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Development computation of performance and economic evaluation of SPV assisted evaporative cooling vegetable vending cart

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Abstract
Storage and transportation losses are one of the major causes in post harvest losses. Small scale peasants and vegetable vendors have difficulty in storing and preserving the quality of the harvested or purchased agricultural produce before it reaches in the hands of the consumers. Cost effective easy to handle and less maintenance requiring storage unit is needed for using in remote areas. Solar photovoltaic assisted evaporative cooling vegetable vending cart has been developed in Swami Vivekanand College of Agriculture Engineering & Technology, Raipur for storing and selling of agricultural produce in small scale for vegetable vendors. The developed vegetable vending cart consists of cooling cabinet unit, water distribution system and power supply unit. Honey comb cellulose pad is used as cooling pad. The performance of the cooling unit was analyzed based on the saturation efficiency under load and no-load condition observed in March and August along with the physiochemical quality of the vegetables placed inside the cabinet and under ambient condition. The overall efficiency in cooling is 88% and the maximum temperature and relative humidity drop was 14 °C and 40% respectively. Physiochemical analysis is performed for tomato and bittergourd and the parameters observed are physiological weight loss, total titratable acids, total soluble solids, pH, firmness and color. The tomatoes and bittergourd placed inside the cabinet retained shelf life upto 19 and 9 days respectively. The tomatoes and bittergourd stored under ambient condition are storable upto 10 and 6 days respectively. The physiochemical changes are observed to be much faster in ambient condition than cabinet. The results obtained highlights that there is significant difference between the ambient and cabinet condition and the developed vegetable vending cart is efficient in storing and transporting the vegetables. Saturation efficiency recorded indicates that cellulose serves as an efficient cooling pad material. Sensory evaluation of the samples placed inside the cooling cabinet and ambient condition yielded a result that the marketable qualities were sustained inside the cooling cabinet. The economic analysis showed that a profit of Rs 6,000 was obtained on selling using evaporative cooling vegetable vending cart.

Keywords: Evaporative cooling, cellulose, saturation, tomato, bittergourd, physico-chemical

1. Introduction

Agricultural goods are hygroscopic in nature. Storage is an important marketing function, which involves holding and preserving goods from the time they are produced until they are needed for consumption. The storability of a produce is improved greatly by managing the aeration, temperature and relative humidity, micro-organisms control, averting moisture loss, and providing sanitation creating a cool and uniform environment. The key role played in degradation of the marketable quality of fruits and vegetables is temperature and relative humidity. Increase in temperature results in increase in dehydration and respiration rate. Respiration is a process in which the produce converts sugar and oxygen into carbon-di-oxide, water and heat. Thus, increase in respiration rate simultaneously increases the transpiration rate resulting in weight loss of the produce. Therefore, reduction in the temperature and increase in relative humidity to a suitable level is essential to increase the shelf life of the agricultural produce. Transportation of the produce also contributes significantly to the post-harvest losses. Proper handling and controlling the environment of the transported produce is necessary from the harvest till it reaches the market as they are subjected to overheating due to lack of adequate ventilation, close- stow stacking patterns and mechanical damage owing to vibration and poor stowage. Low temperature handling and storage is considered as a crucial component to reduce and control post-harvest losses. Evaporative cooling storage of vegetables and fruits is an efficient, economical and feasible mode of storage practices in reducing the temperature and increasing the humidity thereby increasing the storability of the produce (Nkolisa *et al.*, 2018) [9].

Street vegetable vendors face difficulties in carrying their goods during hot summer and cold rainy season. Both men and women visit streets taking fruits and vegetables under unprotected conditions which lead to quality deterioration. On the other hand, for keeping the produce under chill condition people use unclean water resulting in contamination and unhygienic condition. The carrying and transporting of the vegetables physically in baskets is also a laborious and dredging effect.

