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Design and Fabrication of a Passive Solar Dryer for Meat Preservation in the Cordillera Region of Northern Philippines

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ABSTRACT

The production of "etag" or smoked meat in the Cordillera Region of the Philippines is very common and is part of the Igorot culture. However, this is associated with an unsanitary product and even with carcinogenic contents. To provide an alternative and more sanitized setup for the production of "etag," a passive solar dryer was initially designed in this study. The designed capacity is 5 kg of meat.

The design utilizes solar as energy input to dry the products. It is comprised of four major parts: the solar heat collector, combustion chamber, drying chamber, and exhaust/air vent chimney. Dry air will enter through the cylindrical tubes of the solar heat collector where it is basically heated. The air thus contains energy to absorb the moisture from the meat and makes its way to the environment through the air vent.

Key Words: *"etag", highland, meat drying, Northern Philippines, passive solar dryer*

INTRODUCTION

"Etag" is one of the ethnic and traditional meat products of the Cordillera Region in the Northern part of Philippines. It is salted pork that is either sun-dried or smoke-dried primarily for preservation. It is popular among local residents not only as a ready source of protein but also as a condiment added to other soup-based viands. Because of its unique taste and flavor, it is gradually becoming popular even among visitors and tourists who refer to it as "Igorot ham." In fact, promotion of this ethnic food is now being used by the tourism sector to complement the scenic spots to attract more tourists in the region.

At present there is no study conducted in the Cordillera Region to seek a more improved method of "etag" production. Traditionally, "etag" is produced by hanging the meat in an open space and allowed to dry. Another method involves placing the meat on a rack and smoking it using smoke produced during cooking such as in Figure 1. The objective of this study is to design and fabricate a passive solar meat dryer.

Figure 1. Smoke drying (and cooking) of meat slices using high heat in a commercial establishment

MATERIALS AND METHODS

Conceptual Design

The design of the dryer was conceptualized to come up with a more sanitized product. It is comprised of four major parts: the combustion chamber, solar heat collector, exhaust/air vent chimney, and the drying chamber. Though solar heat radiation is enough to dry the meat, the idea of combining a combustion chamber to provide heat makes the dryer more functional during rainy seasons. Design was prepared using AutoCAD 2014. The combustion chamber is cylindrical with walls made of bricks (18 inches x 20 inches, 4"x 2"x 2"). The diameter of the chamber is 32 inches and the height is 20 inches. The walls are constructed with bricks (4"x 2" x 2") with the aid of Portland cement. The conceptual framework of the study is presented in Figure 2.

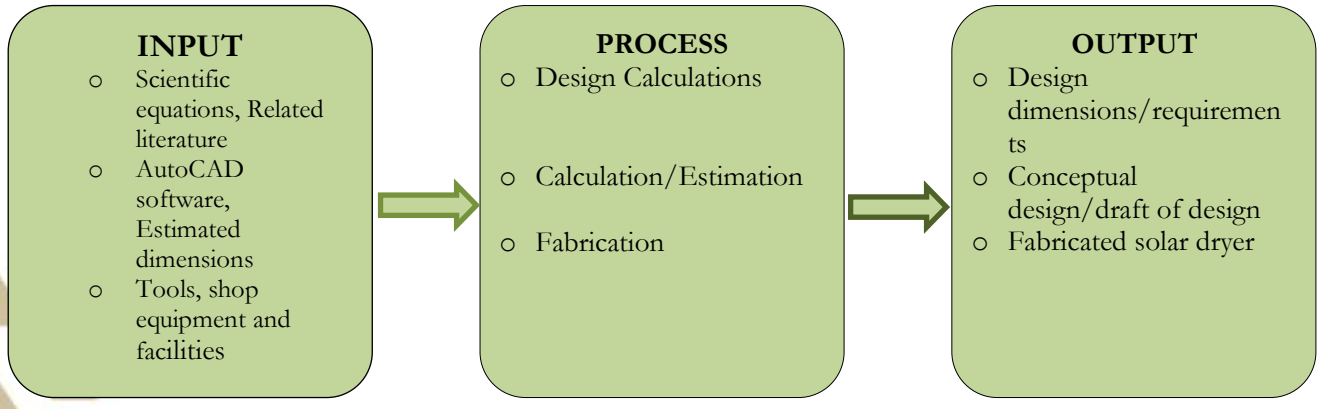

Figure 2. Conceptual framework of the study

Design Calculation

The following formula and scientific data were used as basis in the dimensions of the dryer. Equation 1 was used to estimate the heat transfer from the product to the surrounding area. It was also used to provide a working estimate on the possible quantity of heat absorbed by the solar heat collector and transferred to the drying chamber.

$$q = h_s A(T_a - T_s) \quad (1)$$

where q is the heat transfer rate in J/s; h_s is the surface heat-transfer coefficient J/(m^2 s °C); A is the area through which heat flow is taking place, m^2; T_a is the air temperature; and T_s is the temperature of the surface which is drying, °C.

