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Research and Development of a Shelling and Sorting Machine

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Abstract. This study takes HunanXianglin series, Chalingerxian series, Huashuo series of high yield of Camellia oleifera fruit planting as a reference to grade harvested C.oleifera fruit and effectively solve the C.oleifera fruit and seed with high damage rate, low rate and low degree of shelling and so on. By analyzing the size distribution of C.oleifera fruit, the relationship between the number of C.oleifera fruit and the transverse diameter of C.oleifera was obtained, and the suitable parameter range was obtained according to the design process of the roller sieve. In order to achieve the C.oleifera fruit treatment complete equipment production, the sieve screen with non-differential arithmetic was determined after production experiment. The related parameters: length is 2.2m; diameter is 0.6m; sieve screen number is 6; Rotating speed is 20r/min; motor power is 0.75kw.

Key words: Camellia Oleifera Fruit; Roller Sieve; Classification; Transverse Diameter.

INTRODUCTION

Camellia oleifera is one endemic species of woody oil plant in China.Camellia oleifera is made up by shell and seed. Nut shell does not contain oil, but lignin, pentosan, tannin and saponin, which is adverse for oil processing. Then camellia oleifera fruit should be shelled first.

At present, the fresh fruit processing of Camellia oleifera is mostly done by pure artificial methods. The fresh fruits are piled up, dumped, peeled and sorted by hand. It takes a long time and labor intensity is high, and the site is large. The research on the technology and equipment of shelling fresh fruit of Camellia oleifera is just beginning recently. There is no classification of the size of Camellia oleifera fruit, but mixed processing. Camellia oleifera fruit has different sizes and shapes due to natural, variety and cultivation factors; some large fruit seeds are larger than small fruit, and the probability of small fruit containing single seed is higher; these factors lead to high damage rate and low purity in the process of mechanical treatment of Camellia oleifera fruit, which increases the cost of processing Camellia oleifera fruit. In addition, the cold weather in autumn in southern China has caused damaged tea fruits and Camellia oleifera seeds to be mildewed, perishable and rancid, seriously affecting the quality of products.

Above all, According to the size distribution of Camellia oleifera, the non-equal difference grade of Camellia oleifera was carried out by roller screen, and then the subsequent processing was carried out, which effectively reduced the breakage rate and improved the shelling rate and clarity.

STRUCTURE AND OPERATION PRINCIPLE

The diameter range of Camellia oleifera fruit was 18~48mm, with a wide range of variation, average 29.4mm and standard deviation of 5.32mm. The fruit diameter is mainly 22~38mm, accounting for 90.37% of the total. The area of Camellia oleifera with only seed is mainly concentrated below 26mm.

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Model Fitting of Camellia Fruit Size Distribution

The fruit of Camellia oleifera was divided into 31 groups according to 1mm spacing. The percentage distribution of the total number of Camellia oleifera fruits in each group was fitted by normal distribution, showing the relationship between the number of Camellia oleifera fruits N and the diameter of Camellia oleifera fruits D.

$$N = 14.43?(0.49 + \frac{84.4}{8.52\sqrt{\pi/2}} e^{-2\frac{(d-28.08)^2}{8.52^2}})$$

