Research on Drying Technology for Pressing Landscaping Waste - A case studay of Hibiscus rosa-sinensis flowers

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Abstract: With the gradual enhancement of people's awareness of ecological environment and sustainable development, the concept of green and low-carbon development has received more and more attention. Building a waste recycling system has also become an important task for building a beautiful China. The art of pressed flowers is such an ecological industry for recycling abandoned landscaping plants. Hibiscus rosa-sinensis is a plant widely distributed and loved by the people in China. In order to explore the most suitable drying technology for pressing Hibiscus rosa-sinensis，we study the differences of petal color, anthocyanins content, pH value, enzyme activity, drying status, protecting color, flatness between no-pressed and two different drying methods. Compared with the fresh flowers, the L, a, and C values of dried petal were lower, the pH was higher, and the enzyme activity was lower. But the difference is not significant in anthocyanins content between them. Furthermore, the enzyme activity and pH value of pressed petal with microwave were lower than those with drying plate. On the contrary, the anthocyanins content of pressed petal with microwave was higher than that with drying plate. The final study data shows that microwave pressed flower with 80% microwave power and 60-second drying time, was better for drying Hibiscus rosa-sinensis than drying plate，this method leads to better pressed flower，so as to produce plant products that are more suitable for consumers' needs.

1.Introduction

On February 6,2024, the General Office of the State Council issued the "Opinions on Accelerating the Construction of a Waste Recycling System", the opinions pointed out that the construction of waste recycling system is an important measure to implement a comprehensive conservation strategy, ensure national resource security, actively and steadily promote carbon peak carbon neutrality, and accelerate the green transformation of development mode. As a landscaping plant, Hibiscus rosa-sinensis is widely used and praised in East Asia, its flowers endlessly in all seasons. Its flowers bloom and fall at dusk, and a large number of fallen flowers are produced every day. It will make beautiful pressed flower works if fully recycled, and it will produce better economic benefits and help the construction of urban waste recycling system. Pressed Flower art is such an eco-friendly art, and all of its materials come from natural plants. Pressed dried plants can be used to make various plant products and sell them, thus creating economic value[1]. As a commonly used plant material for pressed flower works, Hibiscus rosa-sinensis has a beautiful flower shape, easy to obtain materials, and good flatness after pressing. However, because of its unstable anthocyanin, the petals are prone to browning and fading during drying pressing, which loses its application and ornamental value. Therefore, the use of scientific physical pressed flower methods to maintain the color of petals and to obtain excellent pressed flower materials is particularly important for artistic creation of pressed flower. Drying plate pressed flower device, microwave pressed flower device and the original color pressed flower device developed by Kane Mori Kuro, Japan, all play an indelible role in maintaining the color of the flower after pressing, and the degree and efficiency of maintaining the color of the flower are also very different[2-3].The original color pressed flower device can basically maintain the color of the petals after pressing and drying, but the research on drying plates and microwave pressed flower devices has been reported less at home and abroad, especially the research on hibiscus rosa-sinensis-pressing is still blank. The author picks up freshly fallen Hibiscus rosa-sinensis petals from the campus as experimental materials, uses the microwave pressed flower device and the drying plate pressed flower device to press the flower materials, and explores the factors that affect the stability of the Hibiscus rosa-sinensis anthocyanin among the two commonly used dry pressed flower methods in the pressed flower field. The color retention method provides a theoretical basis, which has an important reference value and practical significance for the pressing of red petals and the establishment of urban

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plant waste recycling system.

2. Materials and methods

2.1. Test time and place

The research field experiment was carried out in front of Building 18 of South China Agricultural University, and the indoor experiment was carried out in Laboratory 507 and 805 of the College of Horticulture, South China Agricultural University.

2.2. Test materials

We selected 15-year-old red hibiscus rosa-sinensis flowers with good growth and no pests and diseases in front of No.18 teaching building of South China Agricultural University, a total of 5 plants.

