Design and Development of an Apparatus for Grating and Peeling Fruits and Vegetables

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Abstract: Fruit grater and peeler are needed in the processing of fruits in order to reduce the time required for fruits grating and peeling. Grating is important especially to make salad and for decoration purpose. A suitable grater is needed for specific decoration process. It is crucial for food (processing) industry to operate at minimal operating cost. Peeling using hands is time consuming and may require several workers to perform the operation and thus may increase the operating cost. Therefore in this study, a machine was designed to combine the process of grating and peeling in one device. This new designed machine is suitable to be used domestically. The machine is small-sized and lightweight and is convenient to carry and store. It is comprised of a clamping mechanism, grater, peeling blade, movable arm and also a pair of end-cutting blade. The prototype was tested for automatic grating and peeling process and manual peeling was also performed to peel the skin of selected fruits and vegetable. The prototype was able to grate several fruits and vegetables and also reduce the peeling time by 94% when compared to manual peeling.

Key words: Fruit grater and peeler, grating, peeling, fruits, vegetables

INTRODUCTION

Grating of fruits or vegetables is important to obtain the fine shredded products. In current market, graters come in various shapes and sizes and each grater has several different blades. Selection of the right size of blade for specific purpose is important. According to Sharon and Christine (2000), large round holes work the best. However, CIA (2007) stated that the smaller the hole, the finer the end result. The finest side is used for grating and should be used on firm or hard textured food. Currently, available grater design in the market is a box grater that has four sides with openings of different sizes and shapes on each side. Flat grater is a good choice for shredding directly onto a casserole or salad. A flat or curve grater with rows of small cutting edges on the surface is the widely known type. This tool

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generally has a metal surface punched with sharp-edged holes or slits that are used to break foods into smaller pieces (Better Homes and Gardens, 2003). Available grater in the market that specifically used for fruits and vegetables normally handled manually using hands.

Peeling of fruit consists of separating the skin which normally protects the fruit from the flesh or pulp thereof. Traditionally, this operation is performed by means of an appropriately sharpened knife, with the edge of the blade applying high pressure to the boundary region between the pulp and the skin, thereby separating them. Different types of fruits have different shapes and sizes. Thus, several different machines are provided to separately process each of the fruit. Therefore, processing of a particular fruit, such as removing the skin from an orange, is usually performed by a particular machine, for maximizing the processing speed of the system. A peeler would peel the rind (and invariably some flesh) from the fruit. It is well known in the art of peeling machine to employ a machine having two opposing ends that secure and rotate an average sized, spheroid fruit. Devices suitable to peel fruits like apples, pears, etc., on industrial machines are known since, a long time and they are of different kinds. Fruit peeling machines available in the market nowadays are for peeling fruits with smooth skin structure such as oranges and watermelons.

According to Martin (2000), some peeling machine included a rotary clamp mechanism having a pair of clamps which grip and rotate a fruit or vegetable while, rotating cup-shaped cutting blade is moved along the profile of the fruit. Ascari and Ascari (2005) said that although, majority of fruits have a uniform peel thickness throughout their surface, there are fruits which naturally have a peel with a non-uniform thickness; such as oranges, in which the thickness of the epicarp, added to the mesocarp, gradually varies starting from the pole, where, the fruit is attached to the peduncle, to the opposite pole, this continuous variation of thickness being considerable since it may reach 2-4 mm.

There were designs made to mechanize peeling operation by applying fruit to a device operating on the principle of a lathe, with the fruit being mounted between spikes and with one or more fixed or rotary tools being brought to the periphery of the fruit in order to imitate manual peeling, i.e., in order to detach a continuous piece of peel (Cailliot, 1990). There were inventions related to machines for industrial use, suited to peel citrus fruits, such as oranges (Ascari and Ascari, 2004, 2005; Ishikawa, 1988). There were also inventions of machines to peel pineapple (Martin, 2000; Raub and Breton, 1989; Loveland, 1978), melon (Martin, 2000; Heinzen et al., 1997) and mango (Ascari and Ascari, 2005). Some inventors had designed machine not only for peeling of a certain particular fruit but also, adaptable to various kinds of fruits (Ascari and Ascari, 2005; Martin, 2000).

