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Heat Pump Technology for Drying Mango Product in Dak Lak province, Vietnam

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ABSTRACT: In post-harvest technology and agricultural product processing, drying is one of the methods with the longest history and most commonly used. Heat pump (HP) drying technology is also applied by research and businesses in drying agricultural products. This paper studied heat pump (HP) technology for drying mango product in Dak Lak province, Vietnam. The drying experimental result of mango product in Dak Lak province shows that the temperature, humidity and time regimes of the installation process are relatively reasonable.

KEYWORDS: drying mango products, heat pump, saving energy.

I. INTRODUCTION

Researching and creating post-harvest preservation technologies [1] for agricultural products is one of the important issues in the sustainable development of Vietnamese agriculture, helping to reduce the rate of loss during the preservation of agricultural products. diversify agricultural products, increasing the value of agricultural products on domestic and world markets. Drying is one of the important steps in the process of preserving and processing agricultural products [2].

Drying is the process of using heat [3] to reduce the moisture content in raw materials based on the driving force of the process with the difference in partial vapor pressure of water on the surface of the raw material and the surrounding environment. During the drying process, water moves from raw materials to the surrounding environment divided into two processes:

Water diffuses from inside the material to the surface of the material due to the difference in moisture content inside and on the surface; and the diffusion of water from the material surface to the surrounding environment due to the difference in partial vapor pressure of water vapor.

The drying process is divided into two stages:

- Isostatic phase: moisture evaporation rate does not change. During this period, the amount of moisture lost is mainly free moisture.
- Deceleration phase: moisture evaporation rate gradually decreases over time. During this period, the moisture lost is mainly bound moisture.

In post-harvest technology and agricultural product processing, drying is one of the methods with the longest history and most commonly used. The technological purpose of the drying process in post-harvest technology and agricultural product processing is to reduce the moisture content in raw materials; From there, it reduces water activity and inhibits changes due to the presence of water such as the growth of microorganisms and the catalysis of enzymes.

Heat pump (HP) drying technology [4-10] is also applied by research and businesses in drying agricultural products thanks to the following outstanding advantages:

- Provides a source of drying agents with low humidity, temperatures up to 60^0C and can operate independently in a closed environment, so heat pump drying technology is considered a stable solution in terms of quality (color, nutritional composition...) especially for some agricultural products that are sensitive to temperature, color and nutritional composition are easily changed when using conventional drying methods.
- Can use hot source and cold source simultaneously for different purposes (hot source used for drying purposes, cold source used as air conditioning)
- The energy to evaporate 1 kg of moisture when

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using HP is reduced compared to other drying methods. For example, to receive 1000 kcal, the energy needed by using a heat pump is only 40 - 50% compared to drying using charcoal or firewood; 33% compared to drying using thermistor; 12% compared to using gas, oil...

- Simple structure, easy to operate, minimizing environmental pollution.
- The operating process is suitable for Vietnamese conditions, ensuring to meet the needs of drying a variety of agricultural products in our country.

This paper studied heat pump (HP) technology for drying mango product in Dak Lak province, Vietnam.

II. HEAT PUMP TECHNOLOGY FOR DRYING MANGO PRODUCT IN DAK LAK PROVINCE, VIETNAM

The heat pump system combined with Biomass is proposed to dry mango with the following parameters:

- Maximum drying temperature is 45^0C
- Maximum humidity is: 30%
- Set the drying mode in 3 stages as follows:

+ Phase 1: 30^0C; humidity 30%; drying time 6 hours.
+ Stage 2: 35^0C; Humidity 25% drying time 6 hours.
+Stage 3: 45^0C; humidity 20%; drying time 6 hours.

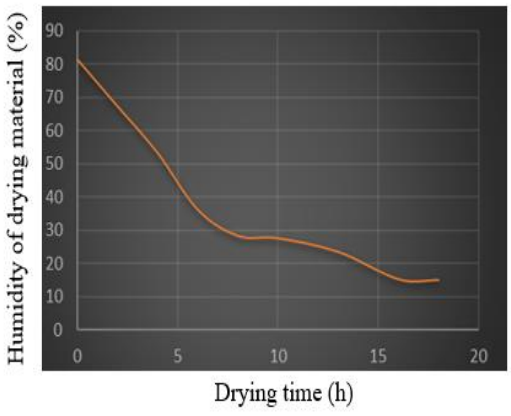

Figure 1. Drying rate curve of fresh mango fruit material

Figure 1 shows the drying rate curve of fresh mango fruit material. When drying mango, the evaporation process is most intense in the first 5 hours, the product's moisture content decreases from the initial humidity of 81.45% to less than 40% in the first 5 hours. During the period of 2 to 4 hours after starting drying, the humidity drops to only 67.34%, and 53.24% corresponding to a 14.10% reduction in moisture content compared to the initial stage.

However, the most intense moisture separation stage is the period from 4-6 hours after drying, when the moisture rate drops to 17.12% compared to the adjacent time point. So it can be seen that, in the first 6 hours, to create conditions for the material to evaporate vigorously, we only operate at low temperature and low humidity.

Setting the temperature regime as above helps the materials in contact with the drying agent to evaporate most intensely from inside the product, but the outer surface of the product is not hardened, which can be a cause of moisture resistance. evaporates in subsequent processes.

During the next 2 hours from 6 to 8 hours after start-up, the moisture evaporation rate slows down to only 7.88% of the evaporated moisture. At this stage, because the amount of moisture physically bound to the surface of the product has evaporated quite quickly, it is necessary to increase the temperature and reduce humidity for the evaporation process to be thorough.

In stage 2, drying is performed at temperature of 35^0C, 25% humidity during 6 hours drying time. However, the moisture reduction rate of the entire 6-hour period only reached 12.69% moisture, and the moisture of the product at the end of the stage reached 23.43%.

Stage 3: drying stage; During this stage, in order to maximize the amount of moisture in the raw materials, the team carried out the drying project at the following temperature of 45^0C; humidity 20%, drying time of 6 hours. During a period of 6 hours, the humidity reduction rate of the whole period is 12.62%.

When the product reaches a moisture content of about <15%, stop drying. Figure 2 presents themango material before and after drying.

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Figure 2. Mango material before and after drying

III. CONCLUSION

HP drying system combined with renewable energy sources has been developed in both quantity and equipment capacity. The drying experimental result of mango products in Dak Lak province shows that the temperature, humidity and time regimes of the installation process are relatively reasonable; After drying, the mango product ensures moisture standards, natural color, and bright yellow without discoloration.

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