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A Review on the Cashew Nut Shelling Techniques

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Abstract: Cashew (Anacardium occidentale L.) nut has not only high economic value, but also has a variety of the medicine and health care functions. However, owing to the size variance of cashew nuts, the cashew nut shelling is still a struggle for engineers and researchers to be resolved. Presently, the increasing number of scientists concentrates on the cashew nut shelling techniques, in order to increase the whole kernel rate of the cashew nut. To supply the future researchers with the valuable guidance, this paper surveys the recent development of the pre-shelling treatment, shelling machinery, and cashew shelling method. Additionally, the current barriers concerning the cashew shelling technology are analyzed, and future research in these areas is also discussed.

Keywords Cashew nut; Pre-shelling treatment; Shelling machinery; Cashew shelling method; Steaming process; Feeding device

INTRODUCTION

Cashew (Anacardium occidentale L.) nut, which is derived from South American countries (Bolivia, Brazil, Ecuador, and Peru), is an extremely important tropical fruit crop [Aliyu *et al.*, 2007]. Cashew fruit consists of an apple that bears fruit in which the kernel is embedded, as shown in Fig.1 [Ogunwolu *et al.*, 2009]. Cashew nut is widely cultivated in tropical regions all over the world, and the production of the cashew nut is mainly centralized in Third World countries like India, Tanzania, Mozambique, Nigeria, Guinea-Bissau and Kenya [Aliyu *et al.*, 2007]. In 2002, India is the largest producer and processor of the cashew nuts in the world with the annual production of 0.46 million tonnes of raw cashew nuts [Aliyu *et al.*, 2007]. Yet, in 2013, Vietnam has become the largest processor of the cashew nuts in the world. The export amount of cashew nuts is approximate 25 million tons in 2013, occupying the largest market share of the world [Uchiyama *et al.*, 2014].

Cashew nut is mainly made up of kernel and shell, as shown in Fig.2 [Ogunwolu *et al*., 2009; Gong *et al*., 2015]. As components of the cashew nut have numerous economic uses, the cashew nut is of significant economic importance. The kernel of the cashew nut is high in oil and protein content, constituting about 40-57% and 21%, respectively [Ogunwolu *et al.*, 2009]. The kernel is mainly used in confectionery and as the desert nut [Ogunwolu *et al.*,

2009]. Now, the kernel is being considered as an additional source of protein concentrates and isolates for use in human food products [Ogunwolu *et al.*, 2009]. The shell liquid (CNSL) is a by-product of the cashew nut and is a natural source of saturated and unsaturated long-chain phenol [Maia *et al.*, 2012]. Recent studies show that the components of the CNSL have been used as antioxidants or as basis for the production of new compounds with antioxidant action [Maia *et al.*, 2012; Patel *et al.*, 2006].

Figure 1. Cashew fruit

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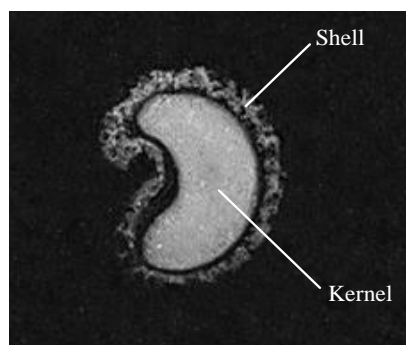
Figure 2. Sectional view of cashew nut

Because of the economic importance of the cashew nut, a large number of cashew nut processing enterprises are established all over the world. Therefore, a lot of novel techniques on the cashew nut processing are invented. At present, the cashew nut shelling technique is the most difficult due to the size variance of the cashew nut, which has dramatically restricted the development of the cashew nut processing industry [Uchiyama *et al.*, 2014]. Thus, many scholars execute couples of studies about cashew nut shelling techniques. And also, the most studies mainly focus on the pre-shelling treatment of the cashew nut, cashew nut shelling machinery, and scientific cashew shelling method. In this paper, the recent study about pre-shelling treatment of the cashew nut, cashew nut shelling machinery, and cashew shelling method are reviewed; the barriers of the cashew shelling technology are analyzed; and the future research and prospects are discussed.