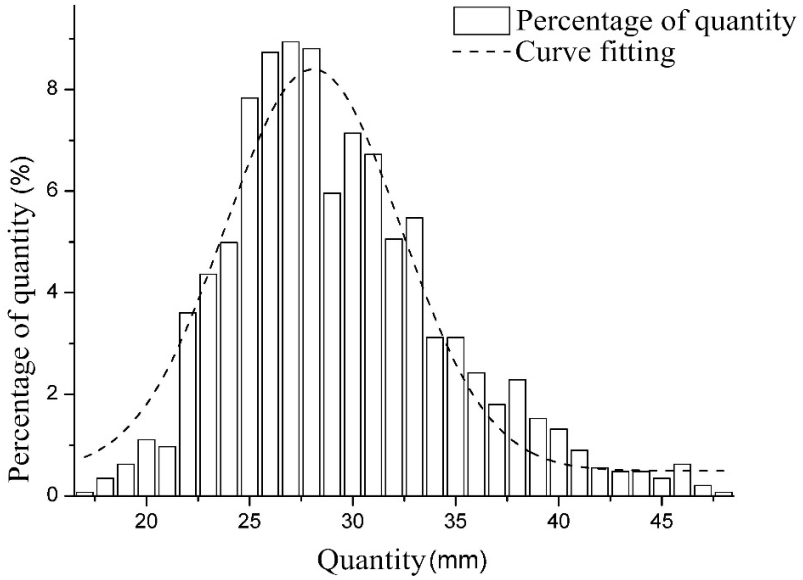
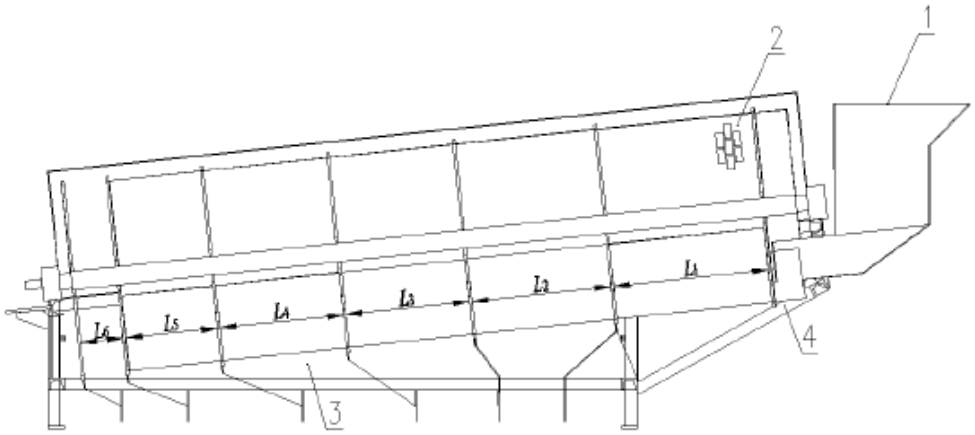


FIGURE 1. Number of different fruit diameter at the equatorial section.

Roller Sieve Design

Roller sieve feeding inlet high end low, divided into several stages, each stage on the distribution of different sizes of rectangular holes, rectangular holes at all levels of different sizes. From the feeding inlet to the final outlet, the dimension of the rectangular hole in the latter group is larger than that in the former group, and the Camellia oleifera fruit smaller than the dimension of the first group falls out of the first group and enters the subsequent processing step, and so on. This classification efficiency is high, and it is widely used in food classification field. Because the Camellia oleifera fruit with a diameter of less than 26 mm has a high probability of single seed, and the single seed is easy to be damaged in shell peeling treatment, the size of the roller screen hole under 26 mm is very small. In order to ensure the processing capacity of the equipment, the size of the sieve size above 26mm is very large.

When working, the camellia fruit enters the sieve barrel by feeding device and rises along the inner wall of the rotating sieve cylinder. When it rises to a certain height, it falls. So repeatedly, gradually move to the other end of the screen. In this process, the material smaller than the sieve hole leaks out through the sieve hole, and the Camellia oleifera fruit larger than the sieve hole is carried to the lower level of the sieve barrel with the rotation of the sieve barrel, thus completing the sorting operation. The overall organization is shown in Figure 2.



1. Feeding hopper; 2. Drum screen; 3. Guide groove; 4. Rack

FIGURE 2. Roller-type classifier

RESEARCH ON TECHNOLOGY

Grading of Roller Screen

Considering the size range of Camellia oleifera and the requirement of subsequent treatment, the classification of roller screen is set to 6 grades. The width of screen at all levels and the quantity of Camellia oleifera in each stage are designed according to the following formula:

$$L_1 : L_2 : L_3 : L_4 : L_5 : L_6 = (\sum_{i=1}^{6} N_i) : (\sum_{i=2}^{6} N_i) : (\sum_{i=3}^{6} N_i) : (\sum_{i=4}^{6} N_i) : (\sum_{i=5}^{6} N_i) : (\sum_{i=6}^{6} N_i)$$

In the actual classification work, the first stage mainly screened out soil, stone, leaves, twigs and other small miscellaneous, while scattering materials. At all levels, Camellia oleifera fruit should be graded according to the required size.

