## FAPC-175 Robert M. Kerr Food & Agricultural Products Center



# FOOD TECHNOLOGY FACT SHEET

Adding Value to Oklahoma

405-744-6071 • www.fapc.biz

## **Dehydrator Optimization:** Reduction of Energy Use and Carbon Emissions

#### **Tim Bowser**

FAPC Food Process Engineer

Food dehydration is an age-old process that is extremely popular today. While production of canned foods is on the decline (Steel Works, 2011), production of dehydrated foods is experiencing a resurgence (Cosgrove, 2010). Jerky (especially beef) continues to be a favorite in Oklahoma, while dehydration of fruits, vegetables and spices are increasing.

Dried foods are inherently stable and safe, but these properties come at a cost. Large quantities of energy are needed to remove the water, and energy use has an obvious environmental impact. Options must be explored to reduce the energy needs and environmental impact of dehydration. This fact sheet describes one method that can be used to reduce energy consumption and carbon emissions associated with food dehydration.

#### **Waste Heat Recovery**

A simple schematic of a conventional dehydration chamber is shown in figure 1. Air in the dehydrator is heated by circulation through a heating coil. Fresh air is brought in through a duct in the side of the chamber and exhausted through a similar duct in the other side of the dehydrator. The exhaust air contains waste heat that can be recovered using a heat exchanger (Krokida and Bisharat, 2004). Heat exchangers are devices used to transfer heat from a source to a sink. Heat exchangers can be observed in everyday equipment like the radiator of an automobile, or the coils of an air conditioner.

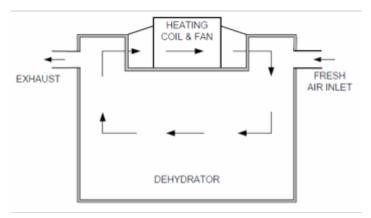
A special type of heat exchanger has been developed for modern air-conditioned homes that are built with virtually air-tight exterior envelopes. This heat exchanger,

#### **R. Scott Frazier**

Biosystems & Ag Engineering, Energy Systems Engineer

known as a Ventilation Heat Recovery (VHR) unit, is designed to capture waste heat in the home ventilation system exhaust stream and use it to preheat incoming fresh air. VHRs are mass produced by several companies (see side bar on page 4) and used in new home construction to provide energy savings and improve indoor air quality. Figure 2 shows an example of a VHR designed for home use that is rugged, durable, cleanable and inexpensive.

Flexible, insulated ventilation ducts can be used to connect a VHR unit to a dehydrator. Figure 3 shows a schematic of how a VHR may be connected to a dehydrator. Fans in the VHR move the air through the unit. Some VHRs have variable speed fans, which can be adjusted to optimize the ventilation rate. The next section describes the results of a study to test the performance of a dehydrator with a VHR installed.



*Figure 1. Conceptual side view of conventional dehydrator.* 



Figure 2. Typical VHR unit used to recover waste heat.

#### **Example of Dehydrator Waste Heat Recovery**

A low-cost home-built dehydrator (Bowser, 2011) was outfitted with a VHR unit (Fantech model SHR 2004, Lenexa, Kansas) and tested on cilantro (*Coriandrum sati-vum*). Cilantro was fresh-cut by hand, water-washed and dripped-dry prior to dehydration on perforated trays. The drying temperature was set at 165 degrees Fahrenheit. A complete description of the test is given in Bowser et al. (2011).

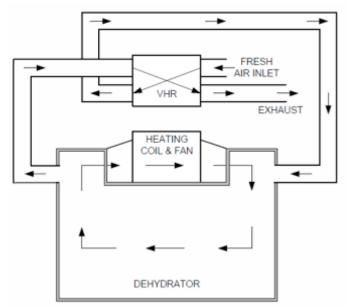
Table 1 shows results of dehydration tests with and without the VHR unit installed. The relative performance number (see column 2 in table 1) gives an indication of how efficiently energy was used in the system (referenced to system performance without a VHR). A higher value of relative performance indicates a better use of energy.

The relative energy efficiency of the dehydrator improved 38 percent when the VHR was installed. Also, the time to dry the product to 10 percent moisture content was decreased by 28 percent.

Table 2 shows calculated greenhouse emissions for the dehydrator based on an annual operation of 1 batch (225 pounds initial product weight) of cilantro per day for 220 days. The temperature set-point of the dehydrator was 165 degrees Fahrenheit. Carbon emissions equivalent (CO2<sup>e</sup>) of the system was reduced by an estimated 34 percent by installing the VHR unit.

#### **Economic Analysis**

A financial analysis of a dehydrator with an installed VHR unit was determined using the assumed system costs and calculated savings shown in Table 3. Calcu-



*Figure 3. Conceptual side view of dehydrator with VHR unit installed.* 

lated savings are based on the difference between the costs of operation of the dehydrator with and without the VHR. Simple payback for the investment requires about 125 hours of dehydrator operation (22 batches of cilantro at 225 pounds/batch). Net present value for the VHR installation based on 1 batch of product per day and 220 days per year is \$51,806 (assuming no residual value for the VHR unit and no maintenance costs). For some products and dehydrators, the processing time may not significantly change after installing a VHR. For this case, simple payback due to energy and carbon emissions savings alone would be 1.5 years with a net present value of \$4,112.

#### Conclusion

As energy, labor and equipment prices continue to rapidly increase, the efficiency of a food dehydration system is becoming more important. Environmental stewardship is also a factor that should be weighed when considering operations of dehydration equipment. Ventilation heat recovery units are now available off-the-shelf and may be quickly installed on most dehydrators. For the example described above, the VHR paid for itself after processing 22 batches.