Choose well-growing hibiscus rosa-sinensis plants and pick up freshly fallen petals in four directions: east, south, west, and north. Pick 5 groups of 20 flowers in each group,and mark the group and number, and quickly take 3 petals per 1 flower for color measurement and take photos. The remaining petals were pressed with a drying plate and a microwave pressed flower machine, and the time required for drying was recorded, the chromaticity after pressing and drying was measured and photographed. Take the chroma of fresh flowers as a contrast. Each treatment has 20 repetitions.

2.3. Pressed flower method

2.3.1. Drying plate pressed flower method

Drying plate pressed flower device (purchased from Korea Pressed Flower Education and Cultural Association) each consists of 6 drying plates containing desiccant, 10 absorbent papers, and 1 sealed bag. When pressing hibiscus rosa-sinensis, the bottom-up placement sequence of different equipment is: drying board, absorbent paper, petals, absorbent paper, and drying board. Repeatedly placed, 5 layers of flowers can be pressed. Then put the drying board together with the flowers in a sealed bag, place a heavy object on the sealed bag, and check it every 12 hours, until the petals are drying, use tweezers to take out the pressed flowers, and use drying paper to wrap it, write the name of the flower material, collection location and pressing time, put it in a ziplock bag, and store it in a drying and dark condition for the next test.

2.3.2. Microwave pressed flower method

The microwave pressed flower machine is purchased from the United States, and consists of 2 microwave prepress flower plates (9 in×9 in), 4 clips, 2 pads and 2. It is composed of a piece of interlining cloth, and can only press one layer of flower material at a time.When pressing hibiscus rosa-sinensis,the order of placing different equipment from bottom to top is: pressed flower board, liner, lining cloth, absorbent paper, petals, absorbent paper, lining cloth, liner, pressed flower board, clamp around the pressing board with clips got up, place in the microwave oven, set the program microwave power to 80%, and drying time 60s, then use tweezers to take out the pressed flowers, wrap them in drying paper, write the name of the flowers, the collection location and the pressing time, and put it in a ziplock bag and store it in a drying and dark place for the next test.

2.4. Measurement of the chromaticity of hibiscus rosa-sinensis flower petals

The color of petals was measured with a Japanese-made automatic colorimeter (Minolta CR-400, Japan). Align the center of the petal with the light collecting hole for measurement, and then take the average value. Among them, L, a, and b are the chromaticity index and represent the petal color, which represents the position of the color in three-dimensional space. The L value is the lightness index, which defines the brightness of the color. L=0 means black, L=100 means white; a value means the red-green bias of colored matter, +a direction means red increase, -a direction means green increase; b value means yellow-blue bias of colored matter, +b direction means yellow color increases, and the -b direction indicates the blue color increases. Calculating the C value according to $C=(a^2+b^2)^{1/2}$, the C value represents the saturation of the color.

2.5. Determination of anthocyanin content of hibiscus rosa-sinensis flower

The content of anthocyanin was measured by pH differential method.

2.5.1. The crude extraction of anthocyanins

Referring to the method of Zhang et al[4], respectively takes fresh hibiscus flower petals, 5 g of the petals pressed by microwave and drying plate, soak them in 1% HCl overnight until the petals fade to colorless, and combine. The extract was filtered and filtered to obtain the crude extract, which was repeated 3 times. Then the crude anthocyanin extract was applied to Amerlite XAD-7 resin chromatography column to remove impurities, and then eluted with 0.1% HCl methanol. The eluate was collected and concentrated on a vacuum rotary evaporator at 40°C, and finally dissolved with 0.1% HCl. Evaporate the anthocyanin on the flask to obtain a preliminarily purified hibiscus anthocyanin concentrate, which is stored at 4°C for later use.

2.5.2. Anthocyanin wavelength scan

Dilute the anthocyanin concentrate with 0.2 mol/L pH 1.0 potassium chloride-hydrochloric acid (KCl-HCl) buffer to a certain concentration, in the wavelength range of 240~800nm, use UV ultraviolet. The visible spectrophotometer scans its ultraviolet-visible absorption

spectrum.

