Pine Nut Post-Harvest Dryer for Lebanese Farms

Claire Coon, John Derry, and Makaila Vasconcellos
Biological and Agricultural Engineering, Texas A&M University

Introduction

The American University of Beirut in Lebanon presented the team with the task of improving the pine nut (pinus pinea) post-harvest process in Lebanon. In chronological order, the main steps of this process are harvesting, drying, processing, shelling, and further processing. The team saw the greatest need for improvement in the drying stage and decided to focus efforts on modernizing this aspect of the process.

[Left] The steps of pine nut processing

Design Objectives

Design an industrialized drying process for pinus pinea that:

- Limits electricity use while still increasing overall process efficiency
- Fulfills the drying needs of the vast majority of pine nuts in Lebanon

Constraints

- Capital costs must fall within a budget of $10,000
- All pine cones must be processed within a period of 90 days

Motor

The team has sized the motor with a one to six gear ratio to reduce costs without sacrificing performance. The gear on the motor will be 7 inches in diameter. The motor will be required to have a torque of 69.3 Newton-meters and a horsepower of at least 0.132 HP. Ultimately a ¼ HP commercially available motor was chosen.

Dryer Design

The current method used by pine nut farmers in Lebanon is sun drying, a lengthy process that results in a high loss of product. Multiple options that mimicked this process were explored, and ultimately the best choice was determined to be an industrial drum dryer. PineWorks' proposed final design is a barrel type dryer 600 gallons in volume. This is approximately equivalent to a diameter of one meter and a length of three meters. The team's design employs forced air convection using a heating element and fan which will flow countercurrent to the flow of pine cones.

A few assumptions were made in order to proceed with the design:

- Two facilities where dryers can be placed already exist
- The dryers will process all of the pine cones in a particular region of Lebanon
- Electric power supply is in place at these facilities

Drum

The drum design requirements were calculated based on the estimated required number of pine cones to be processed in the region. In order to accomodate drying all of the pine cones, each one of the twelve dryers will be one meter in diameter and three meters in length.

Heating Element and Fan

Forced convection is achieved using a combination of heating elements and fans. Hot air is blown in a countercurrent fashion using two, one-foot diameter centrifugal fans on each dryer. Each dryer requires an electric strip heating element that supplies between 15 and 20 kW/hr to properly heat the pine cones to 93 degrees Celsius. In addition to this main heating element, a thermostat and a heating duct are also required to control the temperature and properly ventilate the hot air from the system.

Cost Analysis

Procurement

- Motors, electric heaters and centrifugal fans
  - 6,974,200 Lebanese Pounds (~$4,605 USD)
- Drums
  - Drum cost is to be determined based on current prices of metal and labor available in Lebanon at the time of construction.

Labor and Resources

- Installation
  - Fixed cost of 720,000 Lebanese Pounds ($480 USD)
- Running Costs per 90 day season
  - Electricity - 101,088,000 Lebanese Pounds (~$67,300 USD)
  - Operators - 5,400,000 Lebanese Pounds (~$3,600 USD)

Conclusion

It is suggested that the Lebanese farmers install 6 dryers in both of the existing pine nut processing facilities to replace the current sun drying method. In doing so, the drying time will decrease and the yield per time interval will increase. Further testing is recommended in the future to reduce any uncertainty regarding drying time and the necessary heat capacity of the dryers.

References

Gharibzahedi, S., Etemad, V., & Mirarab-Razi, J. (2010). Study on some engineering attributes of pine nut (Pinus pinea) to the design of processing equipment. Research in Agricultural Engineering, 56(3), 99-106.

Mutke, S., Calama, R., Monteros, G., & Gordo, J. (2015). Pine nut production. Paper presented at the Workshop and MC Meeting Zagreb.

Nurlaila, W., Desa, M., Mohammad, M., Fudholi, A. (2019). Review of drying technology of fig. Trends in Food Science & Technology, 88(1), 93-103.

Özgüven, F., & Vursavuş, K. (2005). Some physical, mechanical and aerodynamic properties of pine (Pinus pinea) nuts. *Journal of food engineering,* 68(2), 191-196.

Sfeir, P. (2011). Stone Pine and pine nuts production in Lebanon. *International Meeting on Mediterranean Stone Pine for Agroforestry*, Valladolid, Spain.