Depending on the particular dehydration equipment installed, the value of production time, energy costs, and value of carbon credits, a ventilation waste heat recovery unit may be a profitable investment. Call or e-mail the Robert M. Kerr Food & Agricultural Products Center (405-744-6071, fapc@okstate.edu) to request assistance with your decisions involving the purchase, installation and operation of VHR equipment for food processes.

		Time to dry	
	Relative	cilantro to	
Condition	performance	10% m.c., hr	
No VHR	1.0	7.86	
VHR	1.38	5.69	
installed			

Table 1. Dehydrator performance with and without a VHR unit.

Table 2. Estimated greenhouse gas emissions (annual) for dehydration of cilantro with and without a VHR unit.

	Emissions at given operating conditions, tons CO <sub>2</sub> e		
Emissions	No VHR	VHR	
source	installed		
Purchased	4.6	3.4	
electricity	4.0	5.4	
Natural gas	15.4	9.7	
Combined			
emissions	20.0	13.1	
(total)			

Table 3. Estimated value of inputs used in an economic analysis assuming a discount rate of 7% and a period of 5 years.

Input item	Value	Annual	Annual	Annual
_		value	value	Savings, \$
		w/o VHR	with VHR	
Natural gas	0.030	\$2,539.63	\$1,606.20	933.43
	\$/kW·hr			
Electricity	0.104	\$141.48	\$102.48	39.00
	\$/kW·hr			
Plant	25.00	1,729 hr	1,252 hr	11,925.00
operation	\$/hr*			
Carbon	10.00	20 ton	13.1 ton	69.00
emissions	\$/ton	CO <sub>2</sub> e	CO <sub>2</sub> e	
	CO <sub>2</sub> e **			
Installed cost	\$1,500	-	-	-
of VHR				
system				

\*estimate of hourly operation expenses for a small dehydration facility. \*\*August 2011 value of carbon credits per metric ton (Carbonfund.org).

"Dehydration is an age old process, but we're constantly learning new methods to improve it." -Tim Bowser

#### Manufacturers of Ventilation Heat Recovery (VHR) units:

## **American Aldes Ventilation Corporation**

4521 19th Street Court E., Suite 104 Bradenton, FL 34203 Phone: 800-255-7749; 941-351-3441 Fax: 941-351-3442 www.americanaldes.com

## Aprilaire, Research Products Corp.

P.O. Box 1467 Madison, WI 53701 Phone: 800-334-6011 Fax: 608-257-4357 www.aprilaire.com

## **Broan-NuTone, LLC.**

P.O. Box 140 Hartford, WI 53027 Phone: 800-558-1711 www.broan.com

#### Fantech

10048 Industrial Blvd Lenexa, KS 66215 Customer Service: Phone: 800-747-1762; 913-752-6000 Fax: 800-487-9915; 913-752-6466 www.fantech.net

## **RenewAire, LLC**

4510 Helgesen Drive Madison, WI 53718 Phone: 800-627-4499 Fax: 608-221-2824 www.renewaire.com

## **Suncourt Inc.**

500 West Second Avenue P.O. Box 40 Durant, IA 52747 Phone: 800-999-3267 www.suncourt.com

#### **More Information**

If you would like guidance calculating the carbon footprint of your food manufacturing facility or products, please call the Robert M. Kerr Food & Agricultural Products Center 405-744-6071 or e-mail fapc@okstate. edu to request assistance.

### References

- Bowser, T.J. 2011. Meat dehydrator construction and operation manual. Available at: http://fapc.okstate. edu/files/DehydratorManualV1.pdf. Accessed on 15JUN11.
- Bowser, T.J., R.S. Frazier, Kakarala, R.R. 2011. Improvement of efficiency and environmental impact of a low-cost food dehydrator. submitted to The Open Food Science Journal, Bentham Science Publications, www.bentham.org/open/index.htm.
- Cosgrove, J. 2010. The future of dehydrating and freeze drying. Available at: http://www.nutraceuticalsworld.com/contents/view/30175. Accessed on 9JUN11.
- Krokida, M.K., G. I. Bisharat, G.I., 2004, Heat Recovery from Dryer Exhaust Air. Drying Technology. 22(7):1661-1674.
- Steel Works, 2011. Canned food alliance (CFA) program overview. Available at: http://legacy.steel.org/Content/NavigationMenu/SteelMarkets/CansContainers/CannedFood/Canned\_Food.htm. Accessed on 9JUN11.

## Ideas to help reduce costs

Reducing the cost of food dehydration will decrease overhead cost for the food processor. Reduced overhead increases profit. Examples of areas in the dehydration process that can be examined to reduce cost include: Out-of-specification product (rework or waste), air leaks from the dehydrator, inefficient gas burners, inefficient electric motors, heat loss (inadequate insulation), overdehydration, excessive equipment downtime, and inefficient startup and shutdown procedures.

Oklahoma State University, in compliance with Title VI and VII of the Civil Rights Act of 1964, Executive Order 11246 as amended, Title IX of the Education Amendments of 1972, Americans with Disabilities Act of 1990, and other federal laws and regulations, does not discriminate on the basis of race, color, national origin, gender, age, religion, disability, or status as a veteran in any of its policies, practices or procedures. This includes but is not limited to admissions, employment, financial aid, and educational services.

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Robert E. Whitson, Director of Oklahoma Cooperative Extension Service, Oklahoma State University, Stillwater, Oklahoma. This publication is printed and issued by Oklahoma State University as authorized by the Vice President, Dean, and Director of the Division of Agricultural Sciences and Natural Resources and has been prepared and distributed at a cost of 74 cents per copy. 0911