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A Study on Beef Drying Regime towards Sustainable Energy

Huy-Bich Nguyen[1,2,*] and Hay Nguyen[1,b]

[1]*Faculty of Engineering and Technology, Nong Lam University Ho Chi Minh City, Viet Nam*

[2]*National Key Laboratory of Digital Control and System Engineering - DCSELAB, Viet Nam National University Ho Chi Minh city, Viet Nam*

**Corresponding author e-mail address: nhbich@hcmuaf.edu.vn*

Abstract: Beef is one of the popular meat as the daily food in general and beef processing technology might become one of the interesting food processing research in Vietnam. There are many researchers and industrial companies study on how to create and to develop more kind of instant beef in which the beef drying plays as one of the common food using in Vietnam. For this aspect, finding out the suitable drying regime with the reasonable energy source towards the sustainable is highly attraction. This paper presents the different experimental studies on beef drying using hot-air dryer, heat pump dryer and solar dryer. The results proved that solar energy can be used as a sustainable energy source for forced convection dryer to drying beef with high quality and passing the food standard requirements. The drying regime for beef is as 1) temperature drying is 50^0C, and 2) the time drying is around 7 hours. The RH of beef might reduce from 75% to 36.7% within 7 hours or the RH rate is around 5.5% per hour when using solar dryer. The quality and color of dried-beef are also tested and it is shown that they are well and satisfied the market requirements.

***Key words*: solar dryer; beef processing; dryer; head pump.**

INTRODUCTION

Beef in generally and dried beef in particularly is one of the popular daily food in Viet Nam (Tran Thi, 2010). Beef processing technology might become one of the interesting food processing research in Vietnam in which how to optimization beef drying regime has attracted many researchers. Drying is one processing component amongst several processing technology. Beef drying is a simple but efficient food preservation activity and is not a clearly defined technology (regional office, 2010). It is not only single purpose of dehydrating fresh beef for extension of storage under ambient temperatures for many months, but also be one of various processing steps during the manufacture of specific beef products. Due to the low water content, microbial spoilage of the muscle proteins can be safely prevented (Li Jin Goh, 2011; K.J. Chua, 2010). The contents of fresh beef mostly are water which takes account for 72-75%, then protein is about 18.5 – 22%, next is lipid with 2 – 3%, and last ones like glycogen (0.3 – 0.8%), Fe, Ca, Mg, Zn, vitamin B6, E, A, etc (Tran Thi, 2010).

The beef drying at present is mostly done under natural conditions by sun exposing (Nguyen, 2013). This basic traditional drying method is also called sun drying, characterized by direct solar radiation and natural air circulation on the product. It is still a popular method in Viet Nam and largely carried out for meat preservation. Pieces of beef are cut to a specific uniform shape that permits the regular and equal drying of whole batches of beef (Fig.1). They are then suspended in the open air or spread on drying trays made of fiber or wire mesh with a wooden or metallic frame (Fig. 2). For sun drying, in particular for the suspension method, the beef is sometimes dipped in salt solution (approx. 14% common salt). This helps to limit microbial growth on the meat surfaces and protects to some extend against insects. However, this method is known to have some certain disadvantages, such as exposure to contamination from sources such as dirt, wind, rain, insects, rodents and birds and even high surface microbial contamination may occur. The other methods like using dryer for beef drying have also been applied but many things need to be clarified and it is not popular right now. They are the drying regime such as drying time and temperature, air speed, drying method etc. suitable for beef drying, the quality of dried beef, and the drying cost.

Figure 1. Cutting of meat in flat pieces in preparation for drying and types of meat suitable for drying

Figure 2. Beef is spreading on the bamboo trays above the metallic frame.

Physically, the reduction of the moisture content is achieved by continuous movement of water from the deeper layers of the meat to its peripheral zone and the evaporation from there into the air or drying in some dryer using hot air might be generated by charcoal fire, wood, paddy husky and so on with suitable temperatures. This paper presents some drying method applied to drying beef towards saving and sustainable energy.

EXPERIMENTAL DEVICES AND DRYING METHODS

In order to investigate and select the suitable drying method for dried beef, some devices have been manufactured. The first dryer is used hot air generated from the electrical energy as described in Figure 3.