A large amount of produce is deteriorated during the transportation and storing before it reaches the hands of the consumer. Many of the farmers do not have access to cold storage facilities in developing countries; this may be attributed due to high cost and also requirement of high maintenance. The vegetable vendors in the market are susceptible to difficulty in storing the vegetables and fruits, because during rainy season the value of the goods decrease as they get wet and become soggy and in hot weather condition the vegetables undergo transpiration, weight loss and shrinkage. The vendor also faces a loss in his business owing to this condition. Thus, the need for reducing losses during storage and transportation in an economical, easier way is emerging so that it can be made accessible even for a vendor who is residing in rural places can purchase this machine and maintain it in a facile way. Evaporative cooling proves to be a cost-effective method for cooling the agricultural produce for short period of time in regions having low relative humidity. The cart is designed with evaporative cooling system to improve the shelf life of the agricultural produce stored inside the cabinet by reducing the temperature and increasing the relative humidity. The cabinet also provides protection from external factors that result in quality deterioration such as rodents, dust and birds. Thereby the losses during transportation are also reduced. Solar power is utilized to run the suction fan and water circulating pump. A 45 Ah lead acid battery is provided to store the excess solar energy, so that it can be used when sunshine is not available. Thus, the developed cart is studied to find the efficiency in storing the fruits and vegetables by comparing with the vegetables stored under normal condition.

2. Materials and Methods

2.1 Place of the Prototype Development

The present study was conducted on a solar photovoltaic assisted evaporative cooling vegetable vending cart has been developed in Swami Vivekanand College of Agriculture Engineering & Technology, Raipur, Chhattisgarh, India.

2.2 Source of Raw Material

The fully matured red tomatoes and bittergourd was selected for the study and procured from the local market of Raipur, Chhattisgarh.

2.3 Description of the Developed Vegetable Vending Cart

A vegetable vending cart provides both storage and transporting facility. In order to design the cart various parameters such as the dimensions of the cooling cabinet, capacity of the cabinet for storing the agricultural produce, amount of heat load inside the cabinet, quantity of water required for removal of heat, the power required for operating the cooling system, capacity of battery necessary for storage of power so that the system can be operated during night or when adequate solar power is not available need to be studied and considered for facilitating optimal storage condition. The material of the vegetable vending cart was taken as GI steel as it is light in weight.GI steel, electric wire, 3 x 3 cm GI steel mesh for fixing cooling pads on the side walls of the cooling cabinet. Storage volume of the cooling cabinet was 150 kg with length, breadth and height as 1.22 x 1.92 x 0.64 m. The power supply system comprised of 45 Ah battery with 125W. The required battery capacity and solar panel size was calculated as followed by Olosunde *et al*. (2015) [11]. The water distribution system comprised of two pumps of 0.25 hp and hose pipes of 2cm diameter and a water holding reservoir with a capacity of 33 liter. The quantity of water required to cool the cabinet was determined according to Ogbaugu *et al*. (2017). Honeycomb cellulose was used as cooling pad material (Malli *et al.*, 2011) [8].

Fig 1: Side view of developed SPV operated vegetable vending cart 1-control switch 2- Battery storage box 3-Water reservoir

Fig 2: Rear view developed SPV assisted vegetable vending cart 1-LED builb 2-Handle 3-Cellulose cooling pad 4- Water inlet port

Fig 3: Front view of developed SPV assisted vegetable vending cart 1-Suction fan 2-Loading door

2.4 Analytical Methods for Evaluation and Measurement of Parameters

Bitter gourd and tomatoes were cleaned and ensured that they were fresh and free from decay and damages. Three replications were done for both ambient and cabinet conditions. 20 kg of vegetables of each were placed inside the cooling cabinet, which was about 15% of the holding capacity of the cooling cabinet. The following procedures were followed to perform comparative analysis of the vegetables placed inside the cooling cabinet and ambient conditions. Three samples from three replications were selected randomly for physico-chemical analysis.

2.4.1 Performance Evaluation of the Designed Vegetable Vending Cart

The efficiency of the cooling pad in reducing the temperature inside the cooling cabinet was determined based on the saturation efficiency which is calculated as given by Goshal *et al*. (2019)

$$SE= \frac{Tdba-Tdbc}{Tdba-Twba} \times 100 \quad ...2.1$$

Where,

SE = Saturation efficiency (%)

T_{dba} = Dry bulb temperature under ambient environment (ºC)
T_{wba} = Wet bulb temperature under ambient environment (ºC)
T_{dbc} = Dry bulb temperature inside the cabinet (ºC)

This was done in the month of March and August to find the effect of weather characteristics in its performance efficiency under no load condition by keeping the cart idle, and the dry bulb and wet bulb temperature of the ambient environment and dry bulb temperature inside the cooling cabinet along with relative humidity was monitored hourly from morning 10am to evening 5pm considering the period where we get maximum sun shine hours. The efficiency was also tested by keeping 20kg of tomatoes and bittergourd inside the cart with the same procedure. Tomatoes and bittergourd were chosen because the shelf life is highly dependent on the temperature and physio-chemical properties has a great impact on storage condition.

