The Separation of Argan Kernels and Shells Using Commonly Applied Agricultural Techniques

An Interactive Qualifying Project Submitted to the Faculty of
Worcester Polytechnic Institute
In supplement of the requirements for the Degree of Bachelor's in Science by
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March 15, 2021

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Introduction

Argan nut processing begins with the harvest of the fruit by hand from the argan tree. The fruits are sun-dried for up to 28 days before they are ready to be processed (Harhar, 2010). After the outer fruit is removed, the nuts are then brought to a processing facility to be cracked. The traditional method of the cracking process involves using two rocks, one flat and one sharp, and firmly striking a singular nut between the two. Once the nut has been cracked, the kernel must be separated from the shell pieces, which is also currently done by hand. A thorough separation is essential as contaminants can decrease the quality of the oil or clog the oil extraction machine. A thorough separation is essential as contaminants can decrease the quality of the oil or clog the oil extraction machine. Once the kernels are separated, they are ready for oil extraction. In Morocco, traditional millstone techniques are used for argan oil extraction; however chemical solvent extraction and mechanical extraction (cold press; the technique used at Kibbutz Ketura) processes are becoming increasingly popular to match the speed required to meet argan oil demands (El Abbassi, 2014). The mechanical press method closely mimics the original hand and millstone technique, but without the manpower and fatigue that comes with manual labour. Once the oil is extracted and filtered, it is ready for packaging and transport where it is distributed to the global market. The most time-consuming and least automated step in argan manufacturing is the separation process. A review of Perry's (2020), Nerd's (1994), and Matthäus' (2010) papers discussing the current state of argan processing has demonstrated that there are few separation techniques that use advanced tools or automation that are workable on the scale that the Kibbutz is growing currently. This means that manual separation is currently the main bottleneck to the growth of argan processing at small facilities (Dodson, 2020). The time taken to separate the pieces is increased by the current cracking techniques including Nadav's nutcracking machine, which are not precise enough to cleanly crack every nut, resulting in dust and kernels being broken. Since separation is mostly done by hand, separating the small kernel and shell pieces takes more time, and therefore, more manual labour.

To give a sense of how difficult and time consuming the work of cracking by hand, stone, and other man-powered tools is, researchers have studied the amount of labour required to produce certain amounts of argan oil. However, these various studies have different numerical claims, so the amounts at different facilities may differ based on current processing factors. Approximately 100 kilograms of dried fruits and 15 hours of a person's manual labour produces about 60 kilograms of argan nuts to be cracked and separated. Those 60 kilograms of argan nuts are converted into about 6.5 kilograms of argan kernels (Matthäus, 2010). Given that the amount of argan oil yielded per nut is around 55%, 3.57kg of argan oil is produced with 15 hours of work from one person, excluding the oil extraction time (Harhar, 2014). In total, 58 gruelling hours of one worker's manual labour is required to create about 2 litres of argan oil (Matthäus, 2010), with each litre selling for as much as $300 (Ash, 2020). Further investigation has shown that there is a discrepancy within these numbers as one study claims that 20-25 kilograms of fruit led to 2 kilograms of kernels, and thus created 1 litre of argan oil (ArganFarm). If this process were to be automated, more argan can be processed using less manual labour, effectively creating more oil.

As Kibbutz Ketura moves more substantially towards argan production, increasing the size of the grove and readying themselves for larger-scale production, they are looking towards the most efficient practices for this venture. Included in more efficient practices is making use of the kernels and shells that come out of the cracking machine and are pulverized, which are unable to be hand-sorted. As production of argan scales, the profit the kibbutz stands to lose from these pulverized nuts will increase. Through the acquisition of a separation process and the suggestion of an implementation plan, the kibbutz will be able to make the separation production process more efficient. This will not only increase the efficiency of the process, but it will also increase the amount of argan oil that Kibbutz Ketura is able to produce.