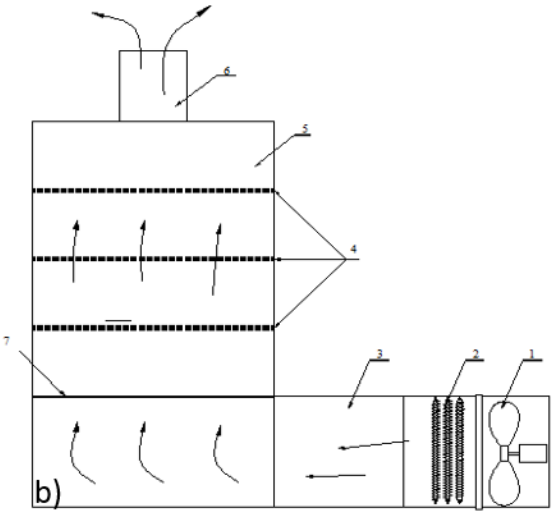


Figure 3. The hot air dryer a) completed manufactured dryer and b) components schematic.
1) Fan;2) Resistance;3)tunnel;4)Trays;5)chamber dryer;6)air out

The dimension of this dryer is (L x W x H) 600 x 500 x 1000mm, power needs for fan is ¼ HP and for resistance is 5kW.

The second dryer developed is shown in figure 4. This dryer bases on heat pump principle and its component includes 12 parts shown in Fig.4b.

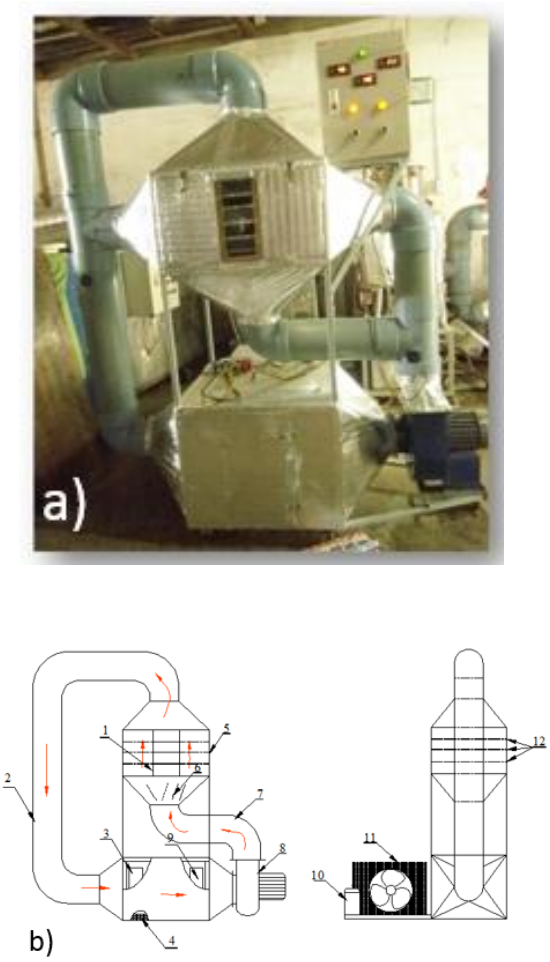
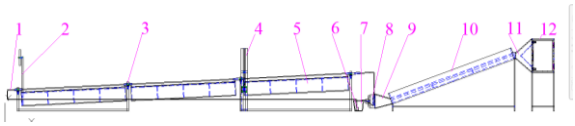


Figure 4. Heat – Pump dryer a) completed dryer b) schematic.

1-dryer door; 2- return pipe; 3- condenser; 4- water out; 5- Drying chamber; 6- guide air; 7- air pipe in; 8- centrifugal fan; 9- heater; 10- compressor ; 11-sub-heater. 12- tray

The last is solar dryer which is presented in figure 5. For drying operations in rural areas, improved approaches have been developed using solar drying. In contrast to sun drying, where the meat is exposed directly to the sun, the solar drying method uses indirect solar radiation. The solar energy produces hot air in the solar collectors, increases the temperature in a given volume of air, decreases the relative air humidity and enhances the water absorption capacity of the air. Finally, the hot air from the collector flows to an attached enclosure, the beef drying chamber (Fig. 5).



a)

1. Coper tube; 2) Balance weight; 3) ball-bearing;4) Solar collector tracking;5)concentrating collector; 6) water-pump;7)water-storage;8) Heat exchanger;9)air in;10) plating collector; 11) turning-air;12) Chamber.

Figure 5. Solar dryer using for investigation, a) Schematic, and b) manufatured solar dryer.

Within three kind of dryer as above, therefore, dried beef is more hygienic as there is no secondary contamination of the products through rain, dust, insects, rodents or birds. The products are dried by hot air only. Especially, there is no

direct impact of solar radiation on the product when dried by solar dryer.

Results and Discussion

Beef is dried by three different drying methods as above. The aim is the reduction of the moisture contents (MC) of the beef and relatively dry air in order to achieve low humidity, where microbial growth is stopped and the beef can be stored over several weeks or months without refrigeration. For the first case, the hot-air dryer has been used. A range of three drying temperature have been set up as 50, 60, and 70^{0}C. Figure 6 presents the change in beef MC during the drying time up to 8 hours.