2.4.2 Determination of Physiological Weight Loss

Physiological weight loss is a direct indicator of amount of moisture content lost in the vegetables. The percentage reduction in weight conveys the amount of moisture content lost due to transpiration. The raw materials were marked and weighed before placing inside the cabinet. The weight of the samples was recorded in an interval of two days until the sample reaches the stage at which its losses the acceptability and not suitable for consumption. The percentage of physiological weight loss is determined using Eqn. 3.2 (Nkolisa *et al*., 2018) [9].

$$\text{Physiological weight loss (\%)} = \frac{\text{Initial weight} - \text{Final Weight}}{\text{Initial Weight}} \times 100 \quad \ldots (3.2)$$

2.4.3 Determination of pH

pH was determined using digital pH meter. The sample solution was prepared by blending the produce in a mixer and filtered to remove the seeds. Then pH probe was placed inside the sample solution and pH was recorded.

2.4.4 Determination of Total Titratable Acids

Total titratable acids (TTA) measure the total acid concentration in a food. Many organic acids such as tartaric acids, citric acid, lactic acid, malic acid and acetic acid are common in foods. The flavor (tartness), colour (through pigments such as anthocyanins and other pH influenced pigments), and microbial sturdiness (through innate pH sensitive microorganisms) are altered by the total titratable acids. It is also considered as one of the maturity indices. Total titratable acids were determined in reference to (AOAC, 2000) [1].

2.4.5 Determination of Total Soluble Solids

Total soluble solids is the amount of soluble solids present in any solution. Total soluble solids can also be used as an indicator for ripening process of any fruit. Fruits and vegetables may contain many soluble solids such as sugars, pectin, organic acids and amino acids among which sugars are the most prevailing compound. Thus, the total soluble solids are expressed in ºBrix values. Total soluble solids were recorded using Digital Refractometer.

2.4.6 Firmness and Color

Firmness is the main visible parameter that indicates the marketability of the agricultural produce. Firmness of the samples were given by touching and observing the hardness of sample by pressing the sample with fingers. The degree of firmness was given by a hedonic scale with a ranking up to 6. It was monitored every 3rd day regularly. The changes in the texture of the sample were observed by monitoring the extent of shrinkage in the samples. Colour is the primary factor of indication for ripening. Ripening refers to physiological and biochemical changes that occur in a fruit in order to attain the desired colour, flavor. Pigments play a vital role in the colour changes. This can be monitored easily by observing the samples visually. Colour of the sample was monitored by observing the changes in appearance of the samples.

2.5 Sensory Evaluation

Sensory evaluation helps in finding the acceptability level of the food based on taste, texture, consistency, flavour and appearance by perceiving through visual, touch and smelling mode of senses. The samples placed in the ambient and cooling cabinet condition was evaluated based on freshness, appearance, texture, smell at an interval of 2 days, on every third day. Sensory panel comprised of 10 members, and the judgment was done using 9 point hedonic scale as followed by Saadoudi *et al*. (2017) [13], 1= like extremely, 2 = like very much, 3 = like moderately, 4 = like slightly, 5 = neither like nor dislike, 6 = dislike slightly, 7 = dislike moderately, 8 = dislike very much, 9 = dislike extremely.

2.6 Economic Analysis

The fixed costs of the vending cart included the material costs and fabrication cost. The labor cost also was included in the fixed cost. The variable cost included all the variable expenses such as the cost of the vegetable samples, electricity and water cost.

2.7 Statistical Analysis

Statistical analysis was performed using completely randomized design with three replications and four samples. The analysis was conducted to find if the temperature during storage of the vegetables inside the cooling cabinet and ambient condition had significant effect on the physiochemical properties that were evaluated through 'analysis of variance' (ANOVA) by conducting F-test, and comparing the obtained F- value with tabulated value to find the significant effect as given by Steel *et al.* (1997) [14].

