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Performance evaluation of a bolt type pistachio hulling machine

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Most of the pistachio production is hulled by bolt type hulling machine in Iran which is the first world producer of pistachio, the only commercial type of hulling machine manufactured in the country. This study was conducted to evaluate the performance of this machine. The selected machine hulling capacity was 6 tons per hour. The selected pistachio variety was Ohadi, one of the important Iranian pistachios. The performance was measured 3 times at equal intervals of one week for 3 subsequent weeks during the harvesting season. A small box with the volume of 2200 cm^3 holding about 1000 pistachios was used to collect samples from each machine outlet; the numbers of hulled, unprocessed and broken pistachios were counted. These three parameters were used to evaluate the machine performance. Higher number of hulled pistachios and lower number of unprocessed and broken pistachios indicate better machine performance. The statistical analysis of the data indicated that there is no significant difference between the four machines performance. The experiments also showed that there is no significant difference among the percentage of pistachios hulled at the beginning of the season and those hulled at the end of the season (at 3 subsequent weeks). The best machine adjustment, for minimum pistachio breakage which was achieved at a clearance of about 5 mm between the rotating drum and sharp hulling blade. At this clearance the machine hulled 73.8 percent of pistachios, 25.5 percent remained unprocessed which needed further hulling operations and 0.7 percent of the pistachios were broken.

Key words: pistachio, *Pistacia vera* L, pistachio hulling industry, bolt type hulling machine, Kerman

Introduction

The pistachio (*Pistacia vera* L.) is an important crop in Iran. Most of the pistachio nuts are exported to countries around the world and has the important role in the development of national economic value and agro-food industry of Iran. Based on FAO statistics (Food and Agriculture Organization, 2005), Iran produced about 275,000 Million Ton of pistachio in 2003, which was approximately 54.7% of the world's pistachio production; United State, Turkey

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and Syria are other main producers. Proper harvesting, handling, and processing are the key operations, which determine the final quality and marketability of pistachio.

Kerman province produces more thank 79 percent of the total country's production. Bolt type hulling machines are the only machine which is commercially manufactured in Kerman and all of the pistachios are processed by this machine. This machine is being modified and developed from 50 years ago in Kerman province by local industry. About 1000 machines are produced each year. Although increasing the pistachio cultivation area and practices has been due to invention of hulling machines but, still there is not enough information and documented research on working principles and performances of these machines. This study was conducted to evaluate the performance of bolt type pistachio hulling machine.

Hulling is the main process undertaken on pistachios after harvesting. In this process the soft pink color skin is removed. Hulling can be divided into: manual, semi-mechanized and mechanized methods. In manual method workers peel pistachios by hand or spread them on a clean and smooth surface and smash pistachios by a flail or stick. It is an old method and is not being used anymore. The semi-mechanized method is based on friction; the machine consists of a stationary vertical perforated cylinder with a circular rotating bottom plate. The worker turns a handle and the bottom which has sharp points start to rotate. Centrifugal forces hit pistachios to stationary cylinder and sharp points of the rotating bottom. The skin separate and flow through the cylinder holes. This method is very slow and demands too much energy. Bolt type hulling machine is the only commercial mechanized method in Iran. The machine has been developed and improved during the last 50 years. The main part of machine is a rotating drum covered by the heads of M6 bolts (Rad and Shamsi, 1980). The soft skin is detached by vertical and shear stresses produced by these bolts against a fixed blade. In a specific model instead of M6 bolts, small rectangular steel sections are welded on the rotating drum. These machines import less stress compared to the bolt type. It is difficult to change the welded section when they are worn; because of this problem farmers are not keen to use this model. Each year there are unripe pistachios among the nut which the bolt type machines couldn't hull them. These are reprocessed in another machine called unripe huller. The machine works like the semi mechanized machine described before, but this machine is powered by an electric motor. If the skin is too sticky a water flow is used to improve the performance. It is like a small Vegetable hulling machine. In United State pistachios are pilled by vegetable hulling machines. The vegetable hulling machine working principles are very similar to the unripe pistachio hulling

machine explained earlier but it is made in large capacities. In these models the rotating bottom of the vertical cylinder insert forces to the nuts and centrifugal forces help to throw away the nuts soft skin. More than 1000 hulling machines are made in Kerman each year. Around 500 units have the capacity of 6 tons/hour and the other half are manufactured with a capacity of 1 and 3 tons/hour (Shamsi, 1994). Fig. 1 shows the working principles of the machine. On a rotating drum of 500 mm diameter and 7mm thickness many M6 bolts are mounted on a helical pattern and are tightened from inside the drum. On top of the drum two inclined plates make the feeding hopper which is also the hulling space. The drum rotates clockwise. Spacing between the plate 1 and the drum makes an exit window for pilled pistachios. Spacing between plate 2 and the drum makes the exit window for skins. This spacing is about 5 mm and less than smallest pistachio's dimensions.

This small spacing does not let pistachios to pass and only skins can leave the hopper. Pilled pistachios slip and fall out from window 1. Plate 2 has two adjustments: a vertical adjustment of few millimeters to prevent pistachios flowing out and horizontal movement of about 50 mm to make a suitable inclined surface for slipping pilled pistachios counterclockwise and discharge from lower edge of plate 1. Spacing between plate 1 and 2 on the drum is about 220 mm. Reducing the spacing between lower edge of plate 2 and drum surface increases the hulling action. This spacing is about 5 mm for normal conditions. If this spacing reduces too much the machine breaks the hard skin and the kernels damage. The diameter of the drum is 500 mm and rotates about 200 rpm in all three models of 1, 3 and 6 tons/hr capacities. The width of the drum is 700 mm for 1 ton/hr models, 900 mm for 3 tons/hr models and 1400 mm for 6 tons/hr models. The 6 tons/hr models are powered by a 4 KW, 3 phase electric motor.

