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Development of Heat and Heat Retention in the Solar Green House Dryer

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Authors' contributions

This work was carried out in collaboration among all authors. Author PS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors EM, KCR and GSK managed the analyses of the study. Author BB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Solar greenhouse drying is a method of removing moisture from the food material in which drying medium is solar energy which is easily available and low in cost for farmers. The solar energy is decreases in the monsoon months in comparison to non-monsoon months. The decrease in the solar energy results in lower temperatures in the solar greenhouse dryer. The aluminium foil which has 88% reflectivity and black mulch sheet which is best absorber and emitter of heat radiation were used to increase the heat in the solar green house dryer. Different orientations of aluminium foil and black mulch sheet were used. By using both aluminium foil and black mulch sheet, the following treatments were experimented: T_1 (control – without modifications), T_2 (black mulch sheet on the floor), T_3 (combination of aluminium foil on southern wall and black mulch sheet on the floor), T_4 (aluminium foil on southern wall), T_5 (aluminium foil on three sides of the dryer), T_6 (combination of aluminium foil on three sides and black mulch sheet on the floor), T_7 (combination of alternate strips of aluminium foil on two opposite sides, aluminium foil on southern wall and black mulch sheet on

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the floor) and T_8 (alternate strips of aluminium foil on two opposite sides and aluminium foil on southern wall). The parameters *viz;* temperature and relative humidity were recorded in both solar green house dryer and ambient conditions. According to the results, treatment T_7 was shown best results in terms of maximum temperature difference and maximum relative humidity difference. Treatment T_7 exhibited maximum temperature difference between inside and outside the dryer of 19.5 °C and also maximum relative humidity difference between outside and inside the dryer of 31%.

Keywords: Solar green house dryer; development of heat; temperature; relative humidity.

1. INTRODUCTION

Fruits and vegetables constitute a major part of the food crops in developing countries. Drying is one of the methods used to preserve fruits. Dried fruits and vegetables are easy to store and transport. At the times of plenty production, processing by drying permits the preservation and utilization in lean seasons. Almost in all parts of rural India cereals, pulses, leafy vegetables, raw mango, amla, tomato and several other fruits are also dried for making pickles, preserves etc. Drying offers a highly effective and practical means of preserving horticultural produce to reduce postharvest losses and offset the shortage in supply. The dried product has a weight only 1/4 to 1/ 9 of the fresh material. Sun drying of fruits and vegetables is still in vogue in many countries [1].

Over the last few decades, traditional drying (open-air drying) has been gradually become more and more limited because of the requirements for a large area, the possibilities of quality degradation, pollution from the air, infestation caused by birds and insects, no control over the environmental conditions and inherent difficulties in controlling the drying process [2]. To counteract the losses during sun or conventional drying, solar greenhouse dryers (SGD) or solar tunnel dryers are developed. A solar greenhouse dryer is essentially an enclosed structure which traps the short wavelength solar radiation and stores the long wavelength thermal radiation to create a favourable micro-climate for higher productivity. In SGD food materials are dried using solar thermal energy, but excludes open air sun drying by the covering material of dryer [3].

Solar drying can be considered as an elaboration of sun drying and is an efficient system of utilizing solar energy. Solar drying is more effective than sun drying [4]. Drying in the solar dryer is faster because inside the dryer it is warmer than outside, less risk of spoilage because of the speed of drying, product is protected against flies, pests, rain and dust, the quality of the product is better in terms of nutrients, hygiene and colour and better prices due to postponed market serve [5].

Among solar dryers, SGD comes under the category of the direct solar drying and also sometimes mixed mode drying. A greenhouse heating system is used to increase the thermal energy storage inside the SGD during the day or to transfer excess heat from inside the greenhouse to the heat storage area [6]. This heat is recovered at night to satisfy the heating needs of the greenhouse. The solar energy decreases in the monsoon months in comparison to non-monsoon months. The decrease in the solar energy results in lower temperatures in the solar greenhouse dryer. To enhance the temperature and its retention in the solar greenhouse dryer in the non-monsoon months, aluminium foil which has 88% reflectivity and black mulch sheet which is best absorber and emitter of heat radiation were used to increase the heat in the solar greenhouse dryer [7]. The present study was taken up with the main objective of improvement of heat retention capacity of the solar greenhouse dryer.

2. MATERIALS AND METHODS

The present study on development of heat and heat retention in the solar greenhouse dryer was carried out at Engineering Section, ICAR-Indian Institute of Horticultural Research, Hessaraghatta. A gable roof even span type solar greenhouse dryer (SGD) having a floor area of (6m x 3m) was designed. The SGD was a galvanized iron framed structure and oriented in north-south direction. The structure was covered with ultra violet stabilized polythene sheet of 200 micron size. The structure have two fresh air inlets, each of 0.6 x 0.3 m were installed at the rear side of the dryer and at 0.15 m height from the ground level for entry of fresh air. Two axial flow exhaust fans each of 50 watt (9'' diameter) capacity were fitted at the front side of the dryer at 2 m height from the ground level, for easy escape of moisture laden air from the dryer, for obtaining higher drying rate. The structure was raised on concrete floor.

