Research and development of Camellia oleifera fruit sheller and sorting machine

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Abstract. Camellia oleifera fruit sheller in this paper was designed by the principle of kneading and extruding. This machine adopted the rolling classification sieve to screen camellia oleifera fruit with different sizes into the husking device, and camellia oleifera fruit was shelled in the mutually co-operative action of transport belt and flexible rubbing washboard. After research, in the condition that the moisture content of camellia oleifera fruit was below 55%, the vibration of the motor frequency was 50 Hz and the horizontal angle of sorting belt was 50 degrees~55 degrees, the processing capacity was more than 900 kg/h, the threshing ratio was more than 97%, the seed broken ratio was less than 5%, the loss ratio was less than 1%. The machine is of great value in actual production, and should be widely spread and applied.

1. 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.

Fruit harvested recently with high water content is easy to mildew if shelling is not in time, which will influence follow-up drying, storage and processing. And finally oil quality and extraction efficiency will be effected. At present time, camellia oleifera fruit is mainly manually shelled that is of low efficiency, high labor intensity, which is not fit for industrial production. Study on Camellia oleifera mechanical shelling technology and equipment is only just in start-ups. Although there are some kind of machines with different structures and functions, most of these devices are of small processing capacity and the technical performance index cannot reach the expected target. There is a huge difference between the sizes of oil tea camellia fruit, and oil seeds will be damaged under stress during shelling. No devices at present adopt size classification of Camellia oleifera fruit. The camellia oleifera fruit would be easily damaged by rigid units during shelling.

Above all, research in integrated technology and machinery including sorting shelling of camellia oleifera fruit and selecting of seeds and shell is little at present. Then people hope that there is one kind of integrated equipment which has the ability of both sorting shelling of fruit and selecting of seeds and shell. This machine adopted the rolling classification sieve to screen camellia oleifera fruit with different sizes into the husking device, and camellia oleifera fruit was shelled in the mutually cooperative action of transport belt and flexible rubbing washboard.
2. Structure and operation principle

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2.1. Structure characteristics

Camellia oleifera fruit shelling and classification machine is mainly composed of two parts, one is the Camellia oleifera fruit shelling machine, and the other is seed sorting machine. The overall structure of Camellia oleifera fruit shelling machine is shown in Fig.1(a) The sorting machine is made up of 1. Classification device, 2. Kneading device, 3. Frame, 4. Transporting device, 5. Pumping polishing equipment.

![Figure 1. Design chart of Camellia oleifera fruit sheller and seed sorting machine.](image)

The overall structure of camellia oleifera fruit sorting machine is shown in Fig.1(b) The sorting machine is made up of 1. Transporting device, 2. Feed hopper, 3. Distributor, 4. Vibration motor, 5. Vibrator, 6. Adjusting frame, 7. AV gear motor.

2.2. Principle of operation

Fresh camellia oleifera fruit had high water content and hard shell, which made shelling difficult. And due to various diameters, the study divided camellia oleifera fruit into three categories according to their diameters during the design of the machinery. The first one is diameter less than or equal to 25 mm, the second one is diameter more than 25 mm and less than or equal to 35 mm, the third one is diameter more than 35 mm. After a large number of measurement of camellia oleifera fruit, the number of that diameter was less than or equal to 25 mm and more than 35 mm were slightly less, while that of more than 25 mm and less than or equal to 35 mm was relatively more. In the design, the drum sieve was applied to screen fruit that different sizes of camellia oleifera fruit entered into the kneading cavity of different sizes respectively and was shelled in the mutually co-operative action of transport belt and flexible rubbing washboard.

It is a big problem to separate seeds from mixture of seeds and shell. It is proved that the density of seeds and shell were almost the same through study on biological characteristics of shell and seeds, and then it was not fit to apply air-separation method. After research, the shape of seeds and shell was different and so was their coefficient of friction that the seeds were round and their surface was...
smooth with small, instead the shell was thin and angular with rough surface leading to more friction coefficient. Therefore, the sorting machine consisting of one rubber conveyor belt with tilted upward movement and the vibration plate was designed to apply different shape and coefficient of friction to achieve the target of separation of seeds and shell.

