CRACK ‘N SNACK

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Abstract
Despite being a popular snack around the world, in-shell peanuts lack a practical means of shelling beyond “by hand” shelling. Currently there is no device that cleanly shells and separates peanuts for personal use. All primary shelling and sorting methods occur in industrial settings, where the shell is broken by applying a force in a variety of ways, and removed by using specific differences in the physical properties of the shell and kernel. These processes are well suited for mass production, but have yet to be adapted for the consumer.

In order to develop a personal device that shells peanuts and separates the kernels, research has been conducted on the background of the peanut industry, physical properties of peanuts, and current methods of processing peanuts. A proof of concept was developed to test the shelling process on a small scale. Initial sorting trials have identified a passive method that separated over 75% of the unwanted debris from the kernels. Subsequent generations of designs led directly to the development of a handheld shelling prototype that achieved 100% shelling success. The resulting prototype incorporates a hand operated rotary sheller with a two stage gravity fed sorter. The culmination of research and prototype testing resulted in an easy to use consumer product that effectively shells and sorts peanuts.

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The Need for Project

The project goal was to create a consumer product that shells and sorts peanuts more easily than the current method of hand shelling. Peanuts are enjoyed by a global consumer audience. In 2012 alone, 35.5 million metric tons of peanuts were produced and processed globally (Rep. 3.4.1). In the United States, in-shell peanut consumption accounts for 9% of overall peanut consumption, or about 40% of total snack peanut consumption. The European Union enjoys in-shell peanuts in even higher quantities, almost 15% of overall peanut consumption (Rep. 3.4.1). While in-shell peanuts remain popular globally, the only method of eating in-shell peanuts on a personal scale is by shelling and sorting them by hand. This method is ineffective, tiresome, and time consuming (Rep. 4.2.5). The goal of this project was to create a consumer device that shells peanuts at a faster rate than hand shelling while effectively sorting out unwanted shells.

The Design Project Objectives and Requirements

The objective of this project is to develop a device that is easy to operate and effective at shelling and sorting peanuts. It must also be portable, affordable, and robust enough for the intended consumer audience. Design Objectives

In order to meet the intended goal of this project, the design must fulfill some specific objectives. As a consumer device, it must be easy to operate by all users and small enough for personal use. It must also consistently break the shell and sort the debris from the kernels. Finally, it must be an improvement over the current method of hand shelling.

Design Requirements

Several design requirements must be met to ensure overall product success. It must be completely machine washable and easy to manufacture. The product must also have a high repeatability of success (75% shelling and debris separation). The cost must be comparable to other small kitchen gadgets (below $20). The overall design must be portable for use at a variety of venues where peanuts are consumed (e.g. sporting events, circus, bars, etc.). Finally, the design and material selection must be robust enough to withstand normal use.
Design Concepts Considered

Five initial design concepts were developed, two of which fully meet the requirements and were tested with a proof of concept design. Several initial design concepts were developed and evaluated based on the design requirements. Initial experiments verified that the optimal peanut shelling method was fatigue loading, defined as the application of a small, repeated load to the outer shell. The two most promising sorting methods were blowers and gravity fed sorters. These shelling and sorting methods were incorporated into five initial design concepts, two of which were pursued and tested in a proof of concept. These concepts were a vertical drum and blower, and a hand crank and two level hopper.

Vertical Drum and Blower

This concept operates by breaking peanut shells as they are forced into the narrow gap between the vertical drum and the outer wall. As the peanuts are shelled, a set of blowers push debris into a removable collection chamber within the drum, while all kernels fall below into a collection shelf. All components of this device are motor driven.

Hand Crank and Two Level Hopper

The hand crank and two level hopper concept breaks peanut shells via a hand operated set of angled paddles. The paddles continuously break the shells into smaller fragments, which are forced into the lower level. The spacing between the two levels is too small to allow kernels to drop into the lower compartment.

