuum drying.

Effect of the different treatments on carotenoid content in *H. monogynum*: Carotenoids are widely distributed biosynthetic products found in higher plant tissues and algae microorganisms. The carotenoid concentration of *H. monogynum* differed significantly among the six treatments. The order was acid solution > hot air drying > natural air drying > vacuum drying > sugar solution > salt solution. The maximum concentration from the acid solution treatment was due to the organic acid inhibiting carotene oxidation.

Effect of the different treatments on the content of total flavonoids in *H. monogynum*: Total flavonoids have anti-free radical and antioxidant effects, as well as antidepressant, anti-tumor, anti-bacterial, and other effects. There was no significant difference in the total flavonoid content of *H. monogynum* between the sugar solution and salt solution treatments. However, there were significant differences among the other treatments. The total flavonoid content from the different treatments was natural air drying > vacuum drying > hot air drying > salt solution > sugar solution > acid solution, and the total flavonoid content from natural air drying was the highest of all.

Effect of the different treatments on L-ascorbic acid content of *H. monogynum*: Vitamin C, also known as L-ascorbic acid, is a key anti-stress element in plants involved in various biosynthetic processes in the human body. The L-ascorbic acid content of *H. monogynum* did not differ significantly between the sugar solution and acid solution treatments, but there were substantial differences between the other treatments. The L-ascorbic acid content's order from the different treatment methods was vacuum drying > hot air drying > natural air drying > acid solution > sugar solution > salt solution, with the highest content from vacuum drying.



(a) Vacuum drying **(b) Natural air drying** **(c) Hot air drying**

(d) Sugar solution **(e) Acid solution** **(f) Salt solution**

Fig. 1. Different pretreatment methods of *H. monogynum*.

Effect of the different treatments on the mineral element content of *H. monogynum*: Figure 3 lists the mineral elements found in *H. monogynum*, a common source of K and Ca minerals. According to this study, *H. monogynum* is high in essential elements like K, Ca, Mg, S, N, and P. The levels of K, Ga, and Mg are particularly high among them, which benefits its general quality, biological resistance, and growth circumstances (Alzate *et al*., 2007). There is a low content of S, N, and P elements, although they are the building blocks of many proteins and biological enzymes in plants.

Effect of the different treatments on the K+ content of *H. monogynum*: Plant K^+ is an essential mineral for plant growth and resistance, which helps to improve plant quality and resilience. Different treatments of the *H. monogynum* samples produced considerable variability in the concentration of K^+; vacuum drying > hot air drying > natural air drying > acid solution > salt solution > sugar solution. The highest K^+ content came from vacuum drying and the lowest from the sugar solution treatment.

Effect of the different treatments on the Ca2+ content of *H. monogynum*: Ca^{2+} is a key component of cell walls that helps stabilize cell membranes. The different treatments of the *H. monogynum* samples resulted in considerable changes in the Ca^{2+} content. It was much higher from the vacuum drying than the other treatments. The order was vacuum drying > hot air drying > natural air drying > acid solution > sugar solution > salt solution.

Effect of the different treatments on the Mg2+ content of *H. monogynum*: Mg^{2+} is a significant component in chlorophyll synthesis and is required to create phospholipids. The different treatments resulted in considerable changes in the Mg^{2+} content of the *H. monogynum* samples. Its levels were vacuum drying > hot air drying > natural air drying > salt solution > acid solution > sugar solution. The highest Mg^{2+} content occurred from vacuum drying and the lowest from the sugar solution treatment.

Effect of the different treatments on the S content of *H. monogynum*: SO_2 is usually associated in nature with plant respiration and enters plants through stomata to generate the thiocompounds primarily found in amino acids, coenzyme A, and other chemicals. The S content of *H. monogynum* did not alter significantly between vacuum and hot air drying. However, there were substantial differences for the other treatment methods. The concentration of S element in *H. monogynum* under various treatments was sugar solution > natural air drying > vacuum drying > hot air drying > salt solution > acid solution. This shows that the sugar solution environment produces the highest amount of the S element and the acid solution the lowest.