Five black coloured platforms were fabricated to place the products filled in plastic tray. Each platform had a dimension of 2.7×1×0.96 m (LxWxH). Four platforms were kept inside SGD and one was used for open sun drying of product. The platforms were fitted with nylon caster wheels for mobility.

2.1 Treatments Applied to Improve Heat Retention in the Solar Green House Dryer

Eight treatments were designed with different orientations of aluminium foil and black sheet inside the dryer and the significant treatment was investigated. The following were the treatments used in the present experiment.

The following are the figures of eight treatments:

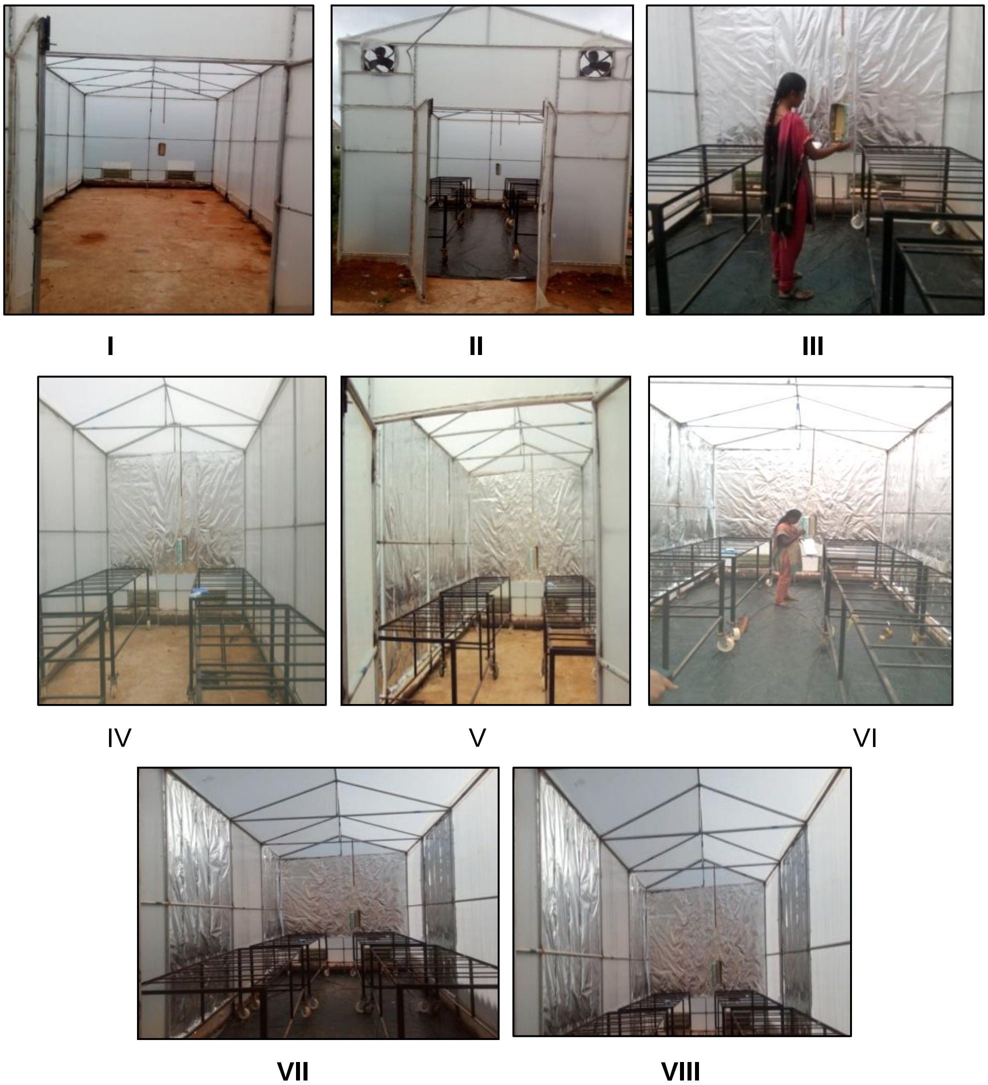


Fig. 1. Different treatments used in the I) Control (Solar greenhouse dryer without modification) II) Black mulch sheet on the floor III) Aluminium foil on southern wall and black mulch sheet on floor IV) Aluminium foil on south wall V) Aluminium foil on three sides VI) Aluminium foil on three sides and black mulch sheet on floor VII) Combination of alternate strips of aluminium foil on two sides, aluminium foil on south wall and black mulch sheet on the floor VIII) Alternate strips of aluminium foil on the two sides with foil on southern wall