2.5.3. Determination of the equilibrium time of the anthocyanin reaction in the buffer

The anthocyanin concentration was diluted 20 times with KCl-HCl buffer of pH 1.0 and sodium acetate-hydrochloric acid buffer of pH 4.5, and UV spectroscopy was used every 10 min. The photometer measures the change in the absorption value of anthocyanins to determine the equilibrium time of the reaction.

2.5.4. The linear range of anthocyanin concentration

Refer to the test method of Chang[5]. The anthocyanin concentrate is diluted with KCl-HCl buffer of pH 1.0 and sodium acetate-hydrochloric acid buffer of pH 4.5 respectively. 10, 20, 40, 50 times, after equilibrating for 100 min, use distilled water as a contrast, and measure the absorbance (A) at λ=514 nm. Calculate the anthocyanin content (mg/mL) of the solution.

2.6. Determination of pH

Take 5 g each of fresh and pressed hibiscus rosa-sinensis petals, add 100 mL of double distilled water, homogenize on a homogenizer for 1 min, and after standing for 20 mins, measure the pH of the homogenate with a pH meter. Repeat 3 times.

2.7. Determination of enzyme activity

For the extraction of anthocyaninase, referring to the method of Zhang et al[6]. Take 2 g each of fresh and pressed (measured immediately after pressing drying) hibiscus rosa-sinensis petals. After freezing in rapid liquid nitrogen, add 0.2 g of PVPP and grind into powder. Then transfer to 10 mL of 0.05 mol/L, pH 7.0 phosphate buffer (containing NaCl 0.5 mol/L), shake vigorously and let stand, centrifuge at 9000 r/min at 4°C for 20 min, the supernatant is the anthocyanin. Crude extract of glycoside degrading enzyme. The determination of anthocyaninase activity is based on the method of Martino et al [7]. and improved. Take 500 μL of enzyme solution, add 500 μL of substrate, and react at 40°C for 10 min. Add 2 mL of 1% HCl-methanol to terminate the reaction. 100℃boiling water bath for 10 min, measured under 525 nm ultraviolet-visible spectrophotometer (UV-2450). Enzyme activity is expressed as OD525 μmol/(h•mL•FW), repeated 3 times.

2.8. Determination of PPO activity

Refer to the method of Guan[8], take 2 g of fresh and pressed (measured immediately after pressing drying) hibiscus petals, and add 5 times (w/v) of 0.2 mol/L, pH 6.8 citric acid-phosphoric acid. Buffer and 0.4 g PVPP, ground in an ice bath, centrifuge at 15000 r/min for 15 min at 4°C, and use the supernatant for enzyme activity determination. The 3 mL reaction solution contains: 2.9 mL buffer solution containing 10 mmol/L catechol, 0.1 mL enzyme solution, and the change in OD398 value is measured. The change in OD398 per minute is 0.001 to represent an enzyme activity unit (U). Enzyme activity is expressed by U/(g•FW), repeated 3 times.

2.9. Statistic and analysis

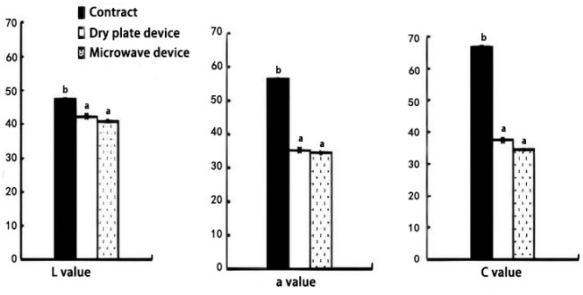
The original datum were standardized or normalized, and SPSS and Microsoft Office 2003 software were used for variance analysis and statistics.