Processing in Agriculture

Separation processes of other nuts that share similar structure may yield success if they are tweaked to handle argan nuts. Studies on the fruit of the argan tree show the general structure of the argan fruit shares similarities to many stone fruits (Sebaa, 2014). A stone fruit is characterized as a fruit with a seed encased by a large, stone-like pits called endocarps. Stone fruit may also be classified as "drupe" which is a synonym for a stone fruit as shown in figure 1. Pistachios, cashews, walnuts, pecans, and almonds are classified as drupes (Zalben, 2019).

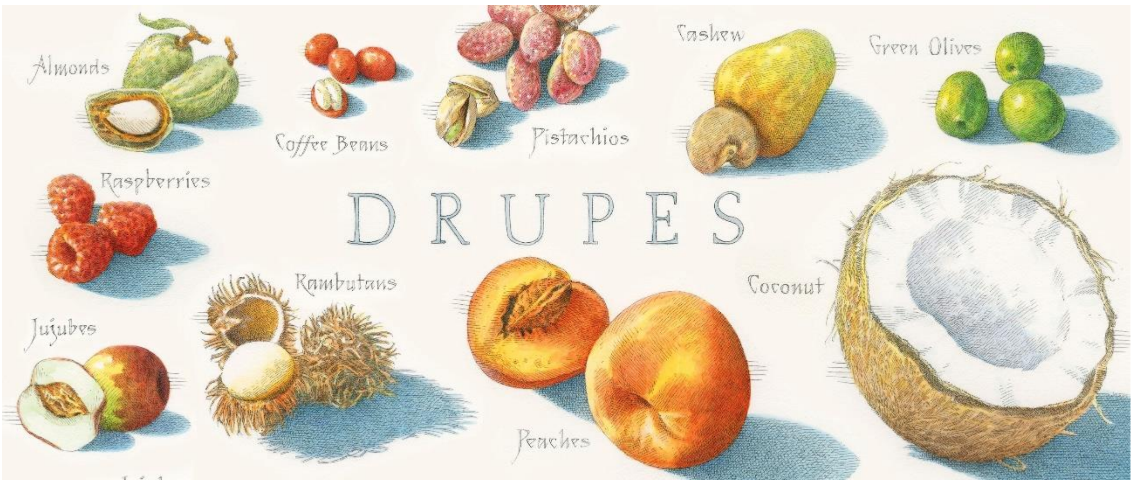

Figure 1: Examples of Drupes/Stone Fruit

Almonds are a drupe that have been seen mass-production primarily in California for a long time, even to the point of people not knowing what almonds look like in their fruit form in the western world. The almond that is most seen in stores is the seed within the almond fruit pit, sharing the same oval shape as an argan kernel ("Almonds are fruit!", 2018). Almonds undergo a hulling and shelling process after being transported from the orchards to the processing facilities. Alongside the raw almond material that requires separation, soil, debris, and pebbles are also brought the material for processing. Post-harvest processing facilities handle either hulling or hulling and shelling of almonds to deliver a final product (U.S Environmental Protection Agency, 1995, pg.1). Two main processes in agriculture are hulling and shelling, which are important for producing many of the oils and snacks we have today. Hulling deals with removing the outer portion of a seed or fruit while shelling handles the removal of the shell of a seed or kernel. For both the almond and argan fruit processing, an integral part of gaining the kernel is the shelling procedure. However, almonds and other harvested agricultural goods must have the orchard debris removed unlike the argan nuts. De-twiggers and de-stoners are two machines that handle the task of removing twigs and stones from the almond bunches for further processing. The main part of almond processing is handled by using gravity tables, which will separate based on weight and density of particles (U.S Environmental Protection Agency, 1995, pg.4). De-stoners also work on the same principle as the gravity tables, but each gravity separator can be tweaked for different purposes.