For small and medium-sized fruit peeler, a fruit or vegetable is held at its both ends between a revolving support and a footstock and is rotated by a motor. A revolving blade is held by a support arm and is rotated by the same motor. Furthermore, the revolving blade is movable along the surface of the fruit/vegetable by the arm and the revolving blade is brought into contact with the surface of the fruit/vegetable. That type of fruit and vegetable peeler is designed to peel and chop fruits without cutting its ends. User needs to remove the ends manually using knife and it may require additional labor work. It is more practical to include, a pair of end-cutting blade to cut the fruit ends after the peeling process completes without the need of removing the fruit in order to cut the ends. Furthermore, this type of peeler does not comprise any grating devices to specifically remove fruit skin with some special structure on it. An exotic type of fruit that is becoming popular nowadays is dragon fruit or pitaya. This type of fruit has scaly structure on its skin which cannot be easily removed using the existing peelers in the market. Since, this type of fruit starts to attract consumers’ attention, hence, the processing of this fruit is now becoming popular in fruit and beverages processing industry. Hence, a suitable peeler is required, which enables the grating and peeling process of dragon fruit skin.
One technical objective of the study was to provide fruits grater and peeler which is suitable to use domestically, which is small-sized and lightweight and which is convenient in carrying and storage. It is also to provide an inexpensive but a promising apparatus with respect to small and medium scale fruit/vegetable based products processing system.

**MATERIALS AND METHODS**

The development of the design process was started in year 2008 and this project completed in year 2009.

**Design Principles and Theory**

This apparatus was designed for grating and peeling fruits and vegetables. It is small-sized and lightweight which is suitable to be used domestically and is convenient to carry and store.

**Conceptual Design**

This invention relates to an apparatus for grating and peeling fruits or vegetables. It is a multifunctional apparatus which can grate, peel and cut fruits and vegetables. The combination of the three functions (grate, peel and cut) differentiates this apparatus from other available peelers/graters in the market. A useful machine to automatically grate and peel fruits/vegetables with or without scales on the skin and also spherical/oval shapes fruits or vegetables: without using manual instruments, that will contribute in reducing time and effort.

A special component was designed to grate fruits and/or vegetables. It can be used to make grated/shredded fruit and vegetable such as grated carrot and papaya respectively. It is useful for salad making and food decoration purpose. In addition to its ability to grate and peel fruits and vegetables, the constructed apparatus should be inexpensive but a promising apparatus with respect to small and medium scale fruit-based products processing system.

The amalgamation between the three functions which are grating, peeling and cutting has contributed to the reduction of operating time. The aim of combining these unit operations into one has resulted in diminished operating cost.

**Concept Selection of Process**

Table 1 shows the design specifications of the machine which combines three operations.

**The Development of the Machine’s Equipments and the Operational Research**

In developing this apparatus, two important methods need to be established. First is the fabrication of the apparatus and second is the operational research of the fabricated apparatus.

**The Fabricated Apparatus**

The front view of the apparatus is shown in Fig. 1. The machine comprises a trident, pushrod, grater, peeling blade, arm and end-cutting blade. The design specifications of the major components of the apparatus have been described in Table 1. This apparatus is constructed from food grade stainless steel (SUS 316). The structures of the apparatus are briefly described as follows:
Table 1: Design specifications of machine combining three operations

<table>
<thead>
<tr>
<th>Required operation</th>
<th>Component</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grating</td>
<td>Grater</td>
<td>Grate fruits or vegetables</td>
</tr>
<tr>
<td>Peeling</td>
<td>Peeling blade</td>
<td>Peel the fruits or vegetables skin</td>
</tr>
<tr>
<td>Cutting</td>
<td>End-cutting blade</td>
<td>Cut the fruits or vegetables after being grated or peeled</td>
</tr>
</tbody>
</table>

![Image of the apparatus]

Fig. 1: Front view of the apparatus. 1: Pushrod, 2: Trident, 3: Grater, 4: Peeling blade, 5: End-cutting blade, 6: Switch, 7: Safety cover, 8: Arm

- **Trident**: The trident is set on the machine body which supports the fruit to be grated and peeled. It supports the fruit, making it spins.
- **Pushrod**: The pushrod is opposite to the trident and on the same axis. It can be moved by adjusting its locking nut and handle knob. It holds the fruit up to enable the rotation and also to push the fruit against the trident.
- **Grater**: The grater is situated on a handle which is movable. One of the functions is to grate fruits and/or vegetables for food decoration purposes.
- **Peeling blade**: The peeling blade is situated on the arm and its function is for peeling fruits and vegetables skin.
- **Arm**: The arm is situated on a sliding vector and it moves parallel to the fruit rotation axis. It supports the peeling blade, which peels fruits and vegetables; an elastic system presses the arm softly on the fruit and holds the peeling blade position against the fruit. The arm enables the peeling blade to move on the profile of the fruit, so that the fruit is completely peeled.
- **End-cutting blade**: A pair of end-cutting blade is situated on another handle and its function is for cutting the fruits ends.
- **Power unit**: The apparatus is powered by a horse power electric motor.