Screen Hole Research

According to the size distribution of Camellia oleifera fruit transverse diameter, the sieve hole sizes of roller screen are designed as follows: a1=22mm,a2=24mm,a3=26mm,a4=29mm,a5=33mm. After being screened by fifth screens, the Camellia oleifera fruit is no longer screened and screened directly into the next processing step.

RESULT AND ANALYSIS

Analysis of Roller Screen Sieve Design Parameters

The design of the complete set of equipment for processing Camellia fruit is divided into 6 grades: the total length is 2.2m. Other main parameters are as follows:

TABLE 1. Main parameters

Number	Parameter name	Reference value
1	Productivity	1.5t/h
2	Friction coefficient between Camellia oleifera fruit and drum screen	0.4~0.6
3	Angle of helix	φ+ (5°~10°)
4	Density of Camellia oleifera fruit	0.9~1.1g/cm^3
5	Filling coefficient	0.05~0.10
6	Transmission efficiency	0.6~0.7

Effect of the Frequency of Vibration and Plane Angle of Sorting Belt on the Threshing Ratio

In the separation process of seeds and shell, vibration motor of sorting machine screened seeds and shell in the primary step by vibration, which the frequency of vibration played a key role in separation of seeds and shell. Different plane angle of sorting belt influenced different directions of seeds and shell under the action of static friction. Therefor too large angle would make the shell and seeds transmitted out from the downward-discharge port, while if plane angle was too small, seeds and shell would not be fully separated.

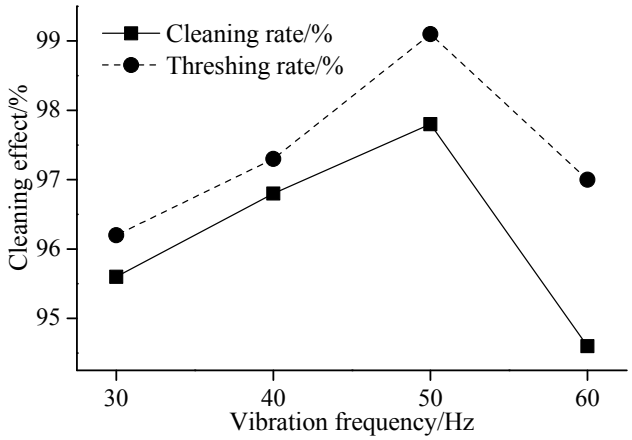


FIGURE 3. Effect on cleaning rate and threshing rate with different vibration frequency of vibration motor

Camellia oleifera fruit that part was cracked and the other part was not cracked all with moisture content around 55% was shelled in the condition of same plane angle and different vibration frequency. It could be seen from Fig.4, with the rise of vibration frequency, the cleaning rate and the threshing rate showed a downward trend after the first increase. When the frequency was 50 Hz, the threshing ratio and cleaning ratio reached the maximum.

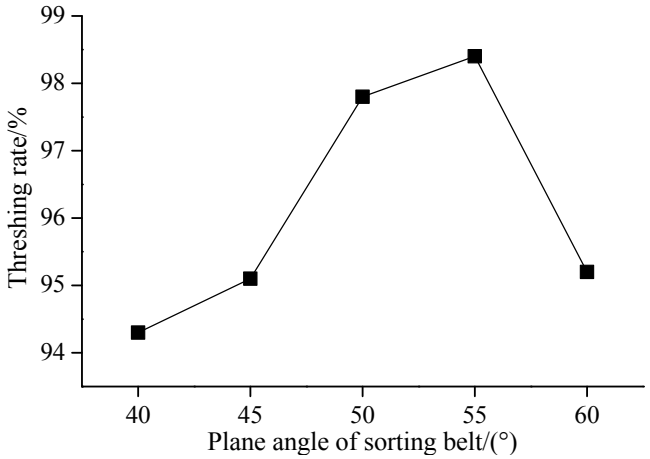


FIGURE 4. Effect on threshing rate with different plane angle of sorting belt

Camellia oleifera fruit that part was cracked and the other part was not cracked all with moisture content around 55% was shelled in the condition of same vibration frequency and different plane angle. It could be seen from Fig.5 when the angle was 50º~55º, the threshing ratio was up to 97%.