3.Results and analysis

3.1. Comparison of chromaticity of hibiscus rosa-sinensis petals pressed by microwave and drying board

As shown in Figures 1~2, the chromaticity values of L, a, and C of the hibiscus petals after being pressed and dried with a microwave and a drying plate are significantly lower than that of fresh petals (P<0.05), and the redness and color saturation are significantly reduced,and fading is obvious. There was no significant difference in L, a, C values of hibiscus petals dried and pressed by two kinds of pressed flower devices. Compared with the petals of hibiscus after being pressed and dried by a drying plate, the appearance of the petals after microwave pressing is flatter, the drying speed is fast (about 60 s), and the drying effect is good. The color maintained by naked eyes is judged to be closer to that of fresh flowers. The pressing effects of the two pressed flowers are shown in Table 1.

A: Flowers contrast
B:Drying plate pressed flower machine-pressing
C:Microwave pressed flower machine-pressing
Figure 1 The effect of different pressed flower methods on Hibiscus rosa-sinensis flowers



Different letters indicate significant differences (P<0.05), the same below
Figure 2 The effect of different pressed flower devices on the chroma of hibiscus

Table 1 Comparison of the pressing effect of different pressed flower methods

Project	Drying speed of flower material	Effect of drying	Effect of flower preserving	Flatness
Microwave pressed flower method	The fastest (60 s)	good	Darker color	Flat
Drying plate pressed flower method	Faster (2 ~ 3 d)	general	Lighter color	Slightly wrinkled

3.2. Comparison of anthocyanin content of Hibiscus rosa-sinensis petals pressed by microwave and drying board

3.2.1. In vitro anthocyanin absorption spectrum

Hibiscus rosa-sinensis petals combined with Figure 3 and Table 2 shows that the anthocyanin solution has two absorption peaks at 289 nm and 514 nm, which are the characteristic absorption peaks of anthocyanin substances. The absorption peak appeared at 330 nm, indicating that hibiscus anthocyanins are acylated anthocyanins [2].

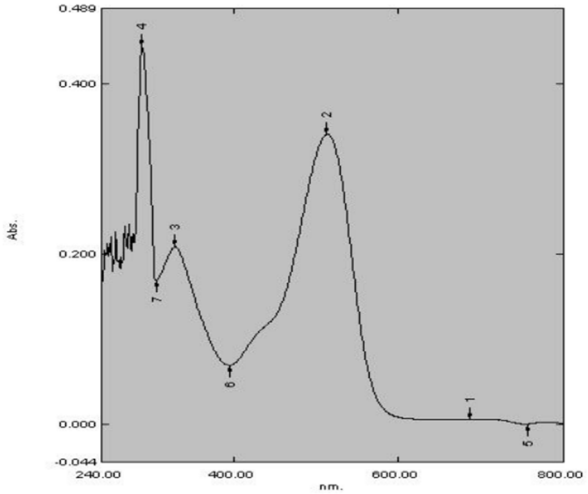


Figure 3 Ultraviolet-visible absorption spectrum of fresh Hibiscus rosa-sinensis flower anthocyanins

Table 2 The characteristic absorption peak of fresh Hibiscus rosa-sinensis petals

Peak number	2	3	4	6	7
Wave length	514.00	330.00	289.00	394.00	305.00
Absorption value	0.369	0.215	0.453	0.075	0.170

3.2.2. Determination of the equilibrium time of the reaction of anthocyanins in the buffer solution

Table 3 shows that，in the buffer solution of pH 1, the time for the anthocyanins to reach equilibrium is 100 minutes, while in the buffer solution of pH 4.5, the equilibrium time is 80 minutes, and the reaction time under the two pHs is combined, and finally the equilibrium time of the reaction is determined to be 100 minutes.

Table 3 Changes in absorbance with time in different pH buffers

Time /min	10	20	30	40	50	60	70	80	90	100
OD514(PH 1.0)	0.324	0.299	0.289	0.288	0.287	0.286	0.288	0.288	0.286	0.286
OD514(pH 4.5)	0.036	0.032	0.032	0.030	0.029	0.029	0.028	0.030	0.030	0.030

3.2.3. Linear range of anthocyanin concentration

Figure 4 shows that the absorbance of the concentrated anthocyanin solution is 0.77, and the anthocyanin content is 0.56 mg/mL. The correlation coefficient of the curve is 0.9928, indicating that the anthocyanin content and absorption value have a good linear range, that is, the concentration of hibiscus anthocyanin is linearly related to the concentration of hibiscus anthocyanin in the range of 0.03~0.56 mg/mL.