Effect of different treatments on the N content of *H. monogynum*: There are two main types of nitrogen in plants, ammonia nitrogen, and nitrate nitrogen. The N content of *H. monogynum* samples from vacuum drying was significantly higher than for the other treatments. It was significantly lower from the sugar solution, acid solution, and salt solution treatments than for the other methods. Its content for the different treatments was vacuum drying > natural air drying > hot air drying > acid solution > sugar solution > salt solution. The highest N content occurred from vacuum drying and the lowest from the salt solution treatment.

Effect of the different treatments on the P content of *H. monogynum*: The P element can promote the differentiation of plant flower buds and improve plant quality. It is an integral component of cell membranes and an organic raw material for protein synthesis. There was no significant difference in the P content of *H. monogynum* samples from the sugar and salt solution treatments, but there were significant differences between the other treatments. The P element content in *H. monogynum* varied depending on the treatment method; natural air drying > vacuum drying > acid solution > sugar solution > salt solution. The highest P content came from natural air drying and the lowest from the salt solution.

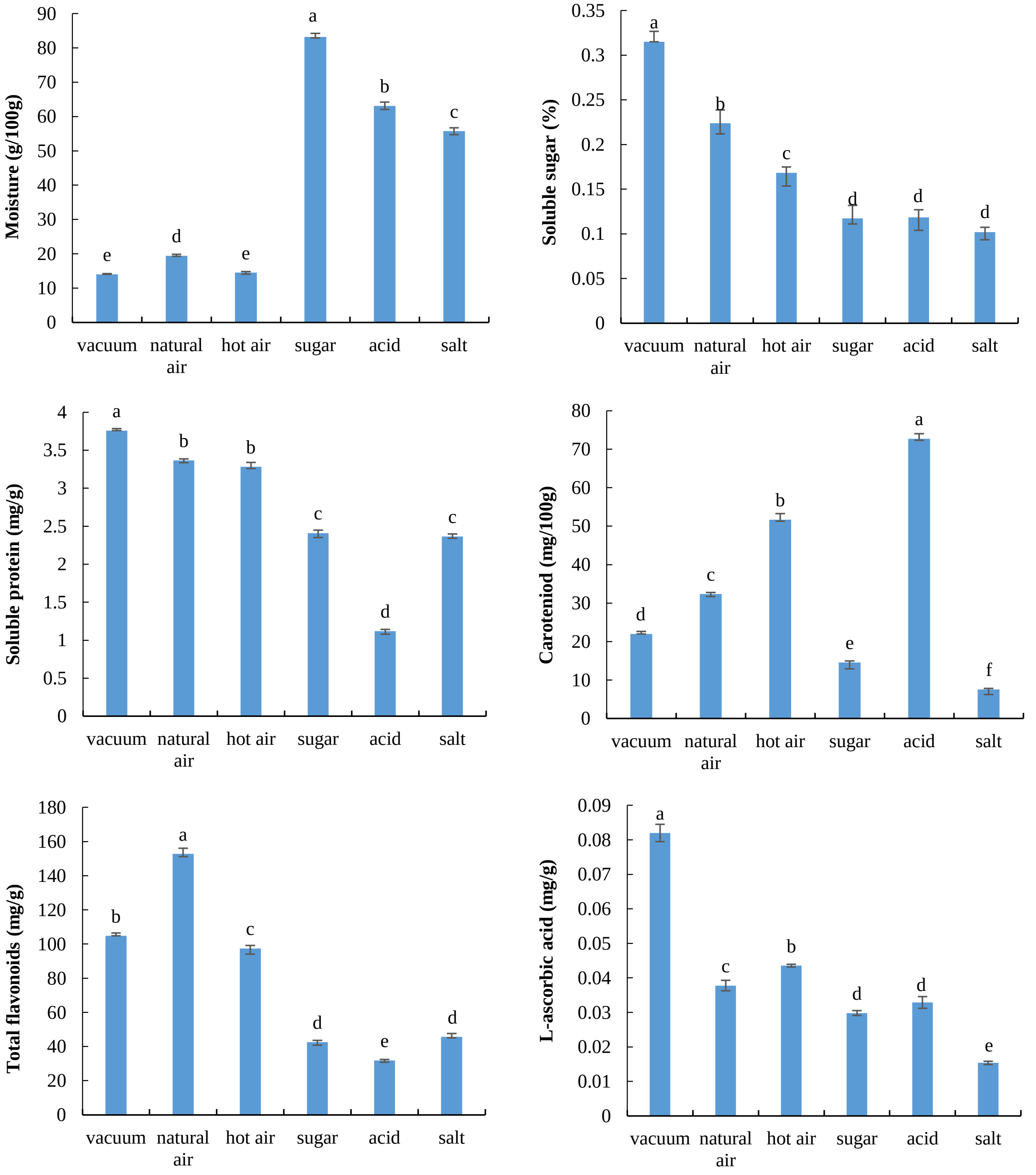


Fig. 2. Effects of different treatment methods on nutrient content of *H. monogynum*.