Other Feature of the Design

The solar heat collector is inclined at 15 degrees at north-to-south orientation to be fully exposed to the sun throughout the day.

Drying Operation

The drying chamber has stainless steel metal hooks to suspend the sliced meat at the upper portion. It is provided with an outlet at the center part of the bottom cover. The solar heat collector collects the heat according to its capacity and transfers heat to the drying chamber. Heating is made by air passing through the cylindrical solar heat collector. The collected heat from the solar collector is transferred to the air and makes its way up to the drying chamber. The dry air absorbs the moisture from the meat and carries it outside. The cycle is repeated throughout the day until the meat is dried to the desired moisture content.

Fabrication of the Device

The design was fabricated at the College of Engineering, Benguet State University in 2014. Tools and equipment used were arc welding machine, grinder, metal cutter, and drill bit. Masonry tools were also used in installing the combustion chamber. The fabrication is presented in Figure 3.

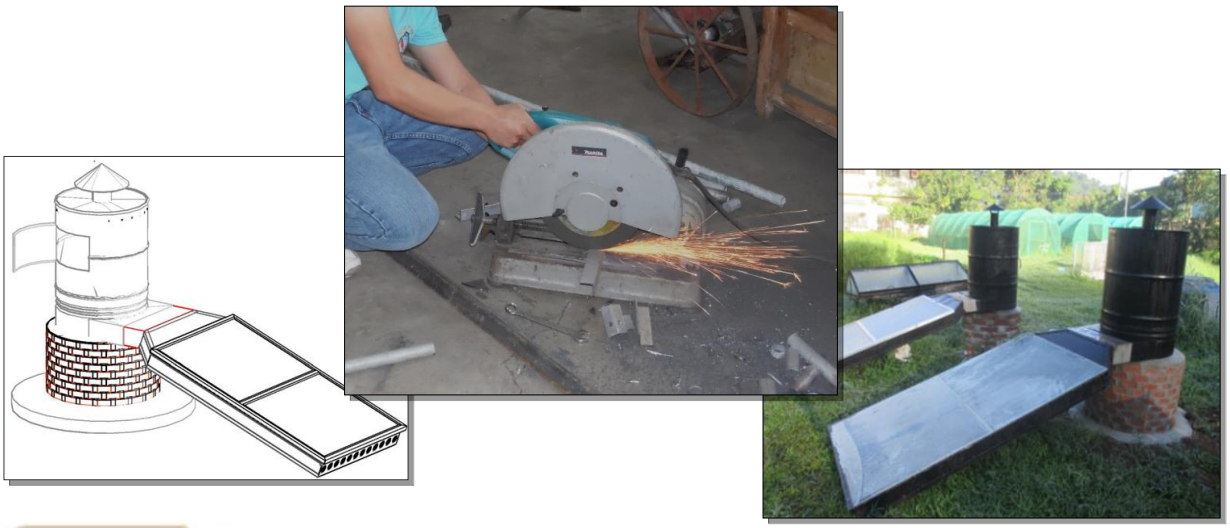

Figure 3. Flow of fabrication

RESULTS AND DISCUSSION

Final Design

Figure 4 shows the final dryer design with the following four (4) major parts: the heat collector, the drying chamber, air vent/chimney, and the smoke pit. The heat collector uses cylindrical aluminum cans joined together to form a tube. For this, recycled aluminum beverage cans were used. Thirteen tubes, each comprising of 14 aluminum cans, were assembled to form the solar collector that is approximately 0.9 m wide and 1.6 m long. It is contained in a rectangular box that is insulated at the bottom and covered with 2 mm-thick glass at the top. The tubes are also painted black to absorb heat. The panel is then positioned at an angle of approximately 15° facing south to maximize exposure to incoming solar radiation.