Chart 1. Treatment details

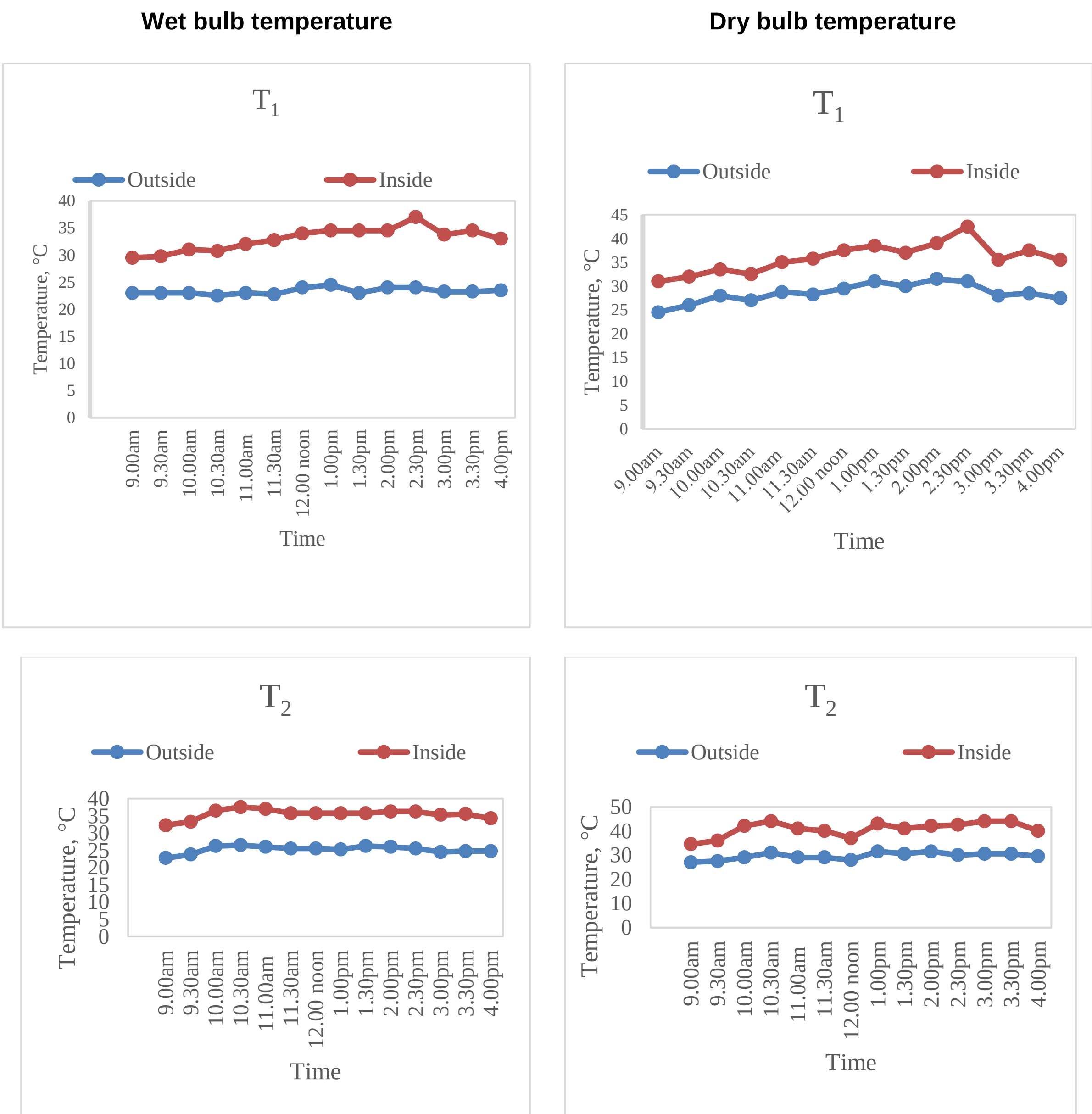
S. No	Treatment	Treatment code
1	Control (solar greenhouse dryer without modifications)	T_1
2	Black Mulch sheet on the floor	T_2
3	Combination of aluminium foil on southern wall and black mulch sheet on the floor	T_3
4	Aluminium foil on south wall	T_4
5	Aluminium foil on three sides	T_5
6	Combination of aluminium foil on three sides and black mulch sheet on the floor	T_6
7	Combination of alternate strips of aluminium foil on two sides, aluminium foil on south wall and black mulch sheet on the floor	T_7
8	Alternate strips of aluminium foil on two sides and aluminium foil on south wall	T_8

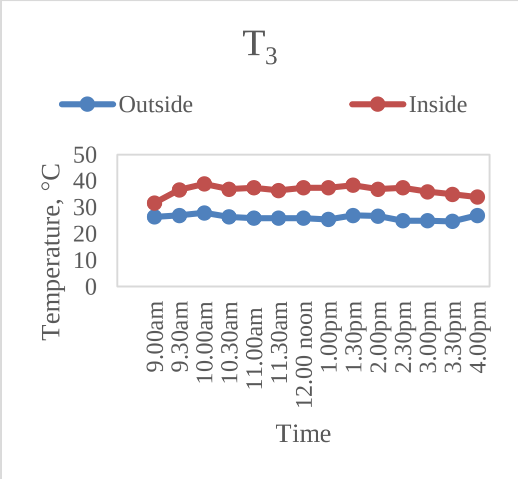
The parameters *viz;* Dry bulb, wet bulb temperatures and relative humidity were recorded in both solar greenhouse dryer and ambient conditions for two days in each treatment. The instruments used for the present investigation were data logger for recording the hourly temperature and relative humidity during the drying period. The parameters measured to study and analyse the microclimate inside the solar greenhouse dryer during experimental trails.