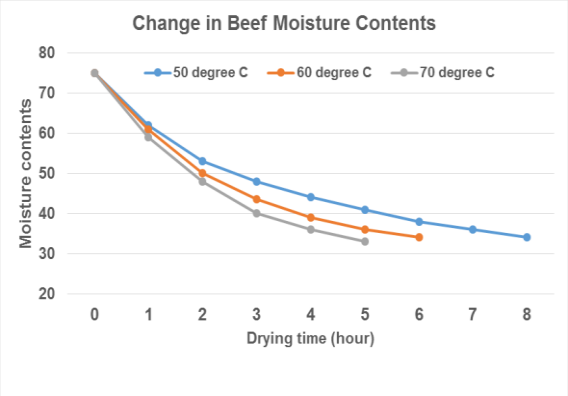


Figure 6. Change in beef MC dried by hot air dryer

The quality and colour of dried beef under drying by hot air dryer at three different drying temperature is also shown in figure 7.

It can be seen that the beef MC reduces quickly within drying at 70^{0}C and the dried beef colour might be not change so much comparing to fresh beef. This colour may suitable with the market and customer requirements. It can be guest that taking long time with low drying temperature might lead the colour of beef change and become more dark like in figure 7.

The other drying method used to drying beef is heat-pump (HP) dryer which presents in figure 4. Figure 8(a) and (b) illustrates the change in beef MC and beef colour dried under this method,respectively. Although the drying temperature is 50^{0}C, the drying time is shorter than it dried by hot air dryer and the beef colour is similarly with products dried by 70^{0}C. This can be explained by the advantages of the HP dryer and fix with some previous studies (Regional Office, 2010; Li Jin Goh, 2011) such as it ensures the product's quality especially food and agriculture products, able to control drying temperature, relative humidity, moisture contain extraction, drying air velocity, drying period and etc. (Regional Office, 2010). As the energy cost enhances continuously, HP system becomes imperative to save energy and improve overall energy efficiency (Li Jin Goh, 2011).

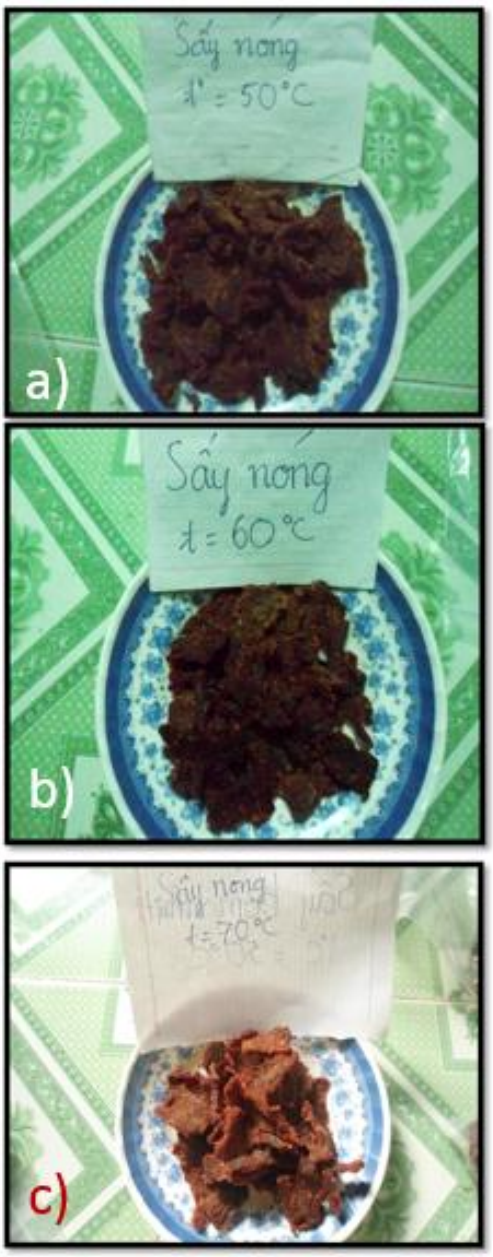


Figure 7. The colour of dried beef at different drying temperature a) 50^{0}C; b) 60^{0}C; c) 70^{0}C