PRE-SHELLING TREATMENT OF CASHEW NUT

Thivavarnvongs, Sakai, and Kitani (1995) suggested that boiling the cashew nuts in water for a certain period of time and then drying the cashew nuts in air for a certain time was the simplest and most economical way for pre-shelling treatment [Thivavarnvongs *et al.*, 1995]. In their research, it was found that the optimal pre-shelling treatment condition was the boiling time of 30 min and the drying time of 24 hr [Thivavarnvongs *et al.*, 1995]. Balasubramanian (2006) executed a research on optimizing different technical parameters to improve the whole kernel recovery and ease the kernel peeling [Balasubramanian *et al.*, 2006]. The cashew nut processing method proposed by Balasubramanian was shown in Fig.3. Kosoko, *et al*. (2009) studied the influence of different steaming times (ie, 20, 30 and 40 min) and diverse drying temperature (ie, 50, 60, 70 ℃) on the chemical properties of the cashew nut [Kosoko *et al.*, 2009]. Additionally, the research shown that steaming time of 40 min and the drying temperature of 70 ℃ were the optimal processing combination of the cashew nut, which could achieve the best quality in the aspect of different properties [Kosoko *et al.*, 2009]. Ogunsina and Bamgboye (2014) studied the effect of moisture content (MC), nut size distribution and steam exposure time (SET)

on the whole kernel out turn (WKO) of steam-boiled cashew nuts [Ogunsina *et al.*, 2014]. Particularly, the research showed that the optimal whole kernel out turn (WKO) was 91.74%, 90.94%, and 86.98% for large, medium and small sized nuts at MC*SET combination of 8.34%*30min, 11.8%*32min, and 8.34%*30min, respectively [Ogunsina *et al.*, 2014]. Gong, *et al*. (2015) utilized the low field nuclear magnetic resonance (NMR) imaging technology and electronic universal testing machine in order to investigate the effect of the steaming process on the physical dimensions and mechanical properties of cashew nut, aiming at scientifically interpreting the reasons that are beneficial to break the cashew nut [Gong *et al*., 2015]. Their investigation argued that there are two main reasons beneficial to break the cashew nut. That is, steaming process not just increased the gap between the kernel and shell, but also increased the brittleness of the shell [Gong *et al*., 2015].
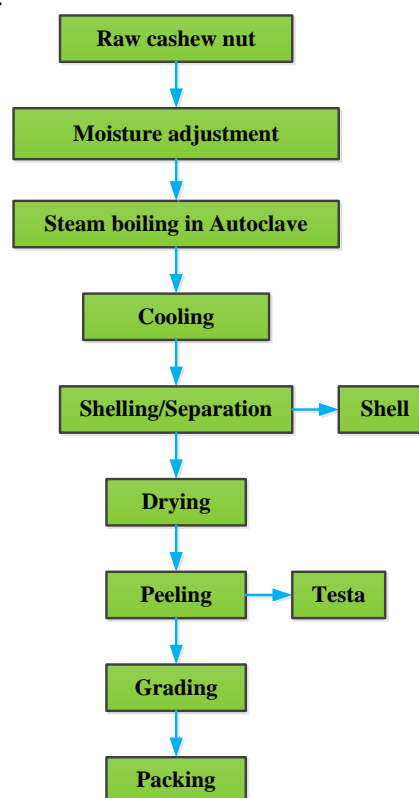

Figure 3. Cashew nut processing method

CASHEW NUT SHELLING MACHINERY

Thivavarnvongs, Okamoto and Kitani (1995) reported two types of manual shelling machineries, as shown in Fig.4 [Thivavarnvongs *et al.*, 1995]. The manual shelling machinery shown in Fig.4(a) mainly consisted of the base, post, bearing plate, lower blade holder, lower blade, upper blade, cutting depth setter, press/twist axle, press/twist lever, ball bearing, and compression spring. The manual shelling machinery shown in Fig.4(b) mainly comprised the base,

fulcrum, brackets, pin, lower blade holder, lower blade, upper blade, cutting depth setter, press/twist axle, press/twist lever, hinged bar torsion spring, and ring. The operating principles of the manual shelling machineries shown in Fig.4 were grouped into four