3. Results and Discussion

3.1 Saturation Efficiency

The saturation efficiency was observed as 88% in the month of March and April. The relative humidity difference between the ambient condition and inside the cooling cabinet was 27% in the month of August and 49% in the month of March. The temperature difference was observed as 6 °C and 13 °C in the month of August and March (Table 1). The temperature and relative humidity difference between the cooling cabinet and ambient environment was observed to be much higher in the month of March when compared to August. This significant difference was observed due to variation in the temperature and relative humidity present in the ambient environment in the month of March and August. This can be explained due to the rate of increase in evaporation during summer days when the air is dry (Ghoshal *et al.,* 2019). When humidity in ambient environment is less wet bulb temperature will also be decreased, this promotes the evaporation of water in the cooling pad of the cabinet resulting in a good temperature difference from the ambient environment. During the month of March, the relative humidity is less, thereby it has the capability to gain more latent heat, which promotes the evaporation of water from the cooling pad, thereby the cooling effect is much more induced, (Chopra *et al*., 2017) [4] inside the cooling cabinet. Thus, a better temperature and relative humidity drop is achieved during hot and dry weather condition.

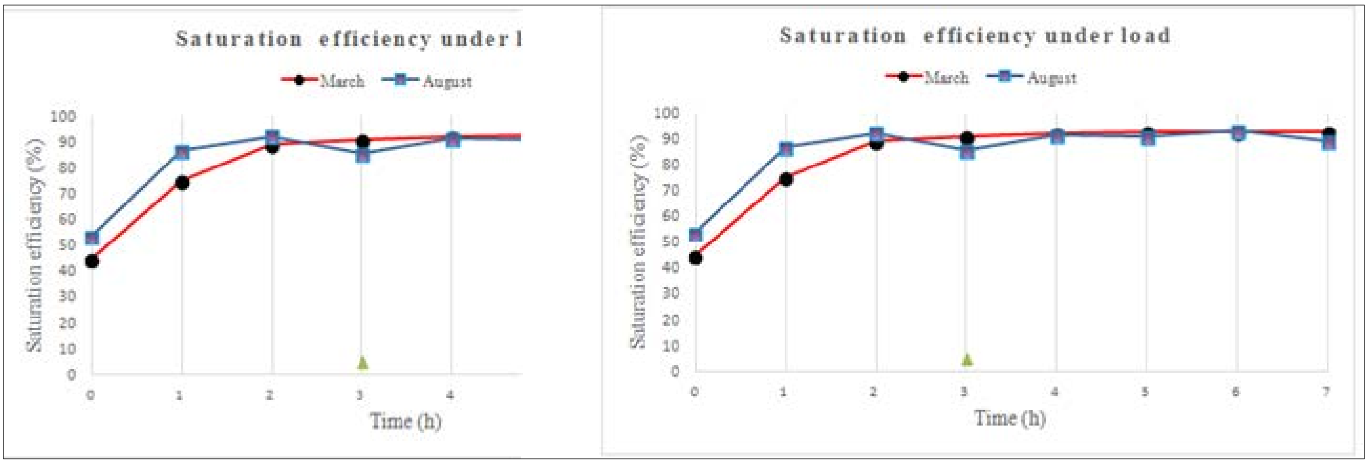

Fig 4: Saturation efficiency of the cellulose cooling pad under load and no load condition

3.2 Physiological Weight Loss

The tomatoes which were kept under ambient condition exhibited physiological weight loss of 15% while the produce placed inside the cooling cabinet had a physiological weight loss of 7% up to 15 days .The physiological weight loss of bitter gourd placed in the ambient condition and inside the cabinet were observed as 40% and 20% respectively (Fig. 5). The samples placed in the ambient became unfit for usage in the fifth day of storage while inside the cooling cabinet the samples had the marketable quality upto 7th day and degraded completely on 9th day.

Agricultural produce is hygroscopic in nature, therefore when stored under low relative humidity moisture loss is also incremented. The physiological weight loss occur in the fruits due to respiration, transpiration and other biochemical changes (Gill *et al.*, 2017) [6], the results obtained was in accordance to the result as reported that the weight loss occurs at a faster rate during ripening period under higher temperature conditions. The statistical test showed that there was significant difference in the effect of temperature on the physiological weight loss between the samples placed under cabinet and ambient condition.

