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ECED Group 13
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Beyond Food Inc.
BEYOND FOOD

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Vacuum Microwave Produce Dryer

Introduction

● Food waste is a huge problem, with tons of edible food going to waste every year, especially from grocery stores[1].

● If this food could be preserved, all this waste could be diverted and many people fed.

● One method of preserving food for up to 2 years is vacuum microwave drying.

● This process uses microwaves to heat food, and a vacuum to remove water.

● It is proven to be very fast, energy efficient, and excellent at preserving produce nutrition, flavor, and appearance.

Design Process

The initial proposed solution was based off a design from another lab group (Fig. 1).

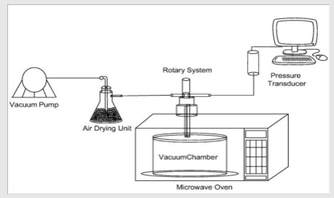

Figure 1. Vacuum microwave dryer system, courtesy of Monteiro, R.L., et al (2015).

This system includes a:
1. Vacuum Chamber
2. Rotary System
3. Pressure Sensing System

However, this solution was reworked due to:
1. Safety Issues - A hole in a microwave would allow the EM waves to escape
2. Unavailability of Parts - Rotary parts are unavailable in microwave-safe material

Hence, a second solution was proposed and initiated. Because testing involved only small quantities of produce, an air-drying unit could be neglected, thus it was possible to vacuum the chamber by using a microwave-safe valve to close the system, and then put the vacuumed chamber into the microwave oven.

Details of Design

Drying process:

1. Put vegetables in vacuum chamber
2. Secure vacuum chamber
3. Pull vacuum until desired pressure is achieved
4. Close valve, turn off vacuum pump
5. Microwave vacuum chamber for desired amount of time

Due to lack of availability, some of the parts used were microwave safe but not food safe, including the plastic valve and tubing.

Figure 2. System Setup

Results

Ideally, dried vegetables should have a moisture content of 5-25% depending on the vegetable, or 7% for use specifically in powders and supplements[3].

The lowest moisture content we were able to achieve with this system was about 17% for kale. However, at this percentage, the kale felt completely dry, and we found that if we dried it further, it began to burn.

Since broccoli had the highest starting percentage of water, it was more difficult to dry. We were not able to produce any samples that felt as dry as kale and the lowest moisture content achieved was 35%.

Sweet Potato had a smaller starting percentage of water but higher sugar content, and it fell between kale and broccoli for drying results. However, it required longer drying times that caused the valve we used to heat up too much and melt.

Figure 3. Dried Kale

Figure 4. Dried Broccoli

Figure 5. Dried Sweet Potato

Table 1. Test Results

Kale						
Time (s)	Starting weight (g)	Final Weight (g)	Power level	Pressure	Starting % water	Final moisture content (%)
35	10	3	10	0.7 bar	84	46.66
40	10	5	10	0.7 bar	84	68
45	10	2	10	0.7 bar	84	20
45	10	2	10	0.7 bar	84	20
50	10	3	10	0.7 bar	84	46.66
50	10	3	10	0.7 bar	84	46.66
Broccoli						
Time	Starting weight	Final Weight	Power level	Pressure	Starting % water	
50	10	6	10	0.7 bar	89	81.66
80	10	4	9	0.7 bar	89	72.5
80	10	5	8	0.7 bar	89	78
80	10	6	8	0.7 bar	89	81.66
90	10	5	8	0.7 bar	89	78
90	10	6	8	0.7 bar	89	81.66
90	10	4	8	0.7 bar	89	72.5
60	10	6	7	0.7 bar	89	81.66
75	10	5	7	0.7 bar	89	78
Sweet Potato						
Time	Starting weight	Final Weight	Power level	Pressure	Starting % water	
40	10	8	10	0.7 bar	77	71.25
60	10	7	10	0.7 bar	77	67.14
66	10	6	10	0.7 bar	77	61.66
90	10	3	7	0.7 bar	77	23.33
90	10	3	6	0.7 bar	77	23.33
105	10	3	6	0.7 bar	77	23.33
110	10	5	6	0.7 bar	77	54
120	10	5	6	0.7 bar	77	54
110	10	4	5	0.7 bar	77	42.5
138	10	6	5	0.7 bar	77	61.66

Discussion

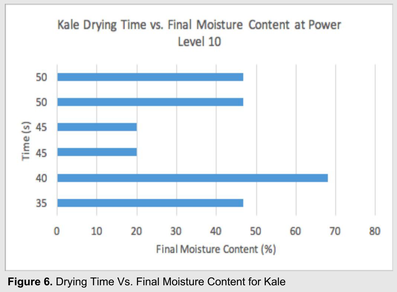

Figure 6. Drying Time Vs. Final Moisture Content for Kale

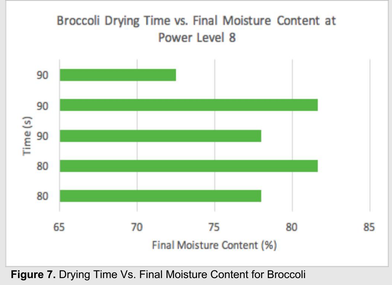

Figure 7. Drying Time Vs. Final Moisture Content for Broccoli

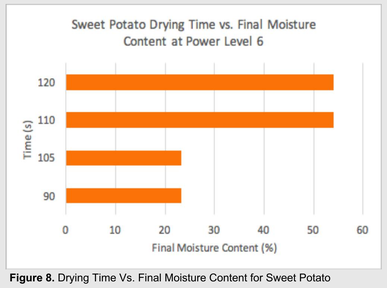

Figure 8. Drying Time Vs. Final Moisture Content for Sweet Potato

Although the desired final moisture contents were not achieved, the team was able to reduce the moisture contents significantly, particularly for kale.

Significant changes to this system would need to be made in order to make a safe, effective vacuum microwave dryer.

Recommendations

● Stronger/more airtight vacuum chamber

● Food safe and microwave safe material

● Integration of the microwave and the vacuum chamber into one system

● Implementation of a method to collect the waste water to make the system zero waste

Conclusion

A small-scale, economically friendly vacuum microwave dryer prototype was developed that can dry kale, sweet potato and broccoli in a fast manner to extend its shelf life.

However, to achieve the optimal moisture content for powders, supplements and dried vegetables products, the system design has to be improved.

Acknowledgements

We would like to thank our external supervisors Dr. Darren Burke and Ms. Laura Purdue for their support and guidance throughout this project, as well as Dr. Sergey Ponomarenko, Dr. Chen, Dr. Kamal El-Sankary, Dr. Jose Gonzalez, Mr. Dean Grijm and Mr. Peter Jones for their help.

References

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[2]Monteiro, R.L., et al (2015). How to make a vacuum microwave dryer with a turntable. *Journal of Food Engineering. 166, 276-284* https://www.sciencedirect.com/science/article/pii/S0260877415002848

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