In the process of shelling and selecting, it was that water content of camellia oleifera fruit, vibration frequency of vibration motor and plane angle of sorting belt that played key roles in the design. Therefor in the process of design and manufacture, these three factors were taken considerations.

3. Research on technology

3.1 Test materials
Test materials were picked from oil-tea camellia planting base in Hunan forestry science and technology Demonstration Park. Camellia oleifera fruit is nearly spherical with diameter around 3-5 cm.

3.2 Test methods
After 15 batch tests, processing capacity of each test ranged in 20~120 kg with measurement of fresh fruit, shell, seeds, water content and processing capacity (Qc).

4. Result and analysis

4.1. Influence of water content on processing capacity and shelling effect
Camellia oleifera fruit harvest period is mainly in October to November each year according to different varieties. Fresh camellia oleifera fruit is of high water content that average water content of shell, seed and whole fruit are 73.2%, 45.6%, 56.5%, respectively. After 3~5 days drying, the shell could crack automatically, the water in the fruit begin to evaporate. Fresh camellia oleifera fruit and that in different periods after drying is selected as research target that the influence of water content on processing capacity, threshing ratio, seed-broken ratio and loss ratio was studied.

[Graphs showing the effect of water content on processing capacity and threshing ratio]

It can be seen from Fig.2(a) that in the condition of the same vibration frequency and plane angle of sorting belt, with the ascending of water content, processing capacity was decreasing obviously. Due to high water content of fresh fruit which is uncracked and compacting, in the process of kneading, it could take longer time and thus processing capacity would be delayed. While with water
content decreasing the cracking degree became larger, the shell and the seeds were separated rapidly that promoted the whole processing capacity significantly.

A further rise in water content of fresh fruit cannot affect processing capacity obviously, and the minimum processing capacity can maintain up to 600 kg/h. Seen from Fig.3b, the effect of water content was also significant on threshing ratio. With the rise of water content, the threshing ratio decreased(from 97.5% to 95%). The change trend of cleaning ratio with different water content was the same as that of threshing ratio. When the water content was below 55%, the cleaning ratio was more than 97%.

![Figure 3. Effect on seed-broken and loss rate of Camellia fruit moisture content](image)

Due to high water content of fresh fruit compacting and not loculicidal, the contact time with rubbing parts was longer and the pressure was stronger in the process of shelling which would make seeds easily broken. However, after 3-5 days drying, when the water content decreased to below 50%, the seed broken-ratio was less than 3%. What’s more, there was little influence of water content on loss ratio which was always less 1%.

4.2. Effect of the crankshaft speed and the track speed on capacity and threshing ratio
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 different crankshaft speed and track speed. Then it could be concluded from the result that with the crankshaft speed and track speed increasing, the processing capacity and threshing ratio was rising with the seed-broken ratio decreasing. When the crankshaft speed and the track speed were 240 ~ 260r/min and 0.4 ~ 0.6 m/s respectively, the processing capacity could reach 1500 kg/h and the threshing ratio was up to 99%. However, with the rise of the speed of the crankshaft and the track, the noise and wear of the device were increasing obviously that was not benefit for stable and sustainable operation.

4.3. 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. Therefore 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.
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.5, 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.

5. Conclusion
After research, in the condition that the moisture content of camellia oleifera fruit was below 45%, the vibration of the motor frequency was 50 Hz and the horizontal angle of sorting belt was 50 degrees~55 degrees, the processing capacity was more than 900 kg/h, the threshing ratio was more than 97%, the seed broken ratio was less than 5%, the loss ratio was less than 1%. Principle of the equipment in this research can be applied to Chinese chestnut, peanuts and other similar to the Camellia oleifera fruit material, which is of universality and great application prospect.
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