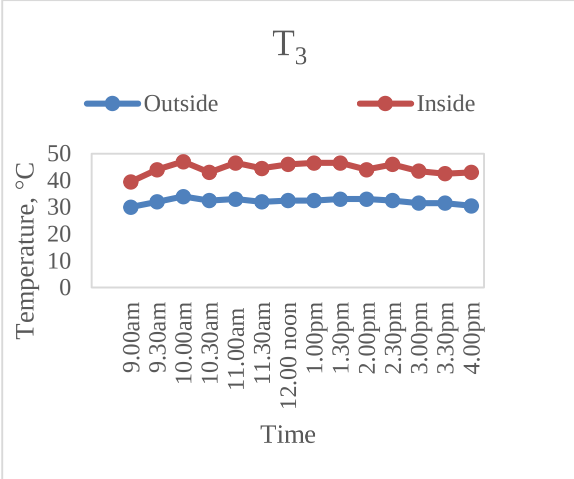
3. RESULTS AND DISCUSSION

The drying rate in the SGD is mainly depend upon temperature and relative humidity attained inside the dryer. The use of aluminium foil and black sheet improved the temperature as well as reduced relative humidity inside the SGD [8]. The temperature and relative humidity obtained in the SGD with all treatments in comparison to ambient environmental conditions is shown in Fig. 2 and Fig. 3, respectively.

3.1 Wet Bulb and Dry Bulb Temperatures Inside and Outside The SGD




T3
Outside
Inside
Temperature, °C
Time


T3
Outside
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Temperature, °C
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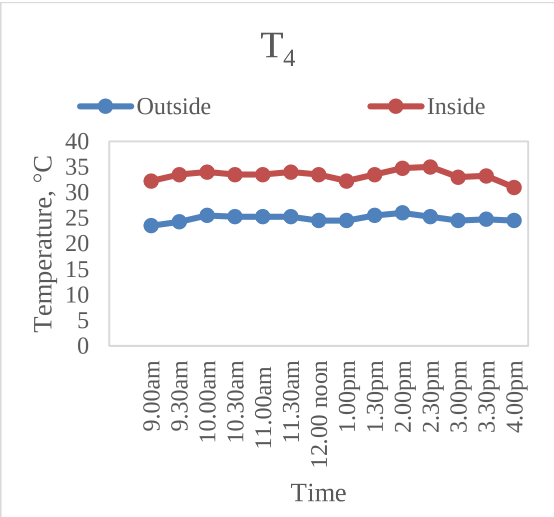
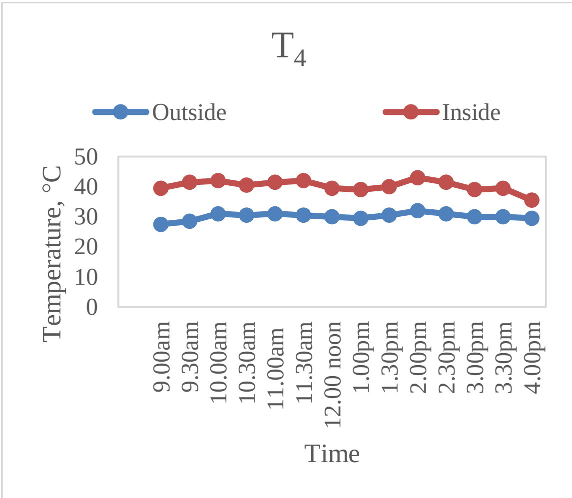
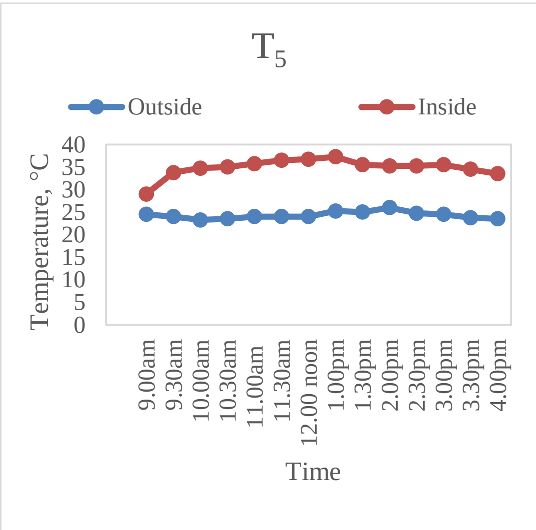
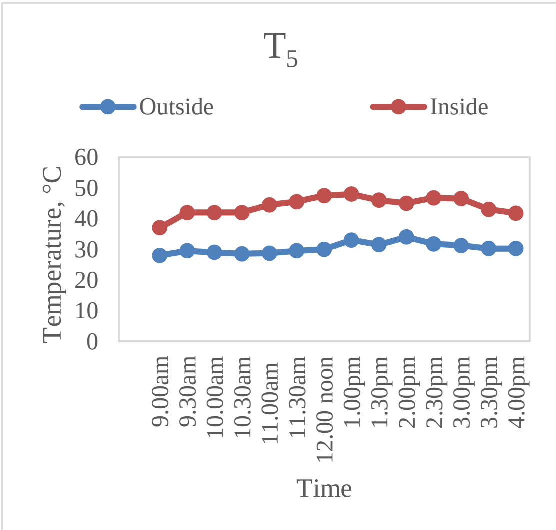