CONCLUSION

In the process of screening Camellia oleifera, the Camellia oleifera has the initial velocity and the roller screen has a certain inclination angle, and there is a cross-grade downscreen. The problem is effectively solved by installing some baffles in the screen, and the screening effect is good.

According to the 8-year-old common varieties of Camellia oleifera according to the fitting model of the number and the transverse diameter, the relevant parameters of the drum screen are designed: the length is 2.2m; the diameter is 0.6m; the screen level is 6th, and the width of the rectangular mesh of each level is: 22mm, 24mm, 26mm, 29mm, 33mm; speed is 20r/min; motor power is 0.75kw. After the production and processing experiments, the processed and processed results of the oil palm fruit were significantly improved: the shelling rate was 99.3%, the breaking rate was 1.7%, and the clarity was 98.7%. Camellia grading technology can provide reference for the tea planting equipment.

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REFERENCES

1. Zhang-Chao Ying,Discussion on the Development of Chinese Oil Camellia Industry, State Academy of Forestry Administration Journal,1,pp. 21-24, 2013.
2. Cui Yong, Lan Feng,Su-Zi Hao,China Southern Agricultural Machinery,China Southern Agricultural Machinery,1,pp. 42-45, 2010.
3. Zhu-Guang Fei, Ren-Jia Jia, Wang Zhen, Xiang Hai, Mu-Ren Sheng, Li-Shao Hua. Design of shelling machine for camellia oleifera ruit and operating parameter optimization, Transactions of the Chinese Society of Agricultural Engineering, 7, pp. 19-27, 2016
4. Xia-Fu Jian, Huang-Feng Hong, Research and practice of Camellia oleifera seed hulling oil preparation process. Journal of China oil, 29, pp. 34-35, 2004.
5. Fan-Li Hai, Fu-Wan Si, Analysis of present development of Camellia Oleifera processing machinery. Journal of Forestry Machinery & Woodworking Equipment, 39, pp. 4-5, 2011.
6. Guo-Chuan Zhen, The design and experimental study of Camellia pericarp seed separation. 2011.
7. Xu-Tian, Zhang-Lin Tao, Chen-Fu, Development status and Countermeasures of Camellia oleifera. Journal of AnHui Agricultural Science Bulletin, 17, pp. 80-83, 2011.
8. Li-Zi Ming, Su-Zi Hao, Xie-Shu, Design on Shell Cleaning Set of Camellia Oleifera Fruit. Journal of Agricultural Engineering, 4, pp.99-100, 2014.
9. Tang-Xiang, Xie-Fang Ping, Li-Xu, Design and test of dehulling machine for Camellia oleifera fruit, Hunan Agricultural University (Natural Sciences), 40, pp. 665-668, 2014.
10. Fan-Tao, Wu-Zhao Qian, Qu-Zhen Xing, Design of green Camellia fruit peeling machines, Journal of Forestry Machinery & Woodworking Equipment, 39, pp. 35-36, 2011.
11. Xiong-Pin Yuan,Wang Yi,Wu-Zuo Kui,Research and design on shelling machine of green camellia frui,Journal of Chinese Agricultural Mechanization,5,pp. 126-129, 2016.
12. Cui-Yong, Lan-Feng, Su-Zi Hao, The study on the mechanization technology mode of Camellia oleifera planting, South Agricultural Machinery, 1, pp. 54-56, 2010.
13. Feng-Guo Kun, Rao-Hong Hui, Xu-Peng, Experimental Study on the Biomechanical Properties of Camellia Fruit and Camellia Flower Buds. Journal of Agricultural Mechanization Research, 12,pp.187-191,2014.
14. Cui-Yong, Lan-Feng, Su-Zi Hao, Design and test on shelling and machine of Camellia oleifera fruit, Transactions of CSAE, 15, pp. 33-39, 2012.
15. Zhang-Feng, Yang-Zhi Bin, Zhang-Jin Fu, Mechanical design principles of Camellia oleifera fresh fruit hulling machine, HuBei forestry science and technology, 3, pp. 21-23, 2013.