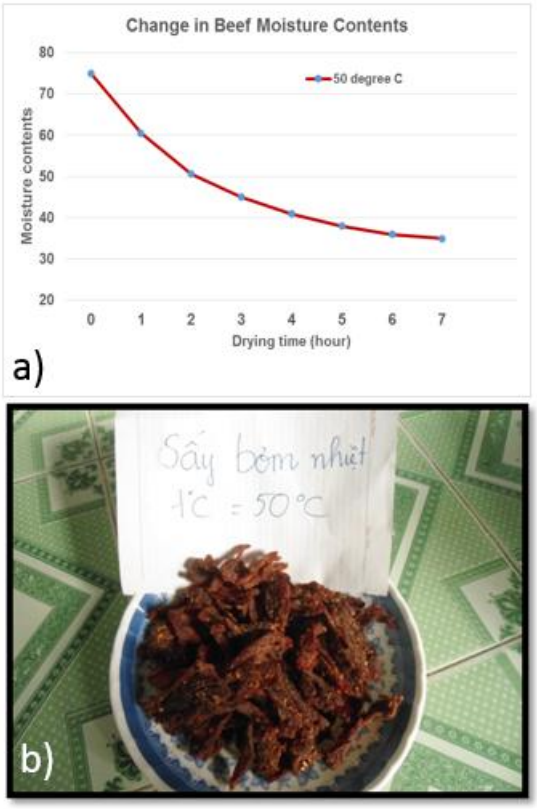


Figure 8. The change in MC (a) and colour of beef (b) dried by HP dryer at 50^0C

Beside HP dryer, towards the sustainable energy, a solar dryer system has also been developed (Fig.5). The change in beef MC and the dried product dehumidified by this system under local solar radiation (figure 9) are presented in figure 10 (a) and (b).

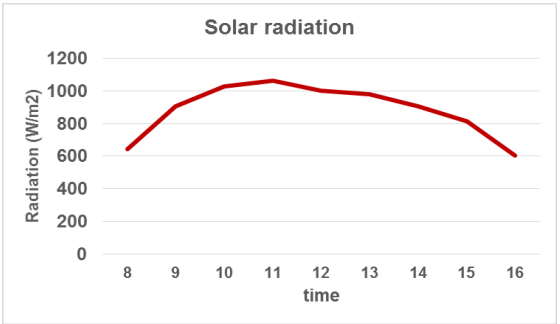


Figure 9. Average sun radiation as input energy for solar dryer

The investigated results indicate that the major part of the thermal energy absorbed is inside the collector, as it is permeable for solar radiation. The hot air is continuously moved by fans to support for chamber dryer with maximum temperature is around 46-51^0C. Comparing to the ones exposed by sun radiation, the MC rate of beef by solar dryer is high within about 5.5 % per hours and therefore drying time is shorter (Fig. 10 (a)). Furthermore, when the skies have been under partly or fully cloudy, the solar energy absorbed by the solar collectors is still remain, which keeps the air humidity low in the system, so that the drying process takes place. In contrast, the process of sun drying will be slowed or stop in cloudy weather conditions.

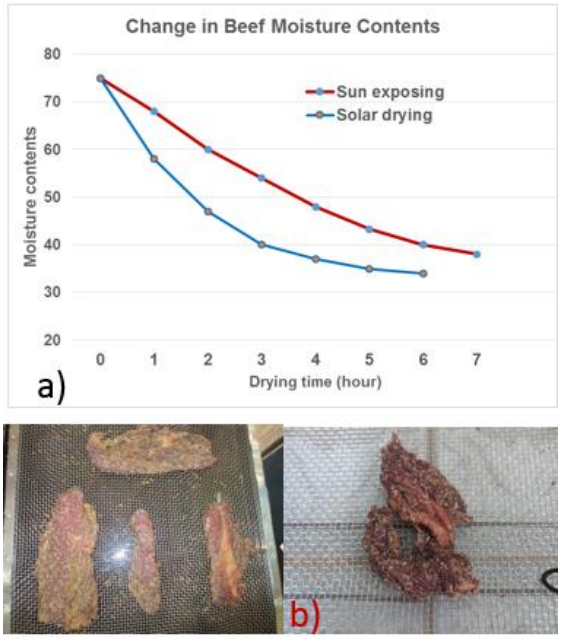


Figure 10. The change in MC (a) and colour of beef (b) dried by solar dryer

Figure 10 (b) shows the color and shape of beef after drying by solar dryer. It is clearly to see that continuous evaporation and weight losses during drying cause changes of the shape of the beef through shrinkage. The beef pieces become smaller, thinner and to some degree wrinkled and darker in color. The texture has been tested that indicates beef changes from soft to firm to hard. Most nutritional properties of beef, in particular the protein content, remain unchanged through drying.

CONCLUSION

This paper has presented a study for comparing different methods to drying beef. All methods can be applied for drying the fresh beef. Using hot air dryer with 70^0C of drying temperature can make dried beef has good color and might suit to market. However, energy consumption for drying is high and needs electricity power. Alternatively method is HP and solar drying. With average

drying temperature is around 50^0C, the solar dryer system can be replaced for beef drying with high quality and make sure the food safety. The quality and color of dried-beef are also tested and it is shown that they are well and satisfied the market requirements. However, the solar system needs electricity to drive the fans which might not suit in rural areas, where no electricity is available. This can be overcome by using photo-voltaic panels to drive the fans.

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