T4
Outside
Inside
Temperature, °C
Time


T4
Outside
Inside
Temperature, °C
Time


T5
Outside
Inside
Temperature, °C
Time


T5
Outside
Inside
Temperature, °C
Time

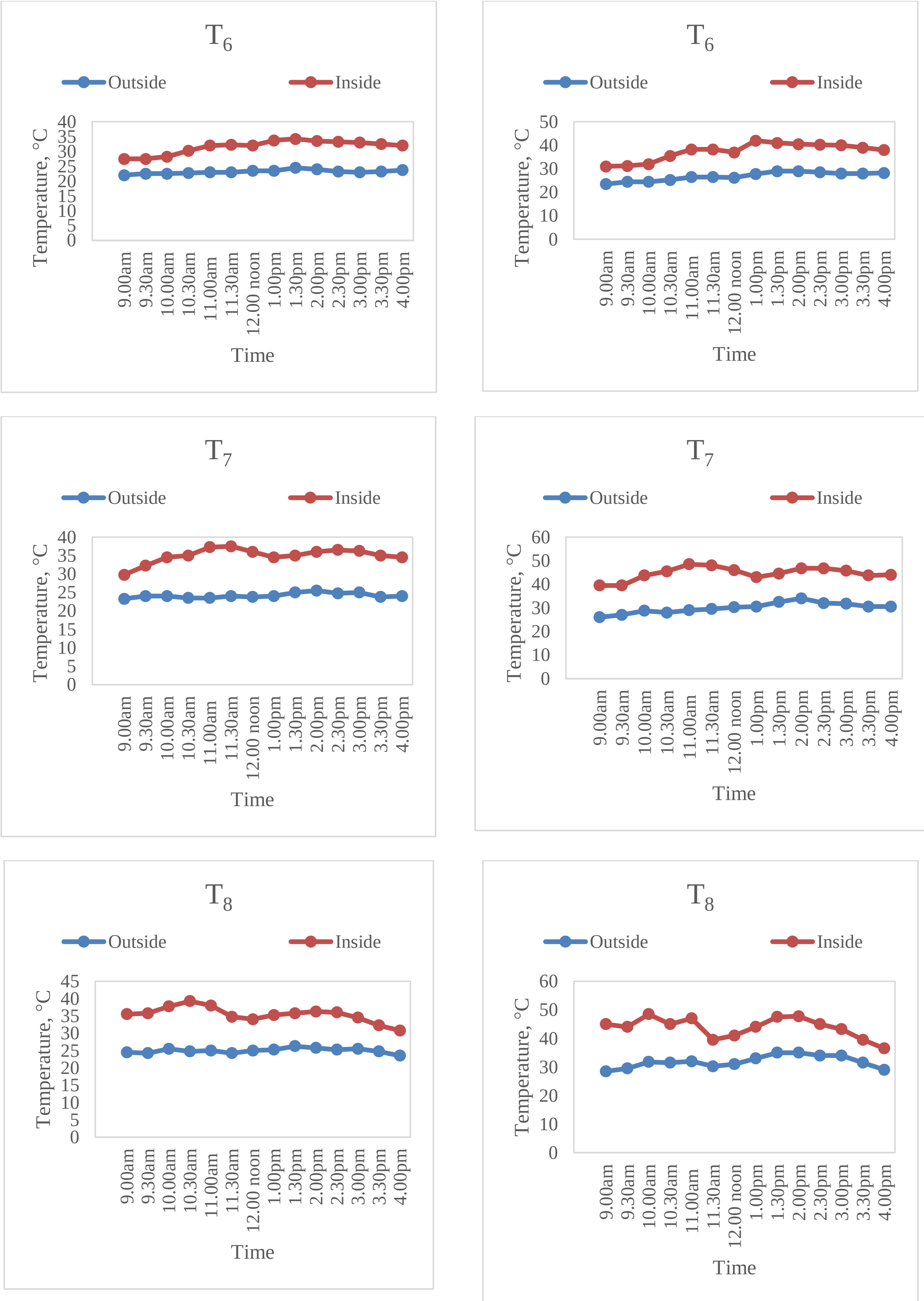
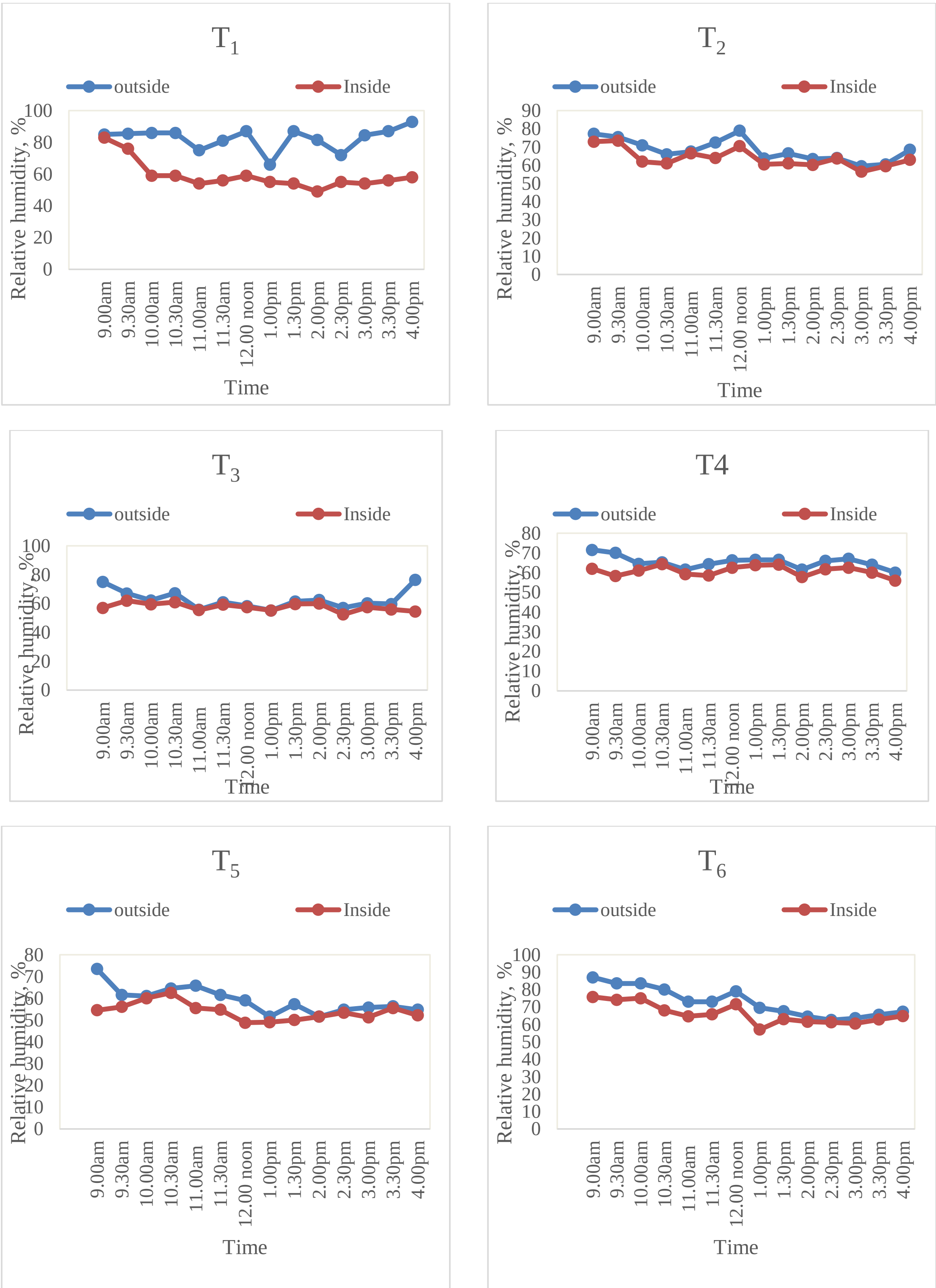
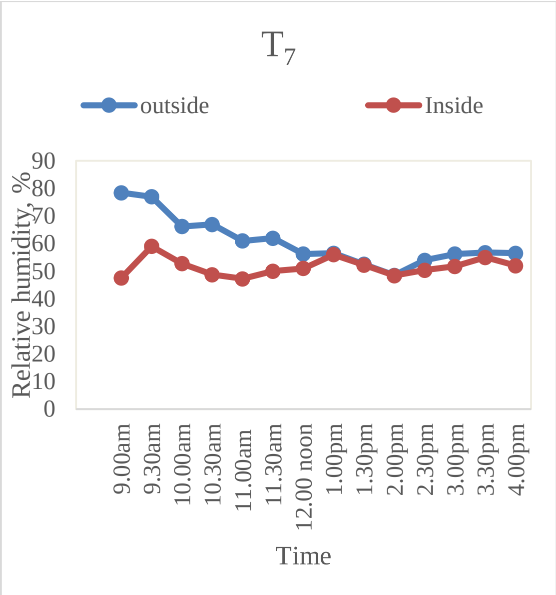