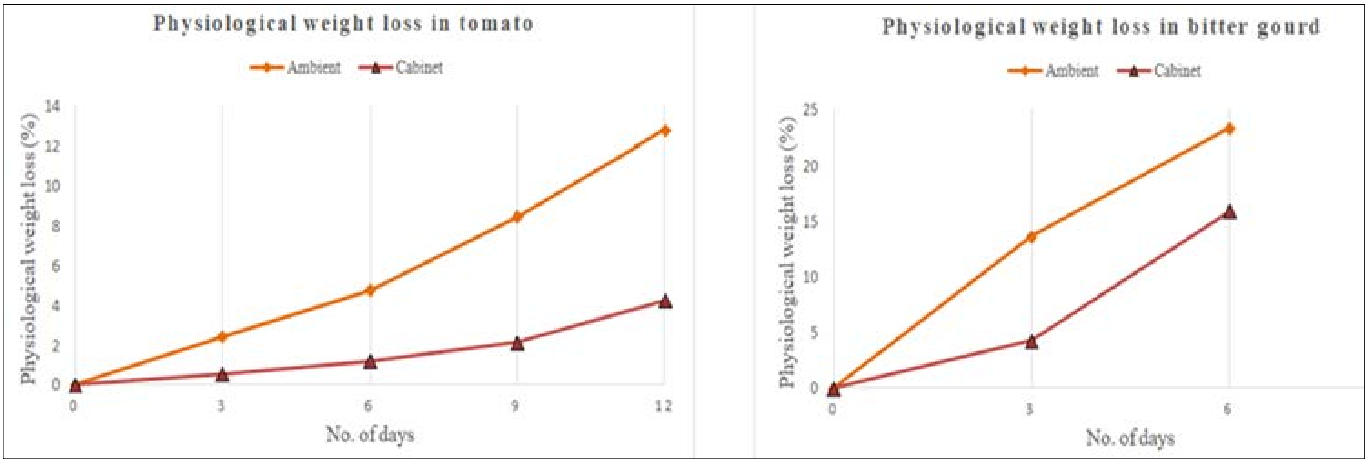

Fig 5: Physiological weight loss of tomato and bittergourd under cabinet and ambient condition

Table 1: Temperature drop and relative humidity drop, saturation efficiency in March and August

Time	Temperature	Drop (°C)	R.H	Drop (%)	Saturation	Efficiency (%)
(h)	March	August	March	August	March	August
0	4.97	3.7	8.3	3.4	44.71	53.45
1	8.6	5.26	18.35	12.2	74.98	86.55
2	11.19	7.98	42.22	19.7	89.21	87.26
3	12.29	8.42	45.1	24.6	90.04	85.72
4	13.12	6.31	46.7	28.45	91.04	89.51
5	13.26	6.26	47.05	26.43	91.02	90.61
6	12.47	5.94	44.6	22.55	90.83	90.33
7	11.89	5.51	42.75	21.55	90.81	88.81

3.3 pH
The pH values of the tomatoes stored in ambient condition ranged between 4.012-4.398 and inside the cooling cabinet the values ranged from 4.014-4.169. The pH values of the bitter gourd stored under ambient condition and in evaporative cooling were 5.32-5.97 and 5.22-5.79 respectively.

There is an increasing trend in the pH values on storage. This is explained by the increase in metabolism activity which uses up the acid content, thereby decrease in the acids resulting in increase in pH (Olosunde *et al.*,2015) [11]. Therefore, the increase in pH value under ambient conditions indicates that the metabolism activity is accelerated at a higher rate when compared to evaporative cooling storage.

3.4 Total Titratable Acids
Total titratable acids for tomatoes under ambient storage decreased from 0.41 to 0.269 while under cabinet condition decreased from 0.422 to 0.345. Bitter gourd stored inside cooling cabinet and ambient condition exhibited total titratable acid values from 0.217 to 0.192 and 0.205 to 0.102 respectively. Statistical test performed indicated that the changes in titratable acids under ambient and cabinet are significantly different.

A decrease in total titratable acids were observed during storage. This trait is observed because pH and titratable acids are interrelated, the decrease in total titratable acids indicate that the acid content gets decreased on ripening. Initially an increase in titratable acids will be observed in both climacteric and non-climacteric fruits, later during the ripening stage the titratable acids will decrease because of decarboxylation of carbohydrates and gluconogenesis (Iqbal *et al.*,2022) [7]. The acidity decreases with maturity, amount of organic acid during maturity because they are substrate of respiration. The vegetables stored under ambient condition undergoes metabolism at a faster rate when compared to evaporative cooling storage.