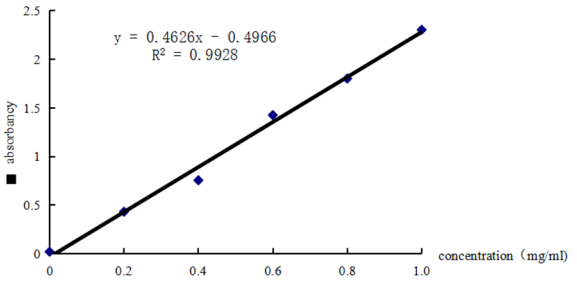


Figure 4 Hibiscus rosa-sinensis anthocyanin concentration-absorbance curve

3.2.4. Comparison of anthocyanin content of hibiscus rosa-sinensis petals pressed by microwave and drying plate.

Compared with the contrast, the anthocyanin content of hibiscus petals after pressing with two kinds of pressed flower devices decreased significantly, and the anthocyanin content of petals pressed by drying plate pressed flower device decreased more significantly ($P<0.05$). Among the petals pressed by the two types of pressed flower machines, the anthocyanin content of the petals pressed by the microwave pressed flower machine was relatively high (Figure 5).

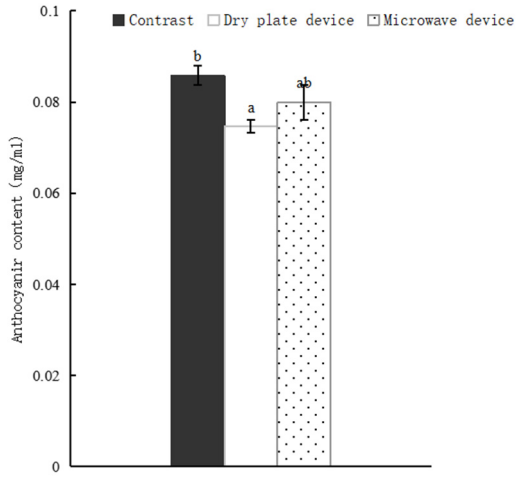


Figure 5 The effect of different pressed flower methods on anthocyanin content

3.3. Comparison of the pH of hibiscus rosa-sinensis petals pressed by microwave and drying board

It can be seen from Figure 6 that, compared with the contrast, the pH of the petals of the Hibiscus rosa-sinensis after the two types of pressed flower machines were increased, showing a significant difference (P<0.05), and the pH of the petals of the petals pressed by the microwave pressed flower method was significantly lower than that of the contrast. The pH of petals pressed by drying plate pressed flower method (P<0.05). Its pH is closer to that of flowers.

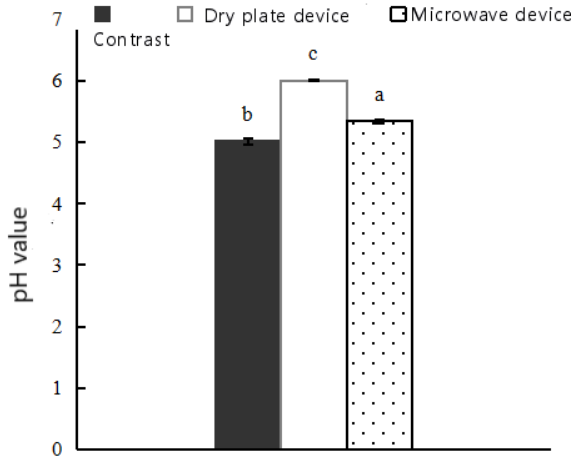


Figure 6 The influence of different pressed flower methods on pressed flower pH

3.4. Comparison of enzyme activity of hibiscus rosa-sinensis petals pressed by microwave and drying board

From Table 4, it can be concluded that the order of the enzyme activity of the hibiscus rosa-sinensis petals pressed by the microwave and the drying plate is: fresh flowers>drying plate pressed flower device>microwave pressed flower device, and there is a significant difference between the three, the petal enzymes after being pressed by the microwave pressed flower device ,the activity was zero, which was significantly lower than the enzyme activity of the petals dried by the contrast and drying plate devices.

