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A systematic review on greenhouse type solar dryers

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A R T I C L E I N F O

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A B S T R A C T

Food and Agriculture Organization reports show that farmers today lose 35–45 percent of their crops during harvesting and transportation due to various reasons. One third of the food consumed is thrown away by people. Greenhouse gases released from these wastes make up about 10 % of the total greenhouse gases released into the atmosphere. If serious attention is not paid to this issue, serious problems such as shortage of high-quality food and high prices will cause more concern for humanity. Drying food products using solar dryers is considered as one of the alternative solutions to this problem. In addition, the use of renewable energy increases the possibilities of reducing dependence on energy obtained from fossil fuels. For this reason, there is a lot of research going on in the field of solar dryers today. In this work, scientific research and review articles conducted in the field of greenhouse type solar dryers for 2013–2023 were analyzed. Based on the PRISMA method, 100 of the 1675 articles were selected and included in this review. According to the analysis, it was found that the energy efficiency of greenhouse-type solar dryers is 11–73 %, and the energy efficiency of solar air collectors and biomass furnaces integrated into them is in the range of 45–81 % and 47–87 %. The lifetime of various greenhouse type solar dryers is between 4–35 years, their price is between 220–10659 USD and the payback period is between 0.3–11 years, embodied energy is 136–18302 kWh, and EPBT is in the range of 1.1–3.63 years.

1. Introduction

According to the estimates of the United Nations Department of Economic and Social Affairs, the population of our planet will exceed 8.5 billion in 2030. 9.7 billion in 2050. and 10.4 billion in 2100 [1]. Rapid population growth requires the provision of ecologically sustainable and healthy food, so reducing food waste and preventing the spread of greenhouse gases in food production are the main issues to be solved [2]. According to the analysis, as a result of global climate change, the average losses caused by climatic effects in agriculture and livestock during 1993–2023 amounted to 123 billion dollars [3]. According to the results based on the method developed by the Sustainable Development Goal within the Food and Agriculture Organization (FAO), the average of 13,2%, of which fruits and vegetables were lost by 31.2 %, meat and livestock products by 13.1 %, root and oil crops by 11.9 %, grains and legumes by 7.2 %. Fruits and vegetables during the harvesting period are lost 45 % in the eastern and southeastern part of Asia, 18 % in the central and southern part, 26 % in the western part, 26–28 % in Africa, 12 % in North America and Europe, 19 % in Latin America and the Caribbean [4]. One of the ancient methods of preventing the loss of fruits and vegetables is drying them, which is a very easy, safe and low-cost method compared to other methods [5]. Drying is a process aimed at preventing the growth of bacteria and maintaining product quality for a long time by evaporating the water contained in the product [6]. Fossil fuels, electricity or solar energy can be used as a heat source in dryers that we can use to dry fruits and vegetables [7]. In many countries of the world, electricity production is becoming more expensive, fossil fuel reserves are limited and decreasing, and the gases released from their combustion are causing climate problems. [8]. Traditionally, product drying using solar energy is used in many developing countries, but it also has several disadvantages [9]. These include the loss of a large part of thermal energy, long drying time, adverse climatic factors, the negative effects of various rodents, insects and fungi [10].

2. Methodology

In recent years, there is a lot of research going on to improve the design and energy efficiency of solar dryers. Fig. 1 demonstrates, the number of articles indexed in the international scientific search database "ScienceDirect.com" by keywords "Solar dryers", "Forced convection solar dryers", "Natural convection solar dryers", "Collector solar dryers", "Greenhouse type solar dryers", "Mixed type solar dryers" and "Hybrid solar dryers" in 2013–2023 (09/12/2023) confirms the growing

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Table 19
Environmental analysis of greenhouse type solar dryers.

Reference	Type of dryer	Energy payback time, year (EPBT)	CO_2 Emitted (kg/year)	CO_2 Mitigation (kg/year)	Net CO_2 Mitigation (Lifetime) (Tons)	Carbon Credit Earned
M. A. Eltawil et al. [38]	roof type even span greenhouse with solar collectorsa) Single layer (I)b) Two-layer (II)c) Three-layer (III)	a) 3.63 b) 3.01c) 2.06	a) 55,380 b) 55,380 c) 595,380	–	a) 17.38b) 21.40c) 31.80	–
L. Mishra et al. [49]	Greenhouse chamber with solar air collectora) natural convection dryerb) mixed-mode forced convection dryer	a) 1.1b) 1.5	a) 13.706b) 40.292	–	a) 9.9b) 9.12	a) 99.95 USDb) 91.24 USD
P. S. Chauhan et al. [55]	roof type even span greenhouse with the shielded north walla) passiveb) active	a) 1.68b) 2.35	a) 15.53b) 21.01	–	a) 33.04b) 36.34	(1$ ≈ 67 INR dated 12 December 2016a) 11.068–44.273 INR b) 12.173–48695 INR
M. Kumar et al. [56]	roof type even span greenhousea) natural convection dryerb) mixed-mode forced convection dryer	a) 1.66b) 1.72	a) 27.79b) 29.50	a) 1400b) 1420	a) 0.561b) 4	a) 14 USDb) 14.25 USD
O. Prakash et al. [60]	roof type even span greenhouse with the shielded north wall a) passive b) active	a) 1.16b) 1.51	–	a) 28,690 b) 28,650	–	a) min: 9470.45 INRmax: 37.826.37 INR b) min: 9456.59 INRmax: 37.826.37 INR
	potatoes; capsicum; tomatoes	a) 1.01b) 1.24	–	a) 33,360 b) 35,010	–	a) min: 10.904.84 INRmax: 43.620.07 INR b) min: 11.555.71 INRmax: 46.222.84 INR
		a) 0.94b)1.14	–	a) 35,360 b) 38,060	–	a) min: 11.699.91 INRmax: 46.680.95 INR b) min: 12.561.70 INRmax: 50.245.49 INR
N. L. Panwar et al. [68]	Walk-in type solar tunnel dryer compared to: a) light diesel oil (LDO) b) liquefied petroleum gas (LPG)	a) 3.03b) 2.26	–	a) 12,150b) 6720	–	–
Hamdani et al. [89]	hybrid active greenhouse drying system (HAGD) attached with evacuatedtube solar collector (ETSC) a) HAGD + ETSCb) HAGD	a) 4.76b) 5.45	a) 553.72b) 300.60	a) 3491.1b) 1652.7	a) 88.12b) 49.58	a) 1321.8 USDb) 743. 47 USD
		a) 8.38b) 10.17	a) 553.72b) 300.60	a) 1983.24b) 885.77	a) 50.49b) 26.57	a) 757.07 USDb) 398.47 USD
		a) 3.69b) 6.56	a) 553.72b) 300.60	a) 4501.29b) 1374.16	a) 135.04b) 41.22	a) 2024.91 USDb) 618.16 USD
S. Ayyappan et al. [90]	large-scale greenhouse solar dryer with biomass back-up heater	–	1518	–	678	18,645 USD

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Research involving human participants and/or animals

Not applicable.

Informed consent

Not applicable.

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