3.5 Total Soluble Solids
The total soluble solids changes in the tomatoes stored inside the cabinet under evaporative cooling condition was 3.4 to 3.7 °B and under ambient condition was 3.4 to 4.3 °B. In bitter gourd the changes under ambient conditions were recorded as 3.1 to 3.5 °B, and under evaporative conditions 3.1 to 3.3 °B. The changes in total soluble solids in the samples placed under ambient and cabinet condition had a significant difference.

An increase in total soluble solids was observed because the starch gets converted to sugar on ripening (Olsounde *et al.*, 2016). Total soluble solids and total sugars increase during ripening due to increase in activity of enzymes resulting in hydrolysis of starch to sugars (Bashir *et al.*, 2003) [2]. The increment in soluble solids is caused by biosynthesis process or degradation of polysaccharides during maturity. Thus, under ambient condition the total soluble solids increase at a higher rate when compared to evaporative cooling storage.

3.6 Firmness & Color
Tomatoes stored under ambient condition exhibited shrinkage from 6th day and became very soft on the 10th day of storage, from 12th day it lost the marketable quality and in 14th day the samples became completely unfit for consumption. The samples stored under cabinet conditions began to turn soft from 8th day, but shrinkage was not observed as compared to storage under ambient condition. This supplements that transpiration is reduced when stored under high relative humidity. The tomatoes became unfit for consumption in 19th day. Bitter gourd under ambient condition became soft from third day and lost its marketable quality on 5th day of storage. When stored under cabinet condition bitter gourd retained its marketable quality up to 9 days of storage. On the other hand, when stored under high humidity, bittergourd was susceptible to fungal attack.

The decreasing fruit hardness is associated with fruit softening due to deterioration of cell wall structure caused by hydrolysis of insoluble into soluble forms (Rooban *et al.*, 2016) [12]. This adds to the fact that the metabolism is accelerated under ambient condition than the cabinet condition. The statistical test reported that there is significant difference in the firmness of the samples stored under ambient and cabinet condition.

Color changes are observed primarily due to the changes in the pigments present in the fruits and vegetables. Pigmentation changes are accompanied during fruit ripening. A structural change occurs in chloroplast, the grand intergranal network become disorganized resulting in the formation of chromoplast. Chromoplast is the site for synthesis of lycopene, anthocyanin, carotenoids (Choo, 2018) [3]. This process is initiated by the ripening hormone ethylene. The color changes are accelerated under ambient condition because ripening process occurs at a faster rate due to the activity of ethylene which is accompanied by the increase in temperature.

3.7 Sensory Evaluation of the Samples Placed Inside the Cooling Cabinet and Ambient Condition
The ratings obtained highlights that the samples retained marketable quality when stored inside the cooling cabinet. The samples when stored under ambient condition lost its freshness from the third day of storage, it became slimy from the sixth day of storage. It was observed that as the deterioration rate is higher under ambient condition, the acceptability level decreases.

When stored inside cooling cabinet the produce retains freshness and was less susceptible to insect and microbial attack as it is stored under protected condition. The samples appeared to be fresh and did not possess any wilt or spot on the skin of the fruits. The judgment panel was much likely towards the samples stored under cooling cabinet condition. Therefore, when stored under reduced temperature and higher relative humidity the change in physiochemical characteristics of the vegetables is slowed down, thereby increasing the shelf life of the vegetables. Thereby, the consumer's level of acceptability is also increased when stored inside the cooling cabinet.

3.8 Economic Analysis
Economic evaluation is done based on the comparison of the profit and produce sold using conventional and evaporative cooling vegetable vending cart. The profit yielded was calculated by considering the cost of tomato and bittergourd which was stored inside the cabinet till it lost its marketability. The 100% marketable shelf life for tomato was 15 days and 8 days for bittergourd. Assuming 200kg of a given vegetable is sold completely within 15 day and 150 kg of bittergourd in 8 days without any wastage. Therefore, in a month 800 kg of tomatoes and 600 kg of bittergourd is handled. In a year 96000kg and 72000kg of produce is

handled. In 2021, the maximum cost of tomato was 120/kg and bittergourd was 60/kg. Therefore assuming 100% of the stored vegetables are sold within the stipulated time without any wastage, the total selling cost was Rs.33,000. Assuming a storage loss of 20% under conventional condition, the selling price yielded was Rs.26,400. Therefore, on comparing the two condition, a profit of Rs. 6,600 was obtained on selling under evaporative cooling condition. Since it machine does not require any maintenance or labor cost only electricity cost for charging the battery was considered.