Table 4 The effect of different pressed flower methods on the enzyme activity of hibiscus rosa-sinensis flower

	Flowers	Pressure dry with drying plate	Pressure dry with microwave
Anthocyanidase /[μmol/(h·mL)]	0.1224±0.0174a	0.04296±0.001b	0c
Polyphenol Oxidase/(U/g)	0.1792±0.062a	0.0596±0.0016b	0c

To sum up, because there is no anthocyaninase and polyphenol oxidase in the hibiscus rosa-sinensis petals that are pressed and dried by a microwave pressed flower machine, a higher anthocyanin content and a lower pH are measured relative to the drying plate. The color also shows a more vivid red. Therefore, in the selection of pressing tools, the microwave pressing flower method is the most suitable pressing flower method for hibiscus rosa-sinensis flowers.

4. Conclusion

The color change of hibiscus rosa-sinensis flower after pressing is related to the change of petal color index, pH, anthocyanin content and related enzyme activity.

4.1. After the hibiscus flowers are pressed, the colors of the flowers are faded

The experiment compared the chromaticity changes of fresh petals of hibiscus rosa-sinensis flower with two pressing methods after pressing and drying. The results showed that the chromaticity values of L, a, C of hibiscus rosa-sinensis petals after pressing were significantly decreased compared with that of fresh petals (P<0.05).), the fading is obvious; while the L, a, C values of the hibiscus rosa-sinensis petals dried and pressed by the two types of devices have no significant difference. Compared with the petals of hibiscus rosa-sinensis pressed by a drying board, the petals after microwave pressing have a smoother appearance, a fast drying speed, a good drying effect, and the color maintained is close to that of a flower by naked eyes.

4.2. The change of hibiscus rosa-sinensis flower color before and after pressing is closely related to the anthocyanin content.

The fresh hibiscus rosa-sinensis anthocyanin solution was obtained by extraction, and UV ultraviolet-visible spectroscopy scanning confirmed that the main pigment contained in it was anthocyanin. Further research showed that the concentration of hibiscus rosa-sinensis anthocyanin was in the range of 0.03~0.56 mg/mL. The concentration of hibiscus rosa-sinensis anthocyanin was similar to that of hibiscus rosa-sinensis anthocyanin.

Linear correlation. Compared with the contrast, the flower color and anthocyanin content of hibiscus rosa-sinensis flower decreased significantly after pressing, so the color change of hibiscus flower after pressing was related to the change of anthocyanin content.

4.3. The fading of hibiscus rosa-sinensis flower after pressing is related to the decrease of anthocyanin content

Compared with the contrast, the anthocyanin content of the hibiscus rosa-sinensis petals after pressing by the two types of pressed flower machines decreased significantly, and the anthocyanin content of the petals pressed by the drying plate pressed flower machine decreased significantly ($P<0.05$), so the petals pressed by the microwave pressed flower machine has a good preservation effect in anthocyanin.

4.4. The fading of the hibiscus rosa-sinensis flower after pressing is related to the increase in the pH of its petals

Compared with the contrast, the pH of the petals of the hibiscus rosa-sinensis flowers after pressing with the two types of pressed flower machines increased, and the pH of the petals pressed by the microwave pressed flower method was closer to the pH of the flowers. Therefore, the hibiscus rosa-sinensis petals pressed by the microwave pressed flower machine were effective in maintaining pH better.