A viable method of separating solids in the agriculture industry is the usage of a gravity separation table based on buoyancy, gravity, and specific gravity. Buoyancy is the force exerted by an object immersed in a static fluid that is caused by the difference in pressure on opposite sides of the object. The bottom surface will have a lower depth compared to the upper surface, so the net buoyant force is usually upwards. Gravity is the force exerted by the Earth on an object on or off its surface towards the centre of the earth. In the case of an object on the surface of earth. the mass of the object is only dependent on the mass of the object. Lastly, specific gravity is the ratio of the density of an object in comparison to the reference fluid. Since air is the working fluid of gravity separators, the reference fluid for specific gravity would be air (Thomas, 1980). The only thing that would have to vary to see a noticeable difference would be the densities of the two objects that are meant to be separated. Combining the three principles bring us the principle of stratification via air to separate materials by forcing air through the particle mixture to create separation based on their weight, or specific gravity relative to air as shown in

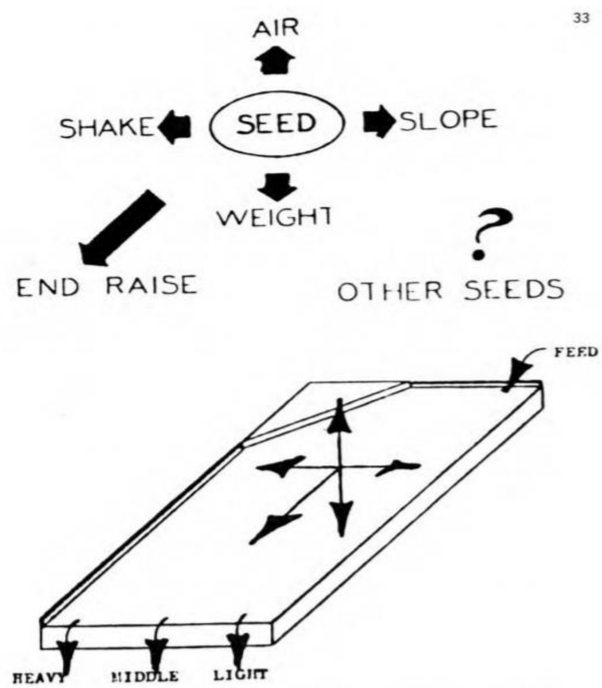

Figure 2: Gravity Table Separation Example and Factors that Influence Separation.

figure 2 (Thomas, 1980). Stratification occurs in a stratifying area where vibration and the light flow of air combine to form layers out of the material from top to bottom following the pattern of low to high specific gravity, respectively. The vibration of the stratification area's surface pushes the heavier layers due to them contacting the surface while the lighter layers float to an exit area for collection.

Stratification Implementations

Stratification has the benefit of precisely separating solids based on simple physical properties, but it does require precision to operate. Argan kernels and shells vary in density by very small increments but it is magnified as seen in the case of certain concentrations of salt water. The applications of salt water cannot be used here so other complications come up in the gravity separation method. Minute differences in the argan kernel in shell will require more technique to handle compared to saltwater separation since multiple concepts are introduced into the process. To compensate for this difference, the amount of area the stratification field requires would need to be increased for clearer layer separation (Thomas, 1980). Furthermore, to process more argan nuts per hour there would need to be more area to handle a large capacity of nuts. The most important part of stratification working successfully would need an adequate flow of air to be generated to ensure there is just enough air pressure across the total surface to lift the light particles above the heavy particles, otherwise, all the material would be blown away as shown by an aerodynamics test. Handling these challenges would require control mechanisms like setting a designated feed rate, exit rate, air pressure, stratification bed tilt, and vibration intensity or vibration oscillation frequency (Thomas, 1980). Finding an ideal setting for multiple batches would be a difficult challenge but it would bring great reward since the process would just need the settings to be documented for easy automation purposes. With the current scale that the kibbutz is working with I believe after the settings are found for a set amount in a batch to be processed then there will be a reliable method to separate nuts until rescaling is necessary. In the future the kibbutz will be trying to increase production rate by introducing more dunams to the argan orchards in place, so recalibration of the gravity separation settings based on argan nut capacity would be necessary and more area would need to be allotted to handle the new capacity. For starters though, the market has many gravity separators for minerals that are approximately $1000 dollars but would need to have adjustments to the air pressure and vibrations to handle the delicate argan nuts.

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