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Design and development of manual water chestnut (*Trapa natans*) decorticator for Kashmir Valley, India

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Abstract

Study was carried out to find the effects of moisture content and screen perforation area on decortication efficiency of water chestnut decorticator. The decortication efficiency was maximum 52.70 % in screen C (area of perforation 38%) at 9% moisture content. Average amount of broken decreased with increase in area of perforations whereas the average amount of unhusked water chestnut increased with increase in the area of perforations of the screens. The decortication time decreased with increase in percentage area of perforation. The shelling efficiency obtained for screen D (i.e. Rhombus Slotted Mesh) was the maximum. The reason for obtaining higher shelling efficiency with the screen D was due to more area of perforations (72%), the shape of the kernel and less residence time required during the process of decortication in comparison to those for screens A, B and C. The shelling coefficient increases with the increase in percentage area of perforation. Screen D (72% perforations) showed maximum shelling coefficient for water chestnut decortication.

Keywords: Water Chestnut, Moisture Content, Physical Properties, Shelling Efficiency, Decortication Efficiency

Introduction

Water chestnut *(Trapa Natans)* which is commonly known as *Singhara* (India) and *Gaer* (J&K) is one of the important annual aquatic warm season crop. The fruits of the crop grow during the warmer part of the year and die out with-the advent of severe winter. The crop can successfully be raised in water basins, shallow lakes and ponds. Water chestnut is grown throughout the country, especially, near the big cities' in northern, central and western regions. It is regarded as poor man’s food, only five percent of its produce is consumed as raw and 95 percent is processed. Its outermost covering has to be removed to make it fit for human consumption. During last decade efforts have been made to design and develop an efficient water chestnut decorticator (Gautam and Tomar., 1992; Singh and Singh., 1994; Singh., 2001) [29, 7, 8, 6]. Water chestnut is considered abnoxious in U.S. because its forming extensive, dense beds in lakes, rivers, and freshwater-tidal habitats. Water Chestnut has floating leathery leaves, up to 5 cm wide, that are broadly triangular or ellipsoid in outline with a toothed margin. The petiole of each floating leaf has a spongy, swollen float that allows the foliage to form a rosette, up to 30 cm in diameter, on the surface of the water. Beneath the surface of the water is a flexible stem, 1 to 5 m long that stands submersed, these submersed leaves drop early and are replaced by pairs of fine, pinnate structures up to 8 cm long. These curl-like structures have been variously considered to be stipules, leaves, or adventitious roots. The small white 4-petaled flowers, which are borne singly in the axils of the floating leaves, yield dark brown woody fruits, 2.5 to 5 cm across, the outer portions of which quickly disintegrate to reveal the "nuts", which sink rapidly to the bottom where they hibernate in sediment. The cultivation of water chestnut is scattered throughout the country, especially, in the big cities of Punjab, Bihar, Uttar Pradesh, Madhya Pradesh, Chennai, Mumbai and other places like Sri Lanka, South Eastern Asia, Malaysia and Tropical Africa. In Madhya Pradesh, the crop occupies about 210 hectares land with an average yield of 1000 Kg/ha. Jabalpur region has major share both in area and production. Water chestnut worth Rs 20 million (2 crore) is produced annually in Jabalpur. This is eaten in different ways. The kernal is delicious and contains carbohydrates (16%), proteins (2%) and essential minerals (Vaughan and Geissler., 1997) [9]. In Kashmir valley water chestnut is presently being consumed by the people as dried nut and is being sold as nut or dehulled nut in the market which does not help the farmers in getting their returns to the extent it should have been. Also, the floor of the water chestnut is being used as floor for diabetic patients and is in great demand in pharmaceutical industries within and outside the Kashmir valley.

In district Bandipora more than 28 villages have major source of income from the water chestnut and is being harvested from Wullar Lake in the month of August to December.

Methods and Materials

Jammu and Kashmir considered as a low mechanized region as compared to other parts of the country. There is no specialised markets for the sale and purchase of farm implements in the state, so mechanised decortication of water chestnuts has not been possible yet, so with this initiative we had tried our level best to present before people a well fabricated design of water chestnut decorticator which will be of great help to our farmers dealing with this crop. Srinagar, Ganderbal, Bandipora and Baramulla districts were selected as the cultivation of water chestnuts is dominating in these areas. The farmers dealing with this crop were cross-examined about the variety, production, harvesting methods and the way by which they do the decortication of water chestnuts using traditional methods (use of knife etc…) which became a source of motivation for us to work on this study. The present study was carried out in the farm machinery workshop and quality control laboratory at division of Agricultural Engineering, SKUAST-K, Shalimar. This study was carried out with the following objectives:

To determine the physical characteristics of water chestnut and development of suitable manual water chestnut decorticator for decortications of water chestnuts.

To evaluate the performance of developed decorticator by optimizing moisture content of the water chestnuts and screens used in decorticator, an

To find out the decortications efficiency of the developed decorticator.