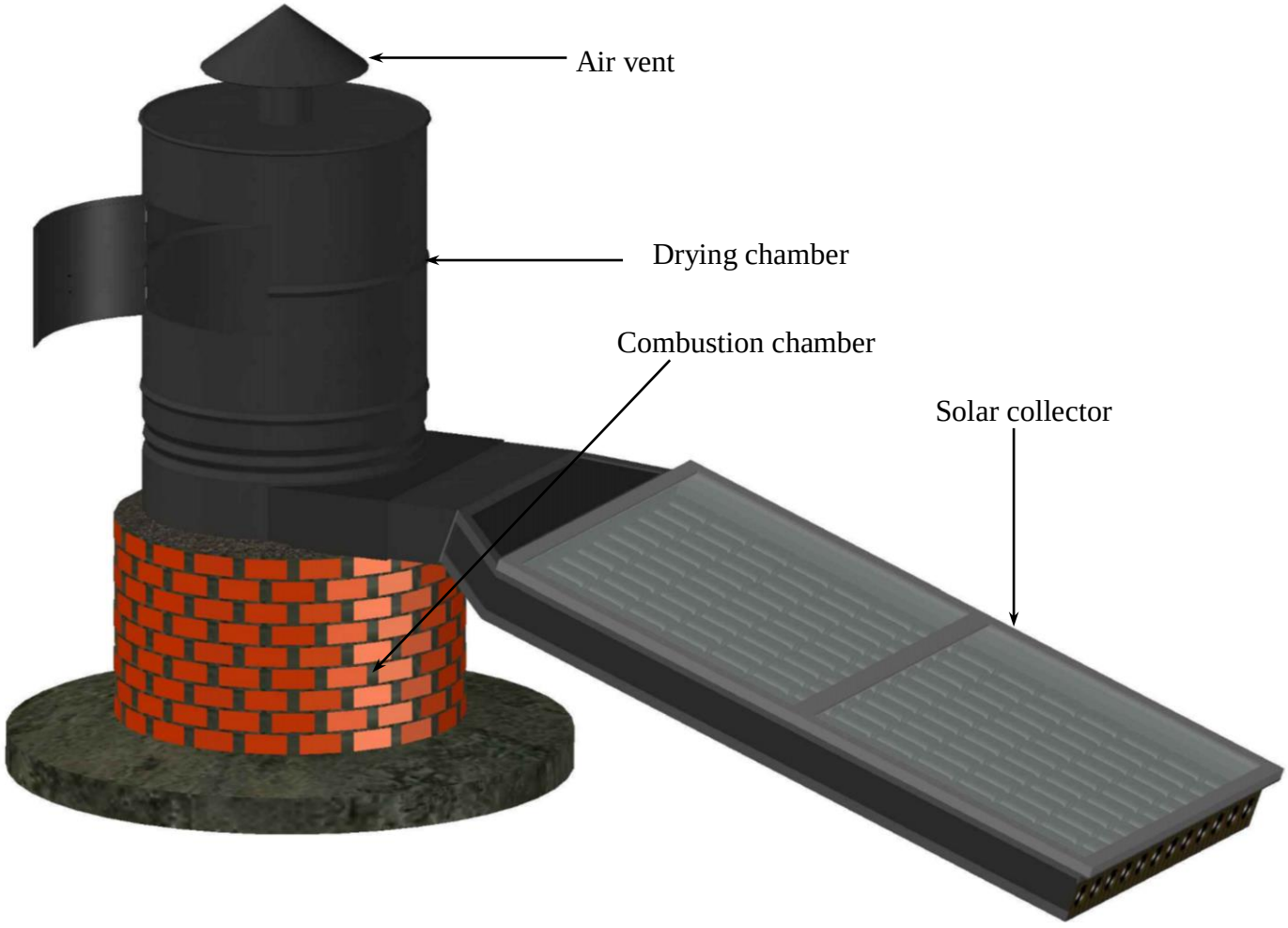

Figure 4. CAD design of the solar dryer

Fabricated Dryer

The fabricated dryer is installed at the College of Engineering and Applied Technology, Benguet State University as shown in Figure 5. It is comprised of the same parts as in the prepared design.

Figure 5. Fabricated solar dryer

Specifications

ITEM	SPECIFICATIONS
Solar Collector	
Cover and frames	
Angle bar	1"x1"
Top cover, glass	Transparent glass, ¼" thick
Heat collector, thin can (cylinder)	Aluminum cylinder, 2" x 4"
Over all dimensions of the solar collector (Face exposed to the sun)	60" x 30"
Combustion Chamber	
Dimension	
Height	26"
Inside Diameter	18"
Material of construction	
Bricks	4" x 2" x 2" (360 pcs)
Plaster, binding agent	Portland cement and sand
Drying Chamber	
Material of construction	
Chamber	Cylindrical
Thickness	¼"
Height	35"
Inside Diameter	32"
Exhaust/Air Vent Chimney	
Cylindrical	8"

The drying chamber, on the other hand, is a 200 liter-capacity oil drum fitted with a door, chimney, and racks for hanging meat slices. The inner surface is also covered with an aluminum sheet to avoid contact with the corrosive metal drum. The bottom and upper portion of the drum are also fitted with screens to prevent the entry of rodents. The base is a 26-inch high cylinder constructed from 1.5" x 3.5" x 6.5" fired clay blocks or bricks. This is used to support the weight of the drying chamber and also serves as the smoke pit for smoke drying. Because the smoke flavor and scent stays with the drying chamber, a different drum with the same configuration is used for the purpose. The system thus consists of two drums used interchangeably. To facilitate air movement, vents are placed at

the lower end of the solar collector and at the top of the drying chamber. A third opening is placed in the smoke pit. Natural movement of air (passive) due to changes in temperature is employed. The dryer can accommodate 5 kg of meat per loading.

Recommendations

1. Evaluate the solar dryer to assess its performance; and
2. Consider the use of heat exchanger in the combustion chamber so that only heat can pass to the drying chamber to avoid contact of smoke and the meat.

Acknowledgments

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