Solar-powered evaporatively cooled vegetable vending cart

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A solar-powered vending cart was designed and developed for storage of fruits and vegetables. It was tested for its performance during summer season. The minimum and maximum drop in temperature ranged between 8.1°C and 11.2°C, and the increase in relative humidity was observed to be up to 15% and 25% inside the vending card chamber in June. The requirement of water ranged between 16.5 and 20.0 litre/day. There was considerable effect on physiological loss in weight of different vegetables kept either inside or outside the mobile chamber. The freshness and shelf-life of vegetables increased substantially after storage in the cart.

Keywords: Evaporative cooling, fruits and vegetables, solar-powered cart, storage.

FRUITS and vegetables account for 92.3% of the total horticultural production in India. Around 2.1% of the production is used by processing industries; the remaining produce is either consumed soon after harvest or stored for later use in fresh form. It is therefore important that effective exploitation of the export capability of fruits and vegetables is ensured. Since fruits and vegetables are perishable, their magnitude of loss is estimated at 35–40% due to poor post-harvest management resulting in huge financial loss each year. India wastes fruits and vegetables each year equivalent to the annual consumption of the United Kingdom.

Absence of sufficient storage facilities after harvest results in deterioration in the quality in fruits and vegetables that reach the market. This has an immediate impact on the distribution and availability of the required amount for human consumption. The most imperative parameters influencing the post-harvest life and quality of horticultural produce are temperature and relative humidity (RH). The deterioration in quality of produce after harvest is the result of physical, biochemical, physiological and biological processes, the rates of which are influenced primarily by product temperature (at harvesting) and RH in the vicinity. Rate of spoilage increases 2–3-fold with each 10°C rise in temperature. The vital activities of tissues, for example, transpiration, respiration, ripening, etc. take place even after harvest. Fresh produce needs low temperature and high RH during storage. Immediate cooling is important to minimize quality loss when the produce is harvested at high temperatures or at an advanced stage of maturity. Preserving such commodities to remain fresh demands that the chemical, biochemical and physiological changes are restricted to a minimum by close control of temperature and RH. The high cost involved in developing cold storage or controlled atmosphere storage on a movable cart is a pressing problem in India and several developing countries. Evaporative cooling is an efficient and economical means for reducing the temperature and increasing RH in an enclosure.

Evaporatively cooled storage has proved to be useful for short-term storage of fruits and vegetables in hot and dry regions[1]. It has been extensively used for enhancing the shelf-life of horticultural produce, which is essential for maintaining the freshness of the commodities[1–3]. Evaporative cooling is an environmental friendly air-conditioning system that operates using induced processes of heat and mass transfer, where water and air are the working fluids[4]. It provides an inexpensive, energy-efficient, environmentally benign (not requiring ozone-damaging gas as in active systems) and potentially attractive cooling system[5].

Figure 1. View of a conventional vegetable vending cart.

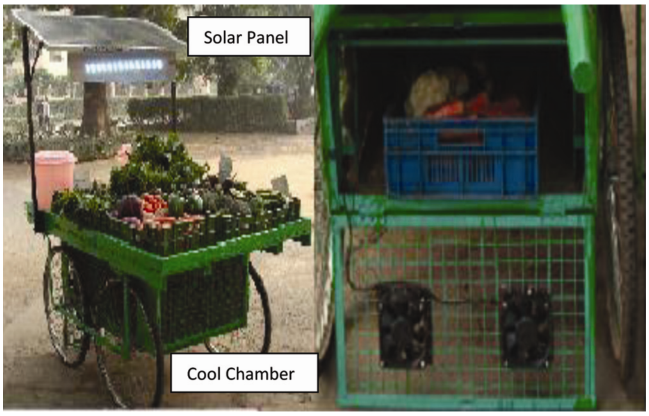

Figure 2. View of a solar-powered evaporatively cooled vegetable vending cart.

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Table 1. Physiological loss in weight (%) of different vegetables at different times

	1st day		3rd day		5th day		7th day		10th day	
Vegetable	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside
Carrot	7.35	1.02	15.32	5.49	21.63	8.14	34.05	10.0	42.76	14.05
Tomato	0.77	0.38	2.28	1.24	3.40	2.06	9.93	3.28	13.05	4.37
Methi	12.11	4.01	29.15	16.19	41.27	24.71	55.19	36.93	61.31	45.07
Cabbage	1.25	0.40	3.44	1.87	5.03	2.96	7.82	4.91	10.24	6.29
Cauliflower	2.99	0.69	9.30	3.57	13.69	5.98	20.66	9.88	27.23	12.76

Figure 3. Cotton wick (regulated) water dispersal system.

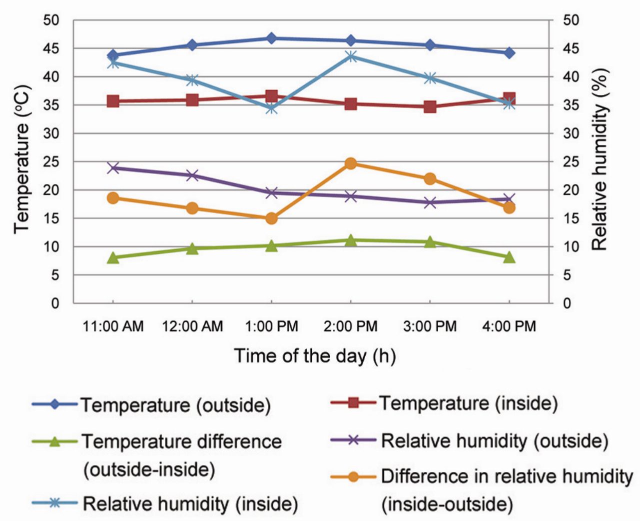

Figure 4. Hourly variation of temperature and relative humidity (outside and inside the chamber).