major steps: (a) Position nut onto lower blade; (b) Press lever down so that both upper and lower blades cut into nutshell; (c) Twist lever to right or left to open up nutshell; (d) Release lever and take out shelled nut.
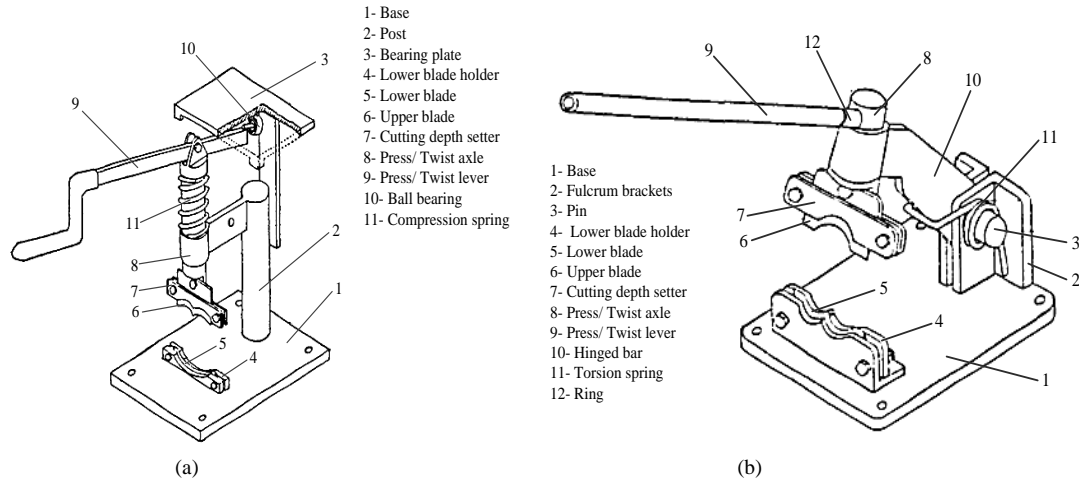
1- Base
2- Post
3- Bearing plate
4- Lower blade holder
5- Lower blade
6- Upper blade
7- Cutting depth setter
8- Press/ Twist axle
9- Press/ Twist lever
10- Ball bearing
11- Compression spring

1- Base
2- Fulcrum brackets
3- Pin
4- Lower blade holder
5- Lower blade
6- Upper blade
7- Cutting depth setter
8- Press/ Twist axle
9- Press/ Twist lever
10- Hinged bar
11- Torsion spring
12- Ring

(a)

(b)

Figure 4. Manual shelling machineries

Uchiyama, *et al*. (2014) presented a category of cashew shelling machine, as shown in Fig.5. Virtually, Fig.5 showed an automatic cashew shelling system, which mainly involved the vibrating cashew feeder, conveyor belts, rollers, cashew milling cutter, and cashew shell splitter [Uchiyama *et al.*, 2014]. To begin with, cashew nuts were placed between a pair of conveyor belts. And then, cashew nuts were

transported into the position between the upper and lower cutters by using the conveyor belt. Finally, a splitter was utilized to remove the shells from the kernels. In addition, the cashew milling cutter was shown in Fig.6 [Uchiyama *et al.*, 2014]. Fig.6 showed that the cashew milling cutter was made of the level, spring, milling blades, and plate disk [Uchiyama *et al.*, 2014].
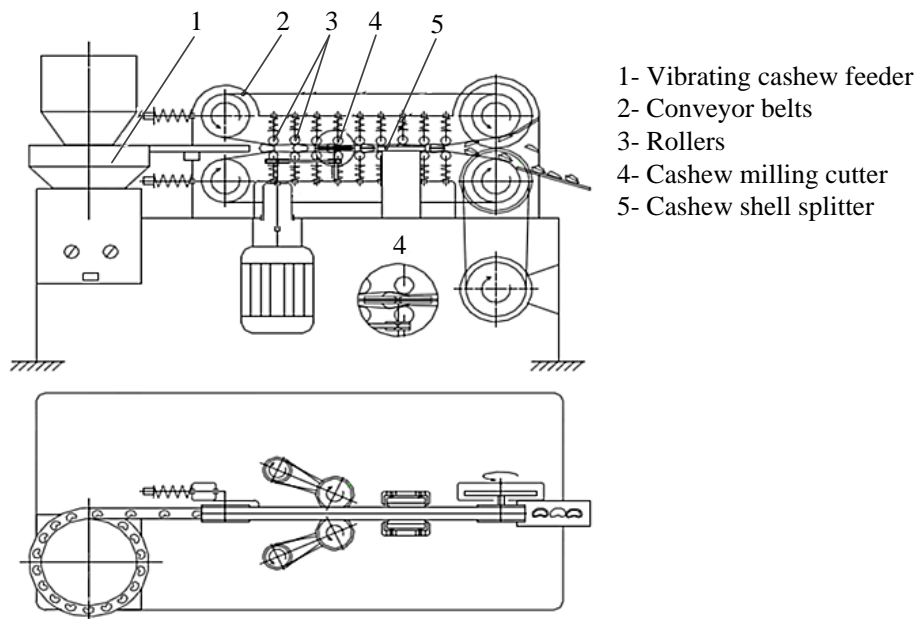
1- Vibrating cashew feeder
2- Conveyor belts
3- Rollers
4- Cashew milling cutter
5- Cashew shell splitter
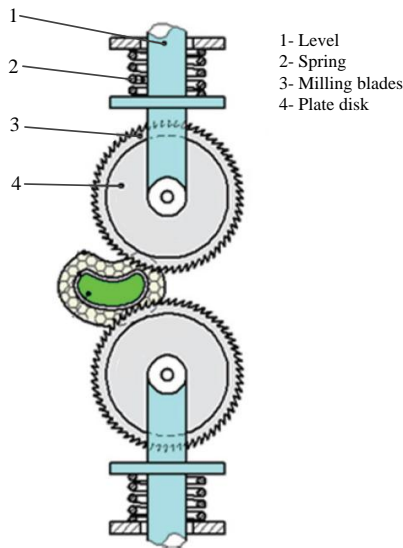
Figure 5. Cashew shelling machine