Fig. 2. Wet bulb and dry bulb temperatures in both inside and outside the solar greenhouse dryer in different treatments

3.2 Relative Humidity Inside and Outside the SGD

Relative humidity





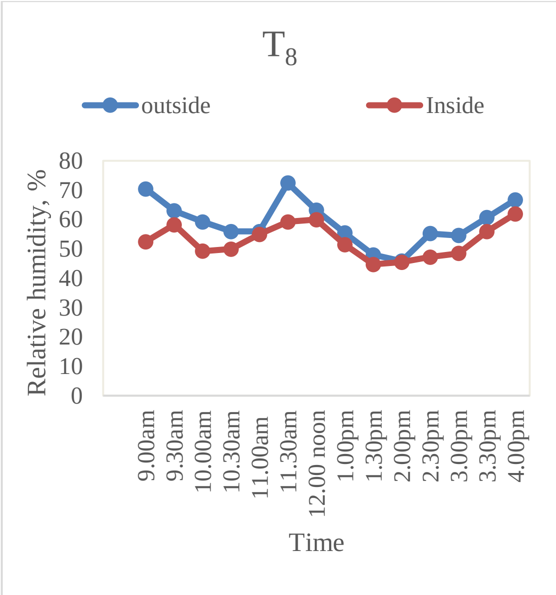
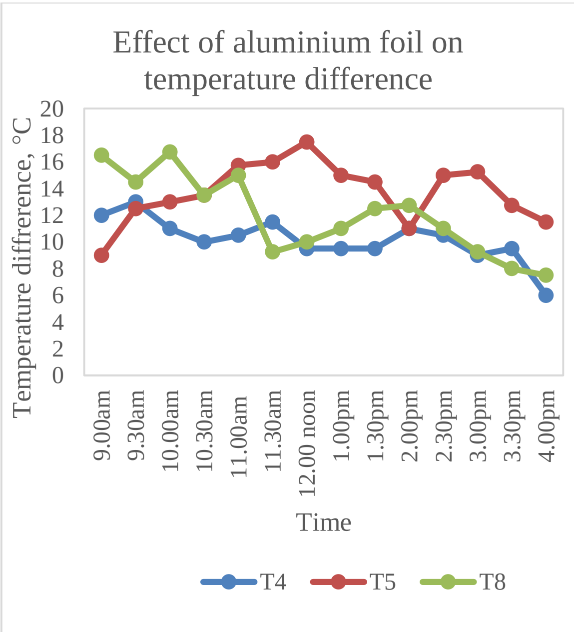
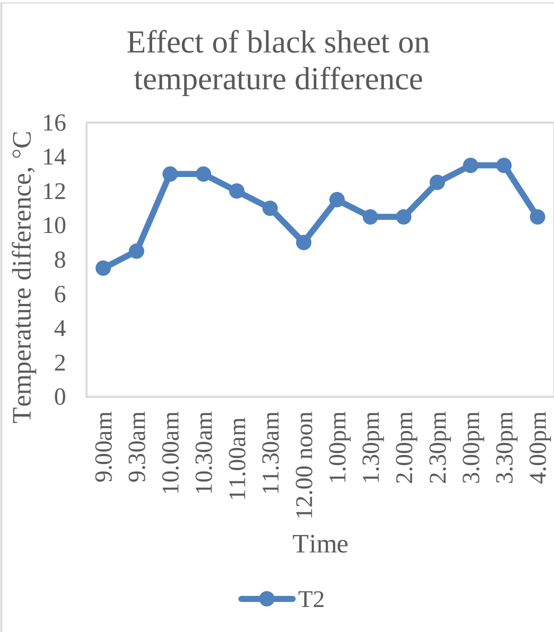


Fig. 3. Relative humidity in both inside and outside the solar greenhouse dryer in different treatments. In all treatments, the temperature inside the SGD for the duration of 8 h was more than ambient temperature due to aluminium and black mulch sheet [9]. The relative humidity inside the solar greenhouse dryer was less than ambient conditions in all treatments. Treatment T_7 exhibited highest temperature of 48.5 °C when outside temperature was 29 °C and low relative humidity of 47.5% when ambient relative humidity was 78.5%

3.3 Effect of Aluminium Foil, Black Mulch Sheet and their Combination

Effect of aluminium foil, black mulch sheet and their combination on temperature difference between outside and inside environment during different treatments





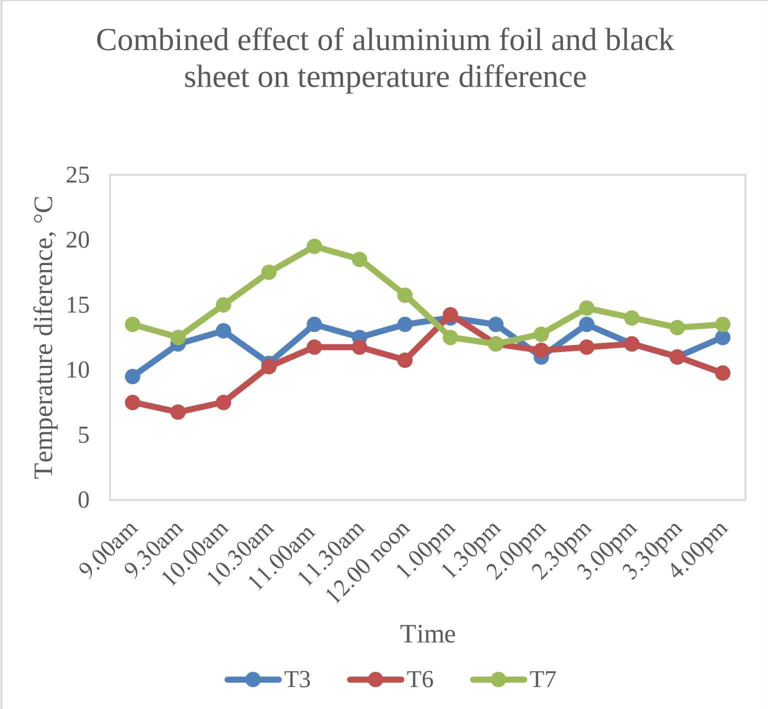
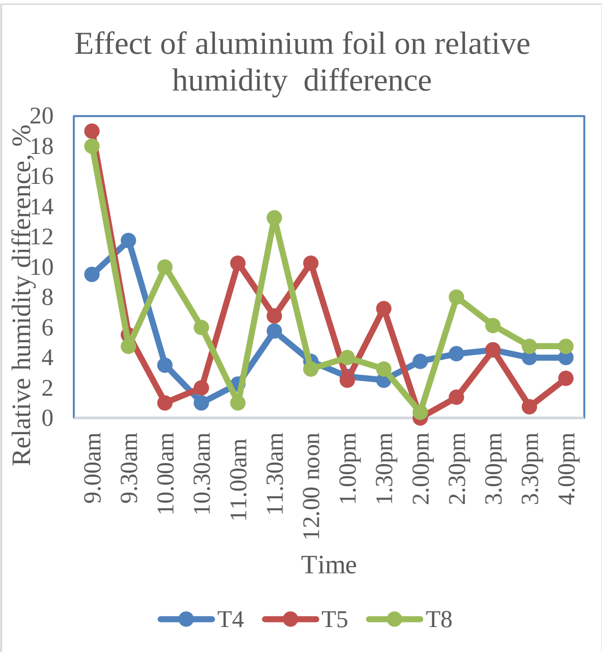
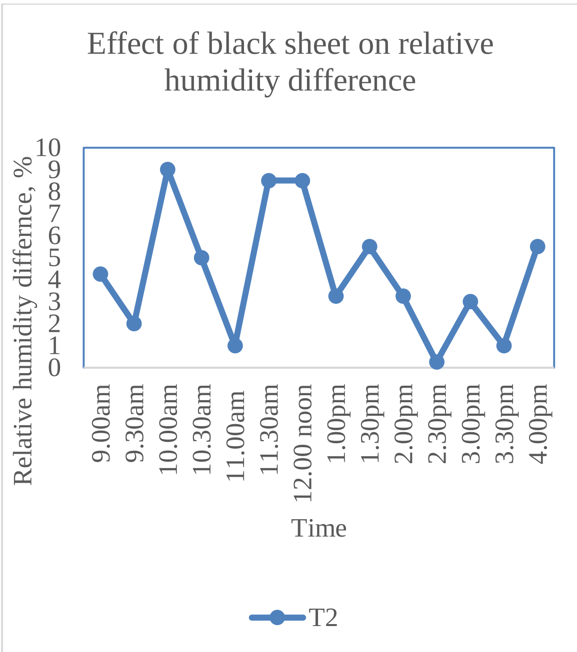