Most fresh horticultural produce contains 65–95% water when harvested. Water is an important constituent of most fruits and vegetables, and it adds to the total weight. Loss of water will reduce the weight of the produce. When the collected produce loses 5–10% of its fresh weight, it begins to wilt and soon becomes unusable. This weight loss comprises both evaporative and respiratory losses. The former, which happens as a result of respiration, depends mainly on the temperature of the surrounding air.

Vegetable vendors are mostly poor people selling vegetables in local areas. They procure vegetables from the wholesale markets for sale. During summer due to high temperature and less RH the vegetables get spoiled within a day or two.

A conventional vegetable vending cart (Figure 1) does not provide any environmentally controlled storage space for vegetables. One of the alternatives to keep the vegetables safe during summer is the use of a refrigeration system. However, this is expensive and dependent on electric power.

In view of this, a solar-powered evaporatively cooled mobile vending cart (Figure 2) has been developed to store fresh vegetables for a short duration. Suitable modifications in the design have been made to provide an additional storage area of about 8.0 cubic feet below the main platform and between the four wheels of the conventional cart. Provision has been made for making the lower section evaporatively cooled so that fruits and vegetables can be kept safely for a longer period of time at the retail vendor's level. Provision has been made for cooling pads and channels for application and distribution of water around the additional 8.0 cubic feet storage space for vegetables and fruits. Also, on top of the platform, provision has been made for water dispersal through cotton wicks and two stationary funnel-bucket assemblies (Figure 3). The evaporative cooling system of the cart uses solar power. A SPV 100 Wp/12 V solar module is used as the power source. It is used to run two forced air fans (DC, 12 V, 0.7 A, 8.4 W each) for the evaporative cooling system and LED bulbs to illuminate the cart during night. A 12 V/7 AH battery is also used to store solar power during the day and to run the system during night or on a cloudy day when solar radiation is not adequate.

The solar-powered vending cart was tested for its performance during summer season. The minimum and maximum drop in temperature ranged between 8.1°C and 11.2°C and increase in RH was observed to be up to 15% and 25% in June (Figure 4). The requirement of water ranged between 16.5 and 20.0 litre/day. There was considerable effect on physiological loss in weight of different vegetables kept either inside or outside the mobile chamber (Table 1). When the produce loses up to 10% of its fresh weight, it begins to wilt and soon becomes unusable. Methi (leafy vegetable) became unusable on the first day itself when kept outside, but was usable when kept inside the chamber. Tomato exhibited minimum moisture loss at the end of storage of up to 10 days, but due to decay it was unusable beyond the tenth day of storage. There was very low moisture loss from cabbage as well, which was usable even on the tenth day when kept inside; cauliflower and carrot could be stored up to 7 days. Therefore, the shelf life of vegetables significantly increased by storing them in the solar-powered evaporatively cooled chamber of the vending cart.

Thus, this system is an excellent alternative for short duration storage of fresh fruits and vegetables at a low cost. It not only reduces the storage temperature but also increases RH which is essential for maintaining the freshness of the commodities. In the solar-powered vending cart, fruits and vegetables can be stored safely for a longer period of time at the retail vendor's level.

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Development of ELISA exploring recombinant variable surface glycoprotein for diagnosis of surra in animals

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In the present study, the variable surface glycoprotein (VSG) gene of *Trypanosoma evansi* was cloned and expressed in *Pichia pastoris* (X-33). The diagnostic potential of recombinant VSG (*r*VSG) in ELISA has been determined using 1818 field sera samples collected from different species across different states of India. The developed test was compared with the standard reference test such as, CATT/*T. evansi*; moreover, the new assay was also compared in ELISA using VSG RoTat 1.2 antigen. The diagnostic sensitivity and specificity of recombinant protein were found to be 95.4% and 93.8% respectively, with Cohen's kappa value of 0.86. The epidemiological study revealed varied prevalence of surra in different species and across different geographical regions of India. Cattle experienced higher prevalence of surra with 42.2% seropositivity from eastern region of India, whereas camel showed 19.9% seropositivity from Rajasthan. Hence, the present study is useful as an effective tool in sero-diagnosis as well as surveillance.

Keywords: Diagnosis, ELISA, *r*VSG, surra, *Trypanosoma evansi*.

TRYPANOSOMA EVANSI, which is considered as a petite mutant of *Trypanosoma brucei*[1], is a causative agent of a disease called surra which results in significant economic loss in the agricultural industry. A wide range of animals such as horses, mules, donkeys, camels, cattle and buffaloes are susceptible to *T. evansi* infection. Cattle, buffaloes and horses are the most likely hosts for surra in the South East Asian region[2]. The clinical symptoms of surra include recurrent fever, anaemia, muscular weakness, oedema, loss of appetite and abortion, with 50–70% morbidity and mortality. The animals which exhibit low levels of fluctuating parasites even after recovery/cure serve as carriers of the disease for years. Hence, detection of carrier animals is the key factor in controlling the disease. Conventional parasitological techniques can satisfactorily detect acute or sub-acute infections. However, chronic/latent infection (where parasitic load is less) diagnosis is difficult by conventional method. The development of new diagnostics such as parasitic DNA detection and/or immunodiagnostics would help in the detection of carrier

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