Watermelon Processing in Triple Purpose Solar Integrated Device

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1. Abstract

Experiments on making watermelon candies were carried out in an integrated three in one solar device having utility as a water heater, cooker and dryer with built in thermal storage to keep the dehydration process continuous during night by heated water. Watermelon crush poured on small trays, was heated in cooking mode and then dehydrated by using the same device in drying mode. The hot water provided energy to continue the drying process during the night. It took 28 hours to dehydrate the watermelon crush. The dried pulp could be rolled in form of spherical candies. The candies were tasty and have long storage. These results of processing watermelon crush for making candies were encouraging and may find a real utility, both in domestic and commercial fronts.

2. Introduction

Processing of fruit and vegetables is getting higher attention for enabling farmers to get higher price of the produce. Due to perishable nature and unavailability of processing units the farmers are left with no option but to sell these produce at throw away prices during peak season after the harvest. The electrical supply in rural areas is intermittent and the conventional sources are fast depleting. The condition is still worse in arid region where hydro electricity is not available and burning of fossil fuel affects the fragile eco system of arid zone. But the region is blessed with solar energy with average daily irradiance 6 kWh/m^2 and by and large the humidity is low. This makes the drying a natural proposition for preserving the fruit and vegetables. But there is a problem of dust in open courtyard drying. Therefore solar dryers are always considered as promising devices. Extensive work was carried out at CAZRI on the development of solar dryers [1-6]. Similarly solar cooking is somewhat an alternative option to supplement the fuel demand. But solar cooker could not replace the conventional cooking due to either mismatch with food habit or early requirements of the cooked food or a need for orienting the psychology of convenience. Stationary solar cookers were developed to avoid the problem of sun tracking, normally required in commercially available solar cookers [7, 8]. However, it was observed that solar dryer has been useful only during harvesting season and solar cooker remained non functional during cloudy days with more diffuse radiation. Therefore, need for dual and multipurpose solar devices were felt. Solar cooker cum drier [8], solar water heater cum dryer cum still [9], solar dryer cum water heater [10,11] and solar cooker cum still [12] were developed earlier at CAZRI, Jodhpur. Considering the performance and practicality, more recently different models of integrated solar water heater cum cooker cum dryer were developed [13-15]. The devices were tested in different modes during different seasons and its utility to dehydrate watermelon was explored considering that solar drying of watermelon is somewhat difficult due to higher moisture content (97%) and probability of getting fungus during the night when the solar radiation are not available and it becomes worse if conditions are humid. At the same time during season there is a lot of wastage of the produce due to non -availability of an appropriate device to process it near the agricultural field. In view of this and considering the extensive experience in solar drying of different produce, attempts

were made to process watermelon for making candies with the help of the integrated solar device.

3. Background

A lot of work was carried out at CAZRI on solar drying starting from the development of improved solar cabinet dryer, inclined solar dryer, low cost solar dryer and forced circulation type solar dryers. However, more attention was given to natural circulation type dryers. Solar cabinet dryer with chimney were used for dehydrating chillies, sugar and catechu coated aniseeds (sweet *saunf*) and tobacco paste in 1980s. Subsequently after the development of inclined dryer [3,6] the technology was used for drying chillies, *aonla*, onion, okra, spinach, coriander leaves etc. However, there were problems of re condensation of moisture in the night and it was particularly difficult to sun dry tomato slices. Therefore a dryer with built in thermal storage was developed and found to provide better results [10,11]. Subsequently different models of three -in -one integrated solar device i.e. solar water heater cum dryer cum cooker were developed after considering the solar earth geometry, optimization of length to width ratio of collector reflector tandem for stationary devices [16,17], irradiance availability on horizontal and vertical planes [18,19] and practicality [20,21]. In the first model there was smaller window on the vertical south facing side and had a larger volume. A compact device (ID-2) was then developed with 40% reduction in volume. Finally a practical model (ID-3) with facility to operate it from the rear side and having slightly more capacity was developed [15]. Performance studies revealed that as a water heater, 50 L hot water of 50-60 ^{o}C could be obtained in winter afternoon while as a cooker food for a family could be boiled with in 2-3 hours (loading time 10 A.M). As a dryer, fruit and vegetables like *ber*, grated carrot, spinach, watermelon flakes, tomato slices etc. could be dehydrated efficiently with regulation of temperature during day time and continuation of the drying process even in the night through the solar heated water. The drying efficiency varied from 18-20 % for different products. Efforts were made to use the system in dual modes to process different produce and the utility of the device was extended to process watermelon utilizing the attributes of the device, especially the continuation of the dehydration in the night by the heated water and raising the temperature at the start in cooking mode to facilitate faster drying and processing of watermelon crush to make candies avoiding the probability of getting fungus during the night.

