Enhancement of Dehydrating of a Mixed Mode Solar Dehydrator with Regenerative Heat Storage System

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Abstract A Natural convection single pass mixed mode solar dehydrator (MMSD) with a regenerative heat storage system was modeled and manufactured with the 1 kg of loading quantity to examine the working for bitter gourd as a crop. This paper presents a performance comparison of different modes of collector configuration of absorber plate. The experiments were conducted with a crop having the water content (moisture) of 95% from this 0.9 kg of moisture must be removed until the 10% wet basis. The drying time and efficiency of the dryer were 12–14 h and 2.6–7.13%, respectively, using mixed mode without regeneration but these parameters were improved up to 8–10 h and 15–20%, respectively, using mixed mode with regeneration. The dried bitter gourd's quality was more to conventional sun dehydrating.

Keywords Single pass · Natural convection · Bitter gourd · MMSD · PCM · Mixed mode with regeneration

1 Introduction

Solar drying could be executed in rare places where the average solar penetration is high in a long sustainable period. This Solar drying or dehydrating system is sorted into two ways of operating: direct and indirect mode solar dryers. This research deals with the MMSD. Essentially it has a solar rays collector, drying chamber, regenerator as well as chimney. Gopi et al. [1] constructed and experimented, based on the solar dehydrator with HSU. In this, the solar dehydrator is a passive type or indirect mode drying happens by trapping the solar energy by the double pass solar collector consisting of a collecting plate, which is painted in black color. And the HSU is working as an energy balance setup. In HSU paraffin wax has been used as the phase changing material. Gopi et al. [2] presented a paper on experimental analyses about indirect mode solar dehydrated systems with a regenerator. Here they deal with the usage of the regenerator and its influence on the mean output of the solar collector's air temperature. It stabilizes temperature fluctuation in the working hours. Papadakis et al. [3] deal with the polyethylene covered greenhouse gases effect on the environment and also analyze about causes and remedies for the reduction of Greenhouse gases. Pangavhane et al. [4] constructed a system which enabled to produce an adequate flow of heat-absorbed air to improve the rate of dehydration and the rate of air flow and improve atmospheric temperature by the solar heat energy collector. Here the dehydrating pulse of the substance was shortened by 43% than the conventional dehydrating. Berinyuy et al. [5] worked on the solar dehydrator of more moisture-contained vegetables. It is shown that the total efficiency of the dehydrator was 17.68%, with an efficiency of moisture removing 79.15% and 9.68 h air flow. Bolaji et al. [6] created an economically mixed mode dryer by using local materials: Inside temperature of the dehydrating chamber was up to 24 °C for about 3 h at midday. The rate of drying, efficiency of collector and moisture removal percentage for dehydrating working substance were 0.60 kg h^{-1}, 57.5 and 84.4%, respectively. Bukola et al. [7] experimentally showed the working of an MMSD for the conservation of foods. Rise in temperature in the dehydrating chamber till 73% for about 3 h after past noon. The range of drying of the system was 0.62 kg/h and efficiency was 57.5%. Cakmak et al. [8] studied the method of dehydrating seeded grapes by solar dehydrator with Phase Change Materials based on a solar integrated collector dehydrating system, it is one that mostly consists of an extended-surface collector with PCMs, and dehydrating space with stream component has been used to work on the dehydrating even after the sunset. Bal et al. [9] studied the Optimization of solar dehydrators with LH systems for agricultural things could sum up the analysis of the sun dehydrating attached to PCM for dehydrating Agri-food products. Chandrakumar et al. [10] developed an MMSD with Forced Convection Based on initial observations under control systems of the dehydrating process outlining the

Fig. 5 Quality of the bitter gourd while dried by using mixed mode with regenerator and direct sun drying

Table 2 Comparison of dehydrating time

Description	Mixed mode with regenerator	Mixed mode without regenerator unit	Direct sun drying
Dehydrating time (h)	8.9	11.6	26

4 Conclusions

The dehydrated bitter gourd contains very rich nutrients, cheap in cost and easy to cook. These parameters are the value added for the dried bitter gourd. The mixed mode regenerator system is used to upgrade the dehydrator. This method was used in the studies to reduce the drying period of bitter gourd significantly. This MMSD by using Solar for bitter gourd takes less than (1/3) the time as compared to conventional sun drying. From the above analysis, the dehydrating period is found that 8.9 h needed for bitter gourd to the level we need, whereas in the conventional method, it took 26 h. The MMSD with regeneration systems efficiency differences from 15.5 to 20%. The dehydrating system is enhanced by the regenerator system. In this MMSD dehydrated bitter gourd retained the minerals (phosphorous 446.55 mg/100 g, iron of 5.91 mg/100 g and chlorophyll retention 53.41 mg/kg). It is way better than the conventional dehydrated bitter gourd minerals (phosphorous 457.16 mg/100 g, iron of 6.68 mg/100 g and chlorophyll retention 139.58 mg/kg).

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