**The Operational Research**

Fruit is positioned at the centre of the trident and pushrod is moved towards the centre of the fruit top to secure the fruit. After that, the machine is switched on to make the machine operates. Turn left the knob to switch on the grater and turn right to switch on the peeler.
Once the machine is switched on, the lower clamp will rotate the fruit and at the same time a grating/peeling blade starts to move parallel to the vertical axis of the fruit which enables the contact between the grating/peeling blade and the fruit.

The fruit/vegetable is grated using the grater which has holes on the curved surface (Fig. 2). The fruit/vegetable is peeled progressively by the combination of arm and peeling blade which moves on the fruit profile. After the fruit/vegetable is successfully peeled and/or grated, both the fruit ends are cut by moving the end-cutting blade holding arm towards the fruit. To perform the operation, the grater is placed in contact with the fruit/vegetable surface while the fruit/vegetable is rotated.

**EXPERIMENTAL TESTING**

**Fruits and Vegetables**

Fruits such as papaya, apple, orange, pear, lemon, red and white dragon fruits were purchased from the local market in Selangor, Malaysia. Vegetables such as cucumber, potato and carrot were also purchased from the same market. These fruits and vegetables were grated and peeled. The performance of the peeler (in this context is peeling blade) was evaluated.

**Size of Samples**

The size of each sample was determined in terms of height (cm) and diameter (cm).

**Determination of Peeling Time**

The fruits and vegetable selected were peeled using the apparatus to determine the peeling time of each sample. Manual peeling has also been performed using knife in order to compare the peeling time between the two methods. All reported values of peeling time indices were means of three determinations.

**Machine Testing**

The fruits machine was tested for the grating, peeling and cutting processes.

**RESULTS AND DISCUSSION**

**Grating**

This is a useful machine to automatically grate the fruits/vegetables with or without scales on the skin. There were some fruits and vegetables such as papaya, carrot and cucumber that was grated using this apparatus as shown in Fig. 3 and 4a-c.
Fig. 3: Grating cucumber

Fig. 4: Grating products: (a) cucumber, (b) carrot and (c) papaya

Fig. 5: Peeling products: (a) papaya, (b) papaya flesh and (c) papaya skin

From Fig. 3, it can be seen that the machine successfully grated the cucumber to produce shredded/grated products. The average time to grate food depends on the size and shape of the material used. If a material has a diameter ranging from 4 to 10 cm, it can be grated between 3 to 8 sec (depending on the height). The grating process can be made continuous depending on the process requirement.

**Peeling and Peeling Time**

This machine also automatically peel the fruits/vegetables that are round (spherical) or oval shapes. There were some fruits and vegetables such as papaya, mango and potato that were peel using this apparatus. Figure 5a-c show example of peeling products.

The results of the test carried out to determine the peeling time of the apparatus are shown in Table 2.

The test carried out using this apparatus indicated up to 94% (Fig. 6) reduction in peeling time of the selected samples when compared to manual peeling. This is useful to enhance the performance of fruits and vegetables processing operation. However, the peeling time is depending on the size and the texture of the skin. Smaller fruits can be peeled faster than the larger ones. For instance, peeling of potato was faster than orange because
Fig. 6: Percentage of reduction in peeling time