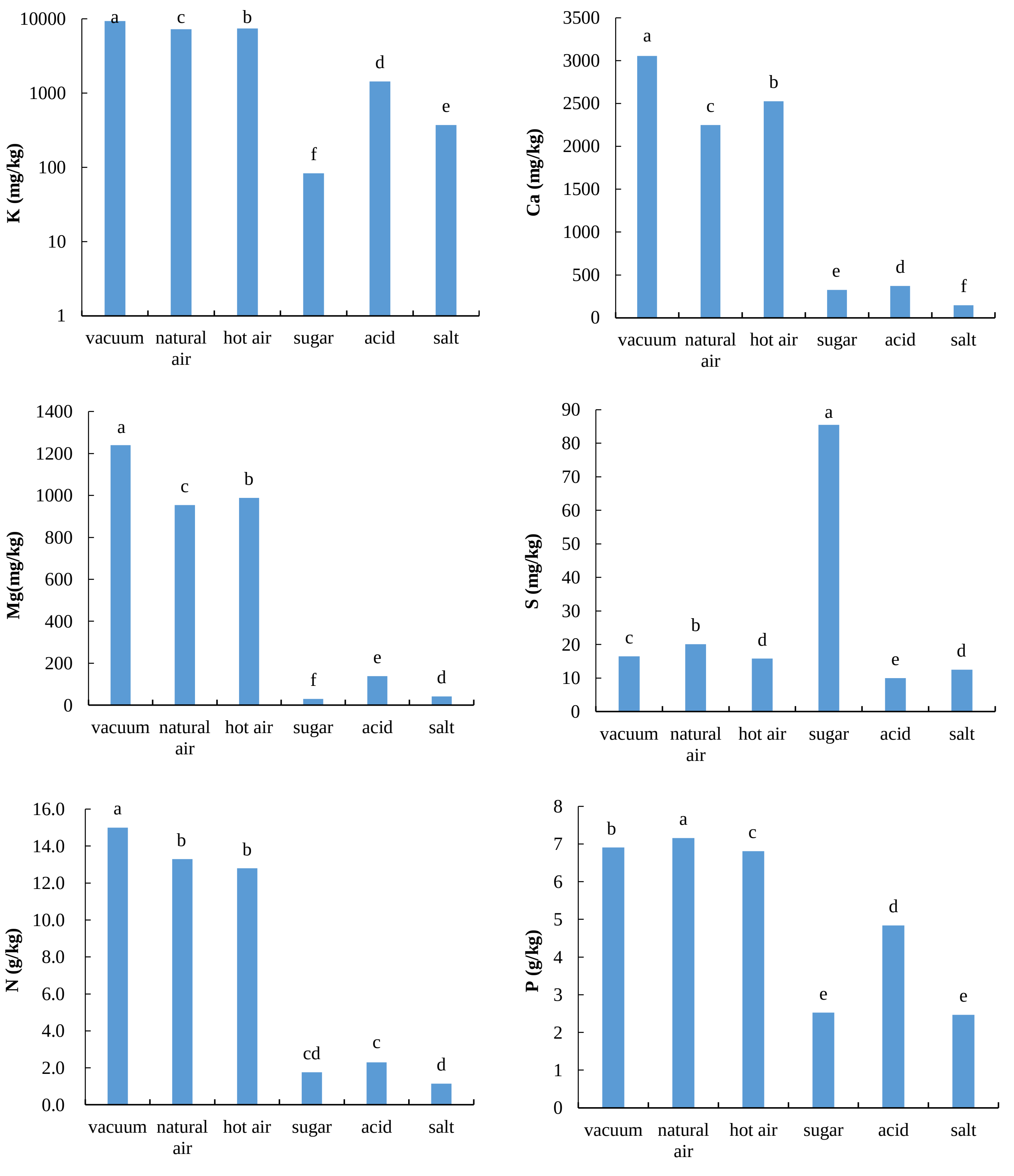


Fig. 3. Effects of different treatment methods on mineral elements of *H. monogynum*.