4. The Project

4.1 The Integrated Device

The integrated solar device comprises especially designed oblique shaped GI tank to hold water, appropriate geometry to use the device in stationary mode, double glazed windows with reflectors at the top and in the front side to utilize solar energy round the year, facility to operate the system as cooker on especially designed cooking cum insulting tray and four plastic pipe nipples with caps for facilitating the air circulation while using it as a dryer with built in storage. This improved three in one integrated device can be used as solar water heater during winter months, solar cooker during clear days and solar dryer on availability of fruit or vegetables. The device (ID-3) has 25% enhanced capacity of water and 13.4 % less area of window but having 35% more effective utilization of energy compared to earlier developed model ID-2 [15].

The geometry of the device [8] enables one to cook food for a family without sun tracking. It can produce about 50 L hot water of 50-60^{o}C utilizing the low altitude position of sun during winter and thus having energy gain both from top and front windows. As a dryer, fruit and vegetables like *ber*, grated carrot, spinach, watermelon flakes, tomato slices etc. could be dehydrated efficiently with regulation of temperature during day time when water works as a

sink and helps continuation of the drying process even in the night through the solar heated water. The cost of the device is about Rs. 6000 ($120), which includes the materials and the fabrication cost.

Fig. 1. Drying of watermelon crush in the integrated device designed and developed at CAZRI. Jodhpur

4.2 Experimental details

In the experiments for making watermelon candies, the watermelon crush was first poured on small trays kept on the cooking tray (see Fig 1), allowed it to be heated in cooking mode till 90 ^{0}C temperature was attained. It was kept in this mode for fifteen minutes and then the caps were opened to facilitate the air circulation and allowing the removal of moisture by the hot air. The water of the tank beneath the trays got heated to about 45-47 ^{0}C during daytime. The hot water provided energy to continue the drying process during the night. It took 28 hours to dehydrate the watermelon crush. The dried pulp could be rolled in form of spherical candies. The candies were tasty and have long storage. These candies prepared in the month of June remained as such up to the end of October till these were consumed. Experiments were conducted with and without sugar. Addition of slight amount of sugar provided a better colour and ease for rolling the dried material in the shape of round candies. There is still scope of more experiments to be conducted on standardizing the whole process and studying storage of the candies for a long duration of time. Nevertheless, these results of processing watermelon crush for making candies were encouraging and may find a real utility, both in domestic and commercial fronts.

5. Conclusions

The three in one integrated device could be used successfully for drying different fruit and vegetables. The experiments for making candies from watermelon crush were quite successful by using the device in cooking and drying mode in succession. The taste of the

candies was good and these could be stored in a covered poly container for six months without having any adverse effect on taste or appearance. Since the novel three in one integrated solar device costing about US $ 120 finds utility through out the year for one or the other purpose, it makes the system more practical and economical. The capacity can be enhanced depending on the requirement and the unique device can be used for processing other agricultural produce also. The device is a practical device for multipurpose applications both in domestic front and if the capacity enhanced can successfully be used for commercial purposes.

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