Table 2: Average size and peeling time of several fruits and vegetables

<table>
<thead>
<tr>
<th>Fruit/vegetable</th>
<th>Height (cm)</th>
<th>Diameter (cm)</th>
<th>Peeling time (manual) (sec)</th>
<th>Peeling time (peeler) (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red dragon fruit</td>
<td>10.74±0.78</td>
<td>10.23±0.15</td>
<td>43.91±0.17</td>
<td>6.41±0.04</td>
</tr>
<tr>
<td>White dragon fruit</td>
<td>12.63±0.13</td>
<td>9.23±0.25</td>
<td>48.17±0.03</td>
<td>6.52±0.04</td>
</tr>
<tr>
<td>Apple</td>
<td>7.70±0.00</td>
<td>7.96±0.31</td>
<td>64.71±6.24</td>
<td>4.39±0.15</td>
</tr>
<tr>
<td>Orange</td>
<td>8.50±0.21</td>
<td>7.73±0.15</td>
<td>42.02±2.05</td>
<td>4.50±0.07</td>
</tr>
<tr>
<td>Pear</td>
<td>7.75±0.07</td>
<td>7.87±0.15</td>
<td>37.27±2.79</td>
<td>4.14±0.17</td>
</tr>
<tr>
<td>Lemon</td>
<td>8.00±0.28</td>
<td>6.77±0.45</td>
<td>64.05±5.28</td>
<td>3.90±0.13</td>
</tr>
<tr>
<td>Potato</td>
<td>6.20±0.61</td>
<td>4.69±0.56</td>
<td>37.89±2.23</td>
<td>3.17±0.62</td>
</tr>
</tbody>
</table>

Values given are the mean of three replicates ±SD. *This result may vary according to the size of the fruit.

Table 3: Summary of some existing design (patent) of grater and peeler for fruits and vegetables

<table>
<thead>
<tr>
<th>Design</th>
<th>Patent No./year</th>
<th>Source</th>
<th>Type of invention</th>
<th>Feature summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grater</td>
<td>US D568,118 S/2009</td>
<td>United States Patent</td>
<td>Box Grater (Chalfant et al., 2008)</td>
<td>The graters were a small grater for home use</td>
</tr>
<tr>
<td>Peeler</td>
<td>US 7,077,058 B2/2006</td>
<td>United States Patent</td>
<td>Fruit and vegetable peeler (Muro, 2006)</td>
<td>The peelers or peeling machines were suitable for domestic use</td>
</tr>
</tbody>
</table>

of the smaller size as in Table 2. The peeling time of fruits and vegetables that were manually peeled were slower than the fabricated apparatus. Therefore, by using this apparatus, apple, lemon and potatoes reduce more peeling time compare with other fruits which below 92%; this might be due to the texture hardness. This new apparatus operates more efficient when peeling harder and firm materials such as apple, compared to dragon fruit which obviously has soft texture.

Machine Characteristics

The existing designed/invention of fruits and vegetables peeling and grating machines are presently available in two separate equipments. Table 3 shows some of the examples of those fruits and vegetable grater and peeler that are disclosed in United States Patent Application. Table 4 describes the characteristics of similar technology compared with this newly designed apparatus. This new apparatus has been filed for patented in Malaysia in year 2008. It is shows that, the new design apparatus has used combination feature of grater, peeler and cutter, which yet not available in current market. The new apparatus makes fruits/vegetables grating and peeling process more efficient, for example the fruit will be grated upon finished the peeling process and it is done within the same apparatus. Table 4 also, shows clearly to differentiate and thus simplifying the advantages of this new designed fruits grater and peeler.
Table 4: Comparison between current technology and the designed apparatus

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Current/existing technology</th>
<th>New design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grater</td>
<td>Available</td>
<td>Combination of 3 functions in one processor unit</td>
</tr>
<tr>
<td>Peeler</td>
<td>Available</td>
<td>USD 1.5</td>
</tr>
<tr>
<td>Cutter</td>
<td>Available</td>
<td>USD 10</td>
</tr>
</tbody>
</table>

Estimated price *

- Grater (Manual): USD 2-5
- Peeler: USD 31
- Cutter (Manual): USD 1.5

*The price was given based on Malaysia market; it may vary according to country

CONCLUSIONS

An apparatus for grating and peeling fruits and vegetables was designed and fabricated. The unit was tested and found capable to grate and peel fruits and vegetables of small and medium size, i.e., apple, orange, cucumber, papaya and potato. Grating using this apparatus worked successfully to grate/shred fruits and/or vegetables automatically. Peeling using this apparatus was found to satisfactorily peel the selected fruits and vegetable. However, improvements are still required in several aspects of the machine such as adding a sensor for cutting process. Further modifications and improvements would definitely open a new potential of this apparatus to be commercialized as a versatile grater and peeler that helps improves the fruit processing operation. This newly designed apparatus is also suitable for domestic use and food dispensing business such as hotels, due to its small-sized and light-weight.

ACKNOWLEDGMENTS

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