Manual water chestnut decorticator consists of a hopper and an oscillating segment. Hopper is made from MS angle iron frame (30mm x 30mm x 3mm) having a diamond shaped slotted sieve (slot of 22 mm x 12 mm size) in the bottom and Four sheets on the sides. Oscillating sector consists of MS flat having a handle on the top and a wooden block cut in curved fashion which is embedded with four sharp point cut saw blades and four knives but placed alternatively of high carbon steel. The water chestnut pods are fed in the hopper and handle is moved in to-and fro motion. The pods are broken into shells and kernels. The mixture passes through the sieve sector on the collecting tray.

Moisture content

The initial moisture content of water chestnuts was determined by using a standard method (USDA., 1970) and was found to vary between 55 % and 65% wb (Table-1).The water chestnut samples of the desired moisture levels were arranged by putting them inside an oven for 24 hours at 65 C° reducing the moisture to 30%, 22%, 15%, 9% and 7% wb (Table-1) for various samples. Also some chestnuts were excessively dried whose decorticating efficiency was considerably reduced, resulting in less efficiency, as different screens use different moisture contents of water chestnuts(here the screen used contain diamond shaped slots of size (22mm × 12mm).Other screen used contains square shaped slots, rectangular shaped slots and rhombus slotted mesh of various dimensions but proved less efficient than diamond shaped which had been put for further modifications to get the whole kernal, but in present case both whole as well as broken kernels were obtained.Almost all the physical properties of the crop were assessed at moisture levels of 7%, 9%, 15%, 22% and 30%wb (moisture meter readings) for five different samples (Table-1). After decorticating dry water chestnuts, it was found that the best shelling efficiency was 79.38% at a clearance of 25mm and capacity of 26.83 Kg/hr, as reported by (Jain *et al*., 1990) [3] that the shell and Kernel percentages of whole dry water chestnut were 30 and 70 % respectively. The shelling efficiency increased with reduced moisture content up to 9.3% for grade1 Kernel for all the screens whereas, for grade-2 Kernel, the shelling coefficient diminished with a decrease in moisture content. It may be mentiond that complete Kernels after decortication process are Grade-1 kernels whereas, partially broken kernels up to 25% are Grade-2 Kernel (Singh and Gupta., 1994) [7, 8].

Size of chestnut crop

The average size of the crop was determined by taking five samples of different sizes, selected randomly. Measurement of the three major perpendicular dimensions of the crop was carried out with a Vernier calliper with accuracy of 0.1 mm and by using graph paper. The geometric mean diameter (D_p) of the seed was calculated, using the following relationship (Mohsenin, 1970) [5]:

$$D_p = (LWT)^{1/3} \quad (1)$$

Mass, Volume and Density

Each nut mass was weighed by a chemical balance (least count 0.001 g). The nut and kernel volume and their true density were determined using the liquid displacement method. Toluene (C_7H_8) was used in place of water because it is absorbed by nuts to a lesser extent. Also, its surface tension is low, so that it fills even shallow dips in a nut and its dissolution power is low (Aydin, 2003) [1].

Results and Discussion

Plots of shelling efficiency for various screens, with different moisture contents of water chestnuts are shown in Fig1 and Fig 2. The shelling efficiency decreased with increasing moisture content and the highest shelling coefficient was obtained at 9% moisture content. The shelling efficiency obtained for screen D (i.e. Rhombus Slotted Mesh) was the maximum. The reason for obtaining higher shelling efficiency with the screen D was due to more area of perforations (72%), the shape of the kernel and less residence time required during the process of decortication in comparison to those for screens A, B and C. The shelling coefficient increased with the increase in percentage area of perforation. Screen D (72% perforations) (Table-1) showed maximum shelling coefficient for water chestnut decortication. Variation of decortication efficiency with different moisture content using four different screens for water chestnuts Fig1 and Fig 2. As depicted the decortication efficiency decreased with increasing moisture content. The decortication efficiency was found to be the maximum with C type screen followed by D, B and A screens. Although the shelling efficiency was higher with screen *D.* If the amount of unhusked and brokens are less, the decortication efficiency will be more. The reason for the better decortication efficiency with the screen C was less quantity of unhusked water chestnut in comparison to screen D. Because of higher perforation percentage in the screen D, the broken percentage was less but amount of unhusked water chestnut was more. A hand operated groundnut decorticator developed had a shelling capacity of 76.0 Kg of pods per hour. The shelling efficiency and breakage of kernel were reported to be 95.5 % and 1.26% respectively.