Material and methods

To evaluate the performance of bolt type pistachio hulling machine a modern processing unit near Kerman city was selected. 4 machines of 6 tons/hr capacity model in best working condition were selected for performance test. A basket of 2200 cm3 volume which can hold about 1000 nuts were picked from each exit when the machine was working in normal and steady condition. The samples were collected with three replications for each machine. The percentages of pilled, unpilled and broken nuts were calculated three times at the binging, middle and the end of harvesting season which takes about one month. It means that the interval between each test is about two weeks. Analysis of variance and Duncan mean tests (Basiri, 2001) were conducted to:

1- Find the pilling percentage of machines

2- Compare the machines performance

3- Find the difference in performance at the beginning middle and end of harvesting season. Letter M was used to show machine and T to show time. In pistachio market broken nuts reduce the market price; therefore, the machine pilling ability is adjusted for minimum breakage of nuts. Extra treatment on nuts to achieve more pilling percentage is accomplished by decreasing the spacing between plate 2 and the rotor.

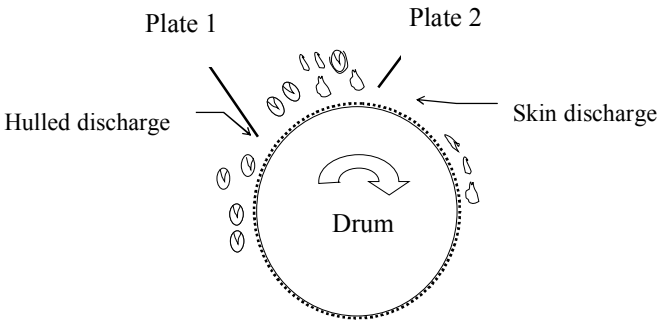

Fig. 1. Schematic diagram of a pistachio hulling machine.

Results and discussion

The results showed that there is no significant difference among the performance of 4 machines. The machines hull were 74.4, 83.3, 71.3 and 66.5 percent of pistachios relatively (Fig. 2). Machines also have equal performance at beginning, middle and end of harvesting season. The machine adjustment is durable and the difference between the required green skin hulling forces of early harvested nuts and those harvested later dose not affect the machine hulling performance. The percentage of hulled, unprocessed and broken nuts at three periods of time, beginning middle and end of the season (Fig. 3).

It can be seen that machines at times T1, T2 and T3 have hulled 76.6, 73.5 and 71.4 percent and 22.9, 25.3 and 25.4 percent of the nuts have passed through the machine unprocessed. The percentage of breakage is relatively 0.27, 0.7 and 0.24. Based on this experiment, it can be generally concluded that during the harvesting season the hulling machine can hull 73.8 percent of the pistachios and 25.5 percent remained unprocessed in need of further processing by a special unripe pistachio hulling machine explained earlier. The average breakage of these machines amounts from 0.4 to 0.7 percent of the pistachios.

In pistachio market broken nuts in a sample decrease the price and therefore the machine is adjusted for minimum breakage. Best setting for maximum hulling and minimum acceptable breakage was achieved when

spacing between plate 2 and the rotor was set at 5 mm. Extra treatment to improve the hulling efficiency from 73.8 percept increases the breakage which is undesirable. Therefore it seems difficult to reach more hulling percentage than 73.8 and this value is the best performance of the machine. It clears that still more investigation is needed to design and develop new machines to improve this valuable industry.

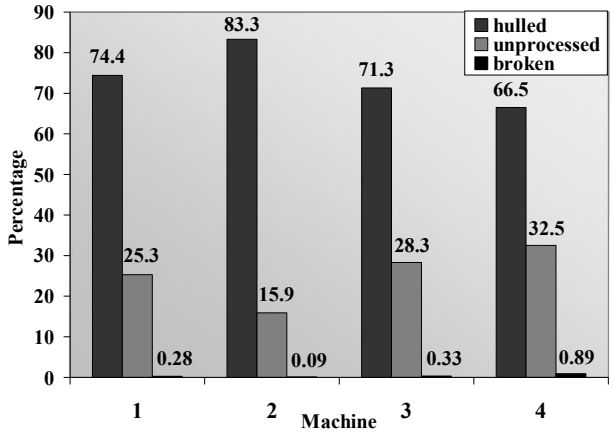

Fig. 2. Relative performance of four machines.

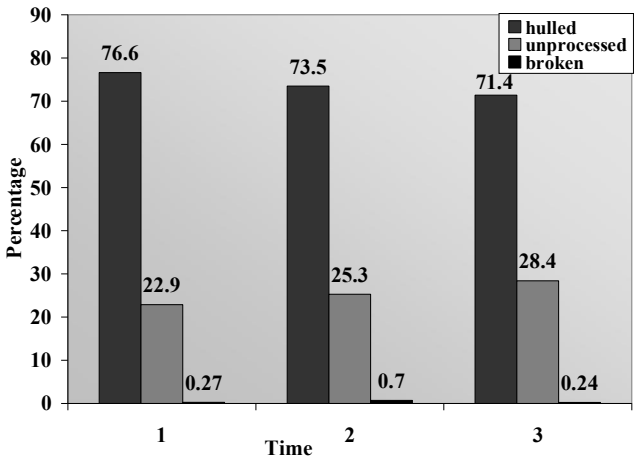

Fig. 3. Machines performance at different times.

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