Figure 6. Cashew milling cutter

Fu, *et al*. (2015) proposed an adaptive cashew shelling cutter, consisting of the fixing frame, spring, tool holder, upper cutter, lower cutter and scraper [Fu *et al.*, 2015]. First, cashew nuts were transported into the position between upper and lower cutters by the driving force caused by the scraper, and then cashew nuts were broken by upper and lower cutters. Particularly, with the help of the spring, the upper cutter can move up and down to meet the size variance of cashew nuts. The schematic of the adaptive cashew shelling cutter was shown in Fig.7 [Fu *et al.*, 2015].
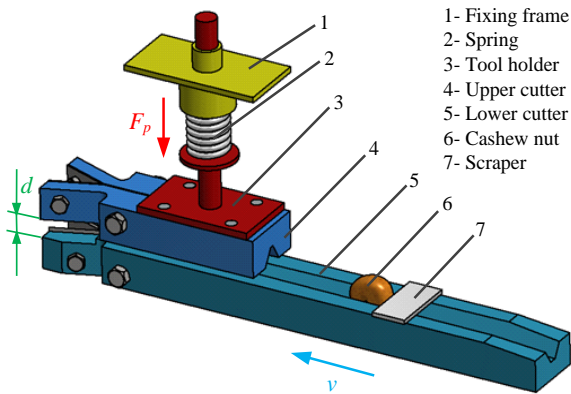

1- Fixing frame
2- Spring
3- Tool holder
4- Upper cutter
5- Lower cutter
6- Cashew nut
7- Scraper

Figure 7. Mechanisms of adaptive cashew shelling cutter

In order to investigate the reliability of the upper and lower cutters, Fu, *et al*. (2015) established an integrated simulation platform by using Hypermesh, LS-Dyna, LS-PrePost, and nCode GlyphWorks [Fu *et al.*, 2015]. The simulation model of cutting cashew nut was shown in Fig.8 [Fu *et al.*, 2015]. By simulation, the damage histogram of the cutter was obtained, as shown in Fig.9 [Fu *et al.*, 2015]. The research showed that the minimum fatigue life of the cutter is approximately 495 days [Fu *et al.*, 2015].
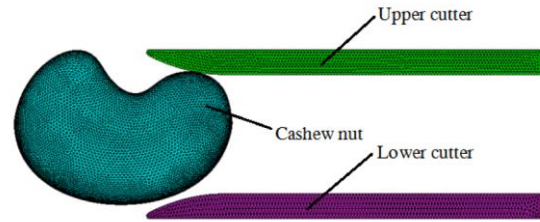

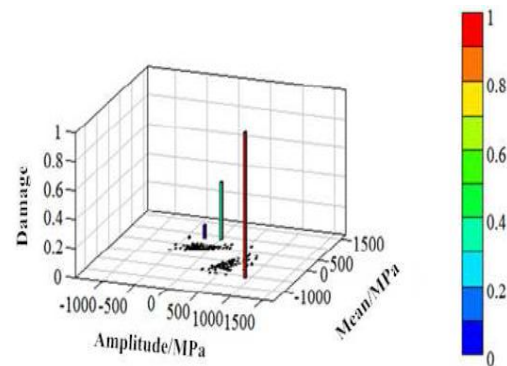Figure 8. Finite element model of cutting cashew nut