Conclusions

Shelling coefficient was maximum (58.80%),with screen D (area of perforation 72%) at 9% moisture content. Keeping

decortication efficiency as the deciding factor, the screens have been optimized within the range of 28 to 72 percent area of perforation.
The screen C (38% area of perforation) showed highest decortication efficiency within this range and was found to be the optimum.
Average amount of broken and partially broken was maximum (335g) with screen A (area of perforation 28%) and minimum (275g) with screen D (area of perforation 72%).
Husk content decreased with decrease in moisture content. On the basis of decortication efficiency and shelling coefficient for water chestnut, 9% moisture content and screen C with 38% area of perforation was found to be the best. The decortication time decreased with increase in percentage area of perforation. This may be due to the fact that with more number of slots the water chestnut gets less time to pass through the screen. It was observed that due to lesser area of perforations (i.e. less number of holes) residence time of water chestnuts after decortication over the screens increased so that the chances of kernels being hammered by shoe and getting broken into pieces also increased. Similarly, if the number of holes on screens increased the chances for small size unhusked water chestnuts passing through the screens without being decorticated also increased. Screen D with 72% area of perforation was optimum showing maximum shelling efficiency (58.80%). Capacity of the decorticator was estimated to be 45 kg/hr.

Sieve A.

Sieve B.

Sieve C.

Sieve D.

Table 1: Independent variables along with their values.

Variables	No of levels	Values
Water chestnut	one	Black variety
Types of screens	Four A. Oval slotted screen B. Rectangular slotted C. Diamond slotted D. Rhombus slotted (mesh)	 28% 35% 38% 72%
Size of slot	one	22mm×12mm
Moisture content	five	7%, 9%, 15%, 22% and 30%
Clearance	three	Adjustable but for Experimental purpose (14mm,12mm&10mm)
Oscillations	one	35 OPM (average)
Time	one	30-40 seconds

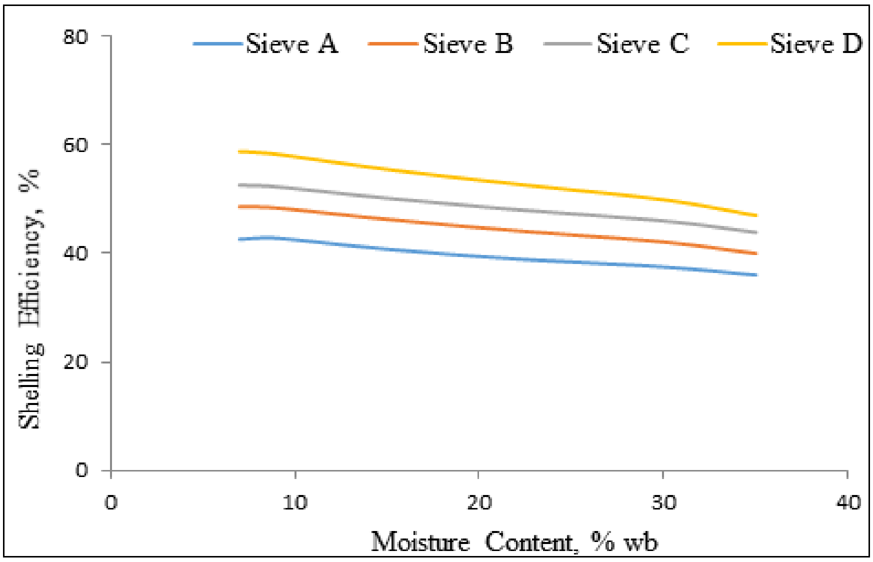

Fig 1: Showing Shelling efficiency on different moisture contents

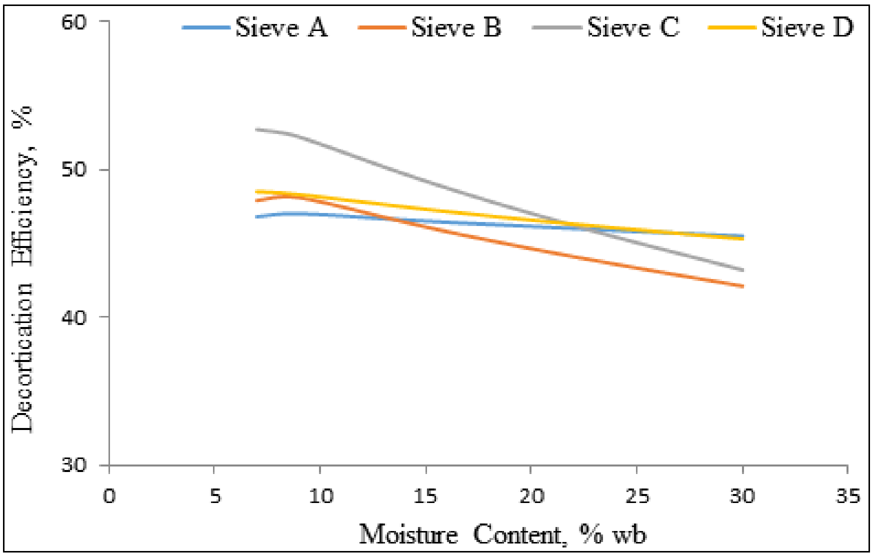

Fig 2: Showing Decortication efficiency on different moisture contents

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