4.5. The fading of hibiscus rosa-sinensis flower after pressing is related to the change of its petal enzyme activity

The order of the enzyme activity of hibiscus rosa-sinensis petals pressed by microwave and drying plate is: fresh flowers>drying plate pressed flower device>microwave pressed flower device. After the microwave pressed flower device, the petal enzyme activity is zero, which is significantly lower than that of the contrast and drying plate pressed flower device. Therefore, the hibiscus rosa-sinensis petals that are pressed and dried by microwave have no anthocyanin and polyphenol oxidase that promote the degradation of anthocyanins, so the color appears brighter red.

Therefore, by studying the chroma, pH, anthocyanin content, and related enzyme activities of fresh hibiscus rose-sinensis petals and two kinds of pressed flower methods, it is concluded that the most suitable pressed flower method for hibiscus rosa-sinensis flowers is the microwave pressed flower method.

5. Discussion

Fading of flower material is inevitable in the pressing process of many flowers, so the choice of pressed flower method is particularly important for changing the cell membrane pigment system of flower material. At present, the two commonly used pressed flower methods in the world are drying plate pressed flower method and microwave pressed flower method, whose role in color retention of flowers is very obvious [1].

There are various methods for drying flower materials, but there are no specific research results on which flower material is suitable for which pressed flower method. This research has created a precedent in the research of flower material pressing methods. Through experiments, the results show that: compared with fresh flowers, the chromaticity indexes L, a, and C values of the hibiscus rosa-sinensis petals pressed by the two pressed flower devices all show a downward trend, showing the phenomenon of fading, which is in contrast to the study of lychee peel color by Zhang et al[6]. The L, a, and C values are consistent with the browning index and anthocyanin content.

The color change of the flower material during the drying and preservation process is related to the pigment structure inside the flower material, the external environmental conditions and the different pressed flower methods during the pressing process. It is the result of the interaction of many factors [1,4-6].In this study, the anthocyanin content, pH, enzyme activity of hibiscus rosa-sinensis flower petals before and after pressing were compared, and it was found that the flower color change was significantly different from the anthocyanin content, pH, and enzyme activity ($P<0.05$). The petals were pressed. The fading of petals in the process is closely related to the destruction of the floral cell membrane system, including changes in the pH of the petal cell fluid. Because the petal cells of flowers have a complete ultrastructure and there is a certain regionalization, the cell membrane structure of the petals is affected by the pressing. The destruction causes the vacuole to rupture, the membrane shrinks, the cell fluid oozes, the petals lose water, and the pH rises, which destroys the intracellular regionalization function, the enzyme reacts with the substrate, and part of the anthocyanin is changed from the red anthocyanin (AH+). It is transformed into the colorless form of methanol pseudobase and chalcone, which causes the petals to fade [3].

Compared with the petals pressed by the drying plate, the microwave pressed flower device has a higher anthocyanin content and a lower pH, mainly because the anthocyaninase and polyphenol oxidase that promote the degradation of anthocyanins by the microwave killed by the high temperature of the microwave. And after the drying plate, the pressed-dried petals still have certain anthocyaninase and polyphenol oxidase activities. Therefore, the difference in anthocyanins in the petals pressed by the two pressed flower devices leads to the difference in fading, while the microwave-dried flowers are closer to flowers in color. Red. This is consistent with the results of Zhang on the browning mechanism, and the degradation of anthocyanins is closely related to browning[6].

At present, the most popular devices used by pressed flower fans in the world are microwave devices and drying plate devices. The author's research shows that, compared with the drying plate pressed flower machine, the

microwave pressed flower machine presses hibiscus rosa-sinensis petals under a working procedure of 80% microwave power and 60-second drying time, and its flower color is maintained better. It is a more suitable flower-pressing method for hibiscus rosa-sinensis, which is consistent with the conclusions drawn by previous studies on pressed flower methods of different flower materials[1,3].

Therefore, in the process of urban garden waste treatment, the microwave pressing method is the most suitable drying method for fallen hibiscus flowers. The plant artworks created with this method have brighter colors and longer color retention. Compared with traditional methods such as burning and making green fertilizer, this study has opened up a more artistic treatment path with greater market development prospects.

Acknowledgments

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