4. Conclusion

Solar photovoltaic cell operated evaporative cooling system offers to be a reliable environmental friendly and uncomplicated technique for efficient storage and transportation of agricultural produce in tropical countries by minimizing the degradation in the vendible attributes of produce such as hindering the microbial growth, enzymatic changes, respiration rate through low temperature and high humidity storage. The developed vegetable vending cart proves to be a good solution for short term storage of harvested agricultural produce for small scale farmers and vegetable vendors.

From the study we can conclude that the developed vending cart not only increases the shelf life of the produce, also protects the produce from biological detrimental factors such as rodents, insects, weather. The cart facilitates easy transportation of the vegetables for street vendors by reducing the heavy work involved in carrying the vegetables. The physiochemical analysis and saturation efficiency conducted highlights the fact that the temperature and relative humidity maintained inside the cabinet is much lesser than the ambient condition which is responsible for extending the shelf life of the produce placed inside. The saturation efficiency graphs obtained indicate that the cooling pad material (honey comb cellulose) sustains the temperature consistently inside the cabinet efficiently. Cellulose serves as a good cooling pad material because of its faster wetting ability, easier maintenance and durability.

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6. References

1. AOAC. 17th edn, Official method 942.15 Acidity (Titrable) of fruit products read with A.O.A.C official method 920. 149. Preparation of test sample, 2000.
2. Bashir HA, Abu-Goukh ABA. Compositional changes during guava fruit ripening. Food Chemistry. 2003;80(4):557-563.
3. Choo WS. Fruit pigment changes during ripening. In Encyclopedia of food chemistry. Elsevier, 2018, 117-123.
4. Chopra MK, Kumar R. Design of new evaporative cooler and usage of different cooling pad materials for improved cooling efficiency. International Research Journal of Engineering & Technology. 2017;4:503-511.
5. Ghosal MK, Dash CD. Studies of Solar Refrigerated Vegetable Vending Cart for Retaining Freshness and Nutrition of Vegetables, EAS Journal of Nutrition and Food Sciences. 2019;1(4):63-67
6. Gill PPS, Jawandha SK, Kaur N, Singh N. Physico-chemical changes during progressive ripening of mango (*Mangifera indica* L.) cv. Dashehari under different temperature regimes. Journal of food science and technology. 2017;54(7):1964-1970.
7. Iqbal HM, Akbar QUA, Arif S, Yousaf S, Khurshid S, Jabbar S. Maturity dependent changes in post-harvest physiological, antioxidant and anti-microbial attributes of tomato. Pakistan Journal of Agricultural Research. 2022;5(1):144-153.
8. Malli A, Seyf HR, Layeghi M, Sharifian S, Behravesh H. Investigating the performance of cellulosic evaporative cooling pads. Energy Conversion and Management. 2011;52(07):2598-2603.
9. Nkolisa N, Magwaza LS, Workneh TS, Chimphango A. Evaluating evaporative cooling system as an energy-free and cost-effective method for postharvest storage of tomatoes (*Solanum lycopersicum* L.) for smallholder farmers. Scientia Horticulturae. 2018;241:131-143.
10. Ogbuagu NJ, Oluka SI, Ugwu KC. Development of a passive evaporative cooling structure for storage of fresh fruits and vegetables. Journal of Emerging Technologies and Innovative Research. 2017;4(8):179-186.
11. Olosunde WA, Aremu AK, Onwude DI. Development of a solar powered evaporative cooling storage system for tropical fruits and vegetables. Journal of Food Processing and Preservation. 2016;40(2):279-290.
12. Rooban R, Shanmugam M, Venkatesan T, Tamilmani C. Physiochemical changes during different stages of fruit ripening of climacteric fruit of mango (*Mangifera indica* L.) and non-climacteric of fruit cashew apple (*Anacardium occidentale* L.). J Appl Adv Res. 2016;1(2):53-8.
13. Saadoudi M, Hambaba L, Abdeddaim M, Lekbir A, Bacha A, Boudraa S. Nutritional composition, physical properties and sensory evaluation of biscuit produced from jujubes (Fruits of *Zizyphus lotus* L.). Annals. Food Science and Technology, 2017, 18(3)
14. Steel RGD, Torrie JH, Dickey DA. Principles and Procedures of Statistics. A Biometrical Approach. 3rd ed. McGraw Hill Book Co. Inc. New York, 1997.