Fig. 4. Effect of aluminium foil, black mulch sheet and their combination on temperature difference between outside and inside environment during different treatments

Effect of aluminium foil, black mulch sheet and their combination on relative humidity difference between outside and inside environment during different treatments





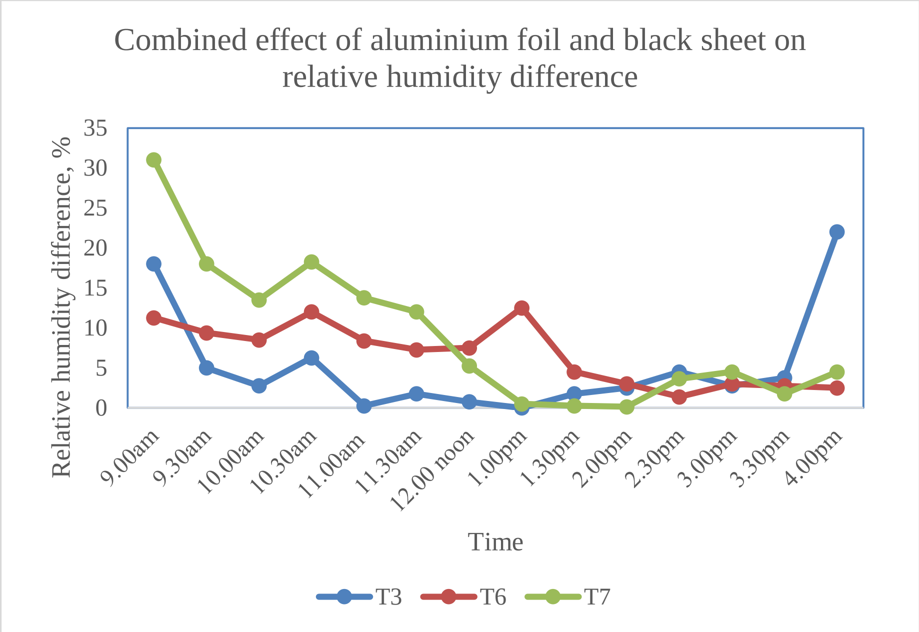


Fig. 5. Effect of aluminium foil, black mulch sheet and their combination on relative humidity difference between outside and inside environment during different treatments
Effect of combination of aluminium foil and black mulch sheet shown significant effect than individual effects of aluminium foil and black mulch sheet. Among treatments T_2, T_3, T_4, T_5, T_6, T_7 and T_8, treatment T_7 was shown best results in terms of maximum temperature difference and maximum relative humidity difference [10]. Treatment T_7 exhibited maximum temperature difference between outside and inside the dryer of 19.5 °C and also maximum relative humidity difference between outside and inside the dryer of 31%

4. CONCLUSION

Solar drying was more effective than conventional sun drying in terms of providing high temperature and low relative humidity that yields good dried products. Modification in the solar greenhouse dryer using aluminium foil and black mulch sheet imparted high temperature and low relative humidity in comparison to solar greenhouse dryer without any modification because reflective nature of aluminium foil and both absorbing and emitting characteristics of black mulch sheet. Highest temperature difference between inside and outside the SGD was observed in treatments T_7.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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