Recommended Design Concept

The current design concept consists of a shelling section and a sorting section which are 100% and 87% effective, respectively. It consists of a simplified 6-part design for easier operation and cleaning. A hand operated proof of concept tested cone and angled paddle shelling inserts and various surface geometries. The cone insert performed the best in all trials and was used in all future concepts. Based upon the proof of concept results, three general design types were considered (a powered sheller/powered sorter, a hand powered sheller/powered sorter, and a hand powered sheller/passive sorter). Using a decision matrix, the hand powered sheller with passive sorter was selected because it most effectively met the design requirements.

Design Description

The current design is completely enclosed within a cylindrical outer housing measuring approximately Ø3.6” X 8.6”, consisting of a sheller and sorter section. A turn cap rotates the cone via a central square rod. Peanuts are loaded into the top of the device, and shelling
operates much like a pepper grinder. As peanuts are shelled, debris and kernels fall into the sorting portion of the device. A two stage gravity fed sorter was used based on background research and testing. The upper stage traps larger shells while allowing kernels to fall through. Any dust and smaller debris filter through the second stage into a lower compartment. The user operates the sorter by shaking the device to facilitate kernel movement.

**Analytical Investigations**

10 male and 10 female subjects were asked to operate a prototype device and answer questions about their overall impressions. All users were able to operate the device with little to no instruction. General feedback led to an overall reduction in height. Subjects generally rated on a Likert scale that the device was an improvement over hand shelling, shelled peanuts in a fairly reasonable time, and could be appropriately priced at ~$15. It was also noted that most users switched between two grip types while shelling.

**Experimental Investigations**

The current design was refined through multiple experiments on each component of the model. Three surface geometries were tested on the cone and inner housing wall to determine the most effective at shelling peanuts. An embossed diamond surface was the only geometry that had a 100% shelling efficiency. Sorter hole diameters ranging from 0.275” to 0.655” were compared based on the effectiveness of separating debris from the kernels. A hole diameter of 0.475” consistently collected all kernels on one side while removing the most debris. Subsequent testing demonstrated that adding a second, lower sorter stage with 0.275” diameter holes increased the overall sorting efficiency from ~80% to ~87%.

**Key Advantages of Recommended Concept**

Overall operation of the current design is similar to that of a pepper grinder, making it very intuitive to use without requiring any electronic components. Stacking the sheller and sorter in a cylindrical configuration increases peanut contact area in a compact and portable design. The device consists of 6 plastic parts which can be easily and cheaply manufactured by an injection molding process. Finally the concept can be broken down into its individual components for easy washing.
Financial Issues

Due to the repeated loading exerted on the cone and inner housing, it was determined that poly methyl methacrylate (PMMA) should be used as the construction material because of its hardness and melting temperature. Since this design is intended to be a consumer product, it must be compatible with high volume/low cost manufacturing to maximize potential product sales. Injection molding was selected to manufacture all parts because the major costs of production are associated with making the molds. With total estimated mold costs of $90,000, a complete unit would cost ~$5.00 - $6.00 at a batch size of 10,000 units.

Due to the high initial investment costs required to manufacture the prototypes in this manner, all prototypes were constructed using rapid-prototyping machines at no additional cost to the University. The total budget for this project came in under $200.

Recommended Improvements

The final production material, PMMA, must be tested to ensure that it is robust enough for repeated shelling. Further investigation into modifying the device for less common peanut sizes and/or other types of nuts should be conducted. This may involve altering the shelling surface geometry, adjusting the sorter hole diameters, and changing the minimum spacing between the cone and outer housing. A more elaborate human factors study involving a wider range of ages should be undertaken to ensure consistent ease of operation for the users. A table top version with higher capacity and a powered sheller/sorter design should be investigated to accommodate a wider range of customer needs.

Efforts should be focused on validating the final production material of PMMA, investigating potential use with other nut types, and a more extensive human factors study.