Discussion

This study determined the content of various nutrients and mineral elements in *H. monogynum* samples after six pretreatments lasting two months each. It was found that the moisture content in the vacuum drying treatment was lower, avoiding mildew and bacterial contamination of the samples. The content of soluble sugar, soluble protein, L-ascorbic acid, metal elements, and N and P were significantly higher from vacuum drying than for the other treatments, making that an ideal treatment for *H. monogynum*. Acid solution treatment maximized the retention of carotenoid content in *H. monogynum*. The S content of *H. monogynum* was highest from the sugar solution treatment, so when *Hypericum* is used as a raw material for food processing, this treatment should be avoided as much as possible.

This research revealed that the different treatments markedly influence the nutrient content of the *H. monogynum* samples. A previous study (Fan *et al*., 2014) showed that factors such as temperature and moisture affect protein secondary and tertiary structures, etc., and protein solubility. Vacuum drying may be better for protecting protein in *H. monogynum* samples by minimizing the protein's denaturation and solubility loss during dehydration. The dried plants have a robust rehydration ability (Jia *et al*., 2019), which is valuable in several industries such as plant fruit processing. According to previous studies (Dereje *et al*., 2020; Okatan *et al*., 2021), citric acid is suitable for storing plant vitamins, and organic acids can keep samples fresh and prevent carotenoids from oxidizing. As a result, the acid solution treatment offers certain advantages for treating carotenoids. *H. monogynum* contains a modest amount of total flavonoids, L-ascorbic acid, and other compounds. Total flavonoids are the major components of *H. monogynum* for antidepressant treatment. Ascorbic acid is an indispensable antioxidant in *H. monogynum* and can also maintain the plant's ornamental appearance (Krasnova *et al*., 2018). It is showed that air drying has a greater impact on the content of total flavonoids (Chen *et al*., 2015). By comparing the total flavonoid content of *H. monogynum* samples for different treatments, it was found that natural air drying is suitable for *H. monogynum* flavonoids. Waqif *et al*., (2010) reported that natural sulfur dioxide is easily combined with aldehydes and ketones in plants, especially sugar compounds, to form bound sulfurous acid. This study found that the content of the S in the sugar solution treatment was much higher than for the other methods, so this treatment method should be avoided for the food-grade processing of *H. monogynum*. N in plants is mainly divided into ammonia nitrogen and nitrate nitrogen. In this experiment, the nitrogen in plants was converted into ammonia nitrogen, and the N content was determined. Studies by Bian *et al*., (2018) and Tang *et al*., (2020) showed that the accumulation of soluble sugar and soluble protein in plants has a certain resistance to salt stress and that the salt treatment can improve the quality of plants to a certain extent. In this study, the content of P in the *H. monogynum* samples from vacuum drying, natural air drying, and hot air drying was significantly higher than for the other three methods. Combined with the analysis of the moisture content of samples, it is conjectured that the P content may be affected by the moisture of the samples.

In this study, the *H. monogynum* samples were collected at the Longhu Campus of Anhui University of Science and Technology in Bengbu, Anhui Province. There may be some variation in *H. monogynum* from other places due to their different geographical locations, climate, and other factors, which could lead to experimental deviation. The results of this experiment are primary, and the effects of different habitats on the contents of the nutrients and mineral elements in *H. monogynum* should be discussed in future research.

H. monogynum has been widely developed in foreign countries for the flowers' appearance, pharmaceutical and antidepressant effects, and so on. However, there are comparatively few domestic studies on it, indicating that *H. monogynum* has a large potential market in China. Although the content of common nutrients and mineral ions in *H. monogynum* was investigated in this study, the composition of the chemicals is complicated, so deep research should systematically analyze and use this species more effectively. It is anticipated that this study will serve as a scientific foundation for future research on *H. monogynum*, allowing for better resource utilization and development.

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