Figure 9. Damage histogram of the cutter

In addition to the research above, Fu, *et al*. (2015) designed a novel feeding device shown in Fig.10, in order to ensure that cashew nuts were transported with the same posture into the position between upper and lower cutters [Fu *et al.*, 2015]. The feeding device for the cashew nut shelling machinery mainly consisted of the retaining nut board, rubber mat, the guide groove of the transport nut, scraping nut board, upper shelling cutter, lower shelling cutter feed hopper, transport nut groove, transport nut wheel, and vibrative discharge chute, which is designed to convey cashew nuts for the adaptive cashew shelling cutter shown in Fig.7.
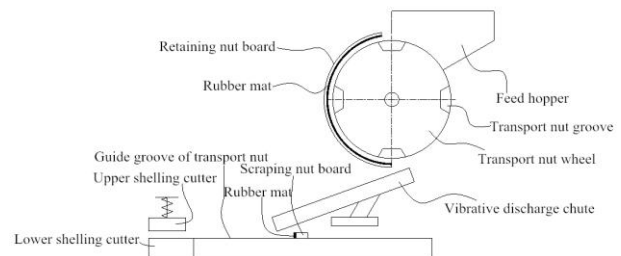

Figure 10. Structure diagram of the feeding device for cashew nuts

CASHEW NUT SHELLING METHOD

Huang, *et al*. (2015) presented a systematic cashew nut shelling technique, which consists of removing impurity, classification, steaming, rapid cooling, shell breaking, and screen. The flow chart of the cashew nut shelling method is shown in Fig.11, which can simply illustrate the whole process of the cashew nut processing [Huang *et al.*, 2015]. First, the vibrating screen and fanning machine are used to get rid of some lightweight things like empty nut shells, branch,

leaves, and the fiber of the apple; the water immersion and mixing method are used to remove the heavier trash, such as the stone and silt. Next, to improve the whole-kernel rate of the cashew nut, the roller with the holes of 20-24mm or screen with the holes of 16-20mm are adopted to execute the classification of cashew nuts. In general, cashew nuts can be divided into 3 types: large, medium, and small classes. Next, to ensure the effective separation of the kernel and shell, the high pressure cooking boiler is used to steam cashew nuts. Moreover, the heating temperature is in the range of 105 to 130℃, and the heating time is in the range between 1 and 3 days. In addition, the storage time is approximate 3 days. After the steaming process, cashew nuts are rapidly taken out and are immediately put into the refrigerator, where the temperature is about 10℃. Then, the cashew nut shelling machine is utilized to break the shell of the cashew nut. Finally, the vibrating screen and winnower are used to remove shells from kernels.
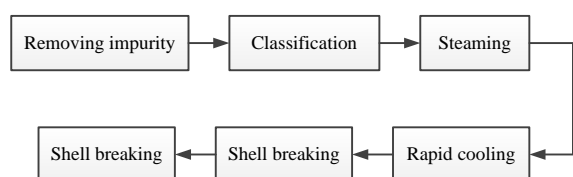

Figure 11. Procedure of cashew nut shelling method

This cashew shelling method has a couple of plus points, which are listed as follows [Huang *et al.*, 2015]:

(1) Removing impurity is capable of removing the stone from cashew nuts, which can ensure the steady operation of the shelling machine.

(2) The classification of the cashew nut is able to reduce the differences among cashew nuts, which can improve the whole-kernel rate of the cashew nut.

(3) The steam heating is benefit to reduce the hardness of the shell and the friction wear of the cutter, improving the whole-kernel rate of the cashew nut.

(4) This method is suitable for the industrial production of the cashew nut.

BARRIERS OF THE CASHEW SHELLING TECHNOLOGY

(1) With the limitation of the current technology, the whole kernel recovery of cashew nuts is still low.

(2) In terms of the automatic level, cashew shelling machines are still remaining at a low level.

(3) The advanced pretreatment machines for shelling cashew nuts should be designed and manufactured, aiming at replacing old devices used in the pre-shelling treatment of the cashew nut.

(4) The systematically theoretical researches regarding the cashew shelling technology are rarely reported.

FUTURE RESEARCH AND PROSPECTS

(1) The cashew shelling cutters should be further enhanced to ensure anti-wear ability.

(2) The mathematical model of the cutting theory of the cashew nut should be established to provide some valuable guidance for the design of novel cashew shelling machines.

(3) The future research should focus on the automatic cashew shelling machine to guarantee the production efficiency of the cashew nut.

(4) The research on the production line of processing the cashew nut should be executed in the future.

CONCLUSION

This paper has attempted to cover a wide range of information in order to facilitate the readers to understand the cashew nut shelling techniques deeply. This review has shown that, in most cases, reported work to dare in this area has a number of the barriers in the aspect of the cashew shelling technology, and further development work is required. However, there is a scarcity of information regarding the pretreatment machines for shelling cashew nuts in the preparation of materials.

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