Eco. Env. & Cons. 30 (February Suppl. Issue) : 2024; pp. (S224-S227)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i02s.047

Cost economic evaluation of infrared assisted hybrid dryer for horticultural produce

Chinmayee Parida, Pramod Kumar Sahoo, Silpa Mandal and Monika Satankar

Division of Agricultural Engineering, ICAR-IARI, New Delhi 110 012, India

(Received 11 July, 2023; Accepted 14 September, 2023)

ABSTRACT

Apple is one of the most widely consumed fruit all over India, loved by all age groups. To avail the product year-round, a widely accepted convectional techniques namely drying is followed in large scale. The process of drying is cost intensive and time consuming by nature. Mechanisation will act as a boon to food product developer in this field. A concise knowledge regarding ownership and operational expenses are required for a food product developer which will be helpful in choosing right one from the options like purchasing a new machine, advancement of existing one or exploring the alternative methods to enhance financial outcome. Therefore, ownership cost and operational cost of developed infrared assisted air impingement hybrid dryer were analysed. The dryer was found to be cost effective as it has low breakeven point and short payback period.

Key words: *Break-even point, Cost economics, Operating cost, Ownership cost, Payback period.*

Introduction

The World Health Organization recommends the consumption of five servings of fruits and vegetable per day. "An apple in a day keeps the doctor away" is a common proverb, indicates the abundance of the fruits with the micronutrients and bioactive compounds, which have potential health benefits. It has therapeutic utility against chronic disorders such as diabetes, cancer, and cardiovascular diseases (Hyson *et al*., 2011; Oyenihi *et al*., 2022).

Post-harvest losses create a gloomy impact on socioeconomic status of the farmers and simultaneously cause a detrimental effect on the environment. From farm to fork level, at each and every step, a large number of fruits and vegetables are wasted which constitute around 20-60 % of total production (Anand *et al.,* 2022). Improper handling and lack of storage facility of high moisture food rises global concerns in post-harvest losses which may unfavourably affect the food safety and quality. High perishability of fruits and vegetables hampers the shelf life of fruit.

The quality of the final dried product is a significant factor to be studied in the drying industry. Loss of nutritious substances (e.g., ascorbic acid) (Marfil *et al.*, 2008), loss of color (Chua *et al.*, 2000) and deformation or internal structure (Vega-Galvez *et al.*, 2012) are some of the negative effects of drying that should be minimized by optimizing the process. Choosing the proper dryer for a particular material, drying within an appropriately limited time, and pre-treatment of the material are factors that affect the quality of dried products.

In recent years, infrared drying has become a significant technique in the drying industry because of its numerous advantages, such as the energy savings, lower drying time, high-quality dried products, intermittent energy source, easy control of the process parameters, uniform temperature distribu-

tion, and clean operational environment, as well as space savings (Mongpraneet *et al.,* 2002).

In spite of advantages, due to the limited penetration depth, IR energy is usually applied in combination with other drying methods, such as hot air, microwave and vacuum drying (Riadh *et al.,* 2015).

Although this hybrid technology has shown greater advantage over conventional methods in drying still not much techno economic research has been done worldwide in this area.

The objective of this work was to evaluate cost economic worth whileness of a developed infrared assisted hybrid dryer. This method has been used for different dryers, but none is available for infrared assisted hybrid dryer.

Materials and Methods

Bill of materials and cost of fabrication of the developed infrared assisted hybrid dryer was calculated by combining the individual cost of all the elements of developed hybrid dryer, which is called initial cost of machine (P). The detailed analysis is based upon the method proposed by Nag *et al.* (2023) with slight modification.

Assumptions are considered for determining the cost of operation of infrared assisted hybrid dryer.

- Useful life hours of machine per year (H) = 2920 h
- Useful life years of machine (L) = 10 years
- Salvage value (S) = 10 % of initial cost
- Shelter and insurance =2% of initial cost
- Price of electricity: 4 Rs /h
- Labour wages: 400 Rs day-1 (8 hours)
- Depreciation method: Straight line method

Cost economic evaluation of developed hybrid dryer was done by taking ownership cost and operational cost into consideration.

Machinery cost: It includes the ownership cost and operating cost. It can be roughly calculated by applying few assumptions regarding life of equipment, its annual use, fuel and labour price.

Ownership cost: Depreciation, interest, taxes, insurance and housing are a few of this cost.

Depreciation: It is the loss of value associated with machines wear and tear, deterioration and life used. A life span of 10 years is considered for this purpose. The annual depreciation value can be calculated by the following expressions.

$$D = \frac{P - S}{L \times H}$$

Where,
D = Depreciation (Rs/h)
P = Initial cost (Rs.)

Interest: If the owner burrows money from a lender, the interest rate will be dependent upon creditworthiness and the market condition. If he chooses to use his own fund, the interest rate should be based upon opportunity cost of that capital in other potential investment within the farm business. Here an average rate of 12 % is taken into consideration.

$$I = \frac{P + S}{2} \times \frac{i}{H}$$

Taxes, housing and insurance

This additional cost which the owner has to bear in terms of sales tax, road tax, insurance, and shelter charge is relatively smaller compared to depreciation. It is estimated as 2 % of average machine cost annually.

$$\text{Taxes, Housing and Insurance} = \frac{0.02 * P}{H}$$

Total ownership cost is the combination of depreciation, interest and Taxes, housing and insurance.

Operating cost

Repair and maintenance cost, labour charges, electricity cost are taken into consideration while the machine is in use. All together these charges can be computed as operating cost which is variable in nature. It is dependent the use hour of machine.

Repair and maintenance cost

It is taken as 10 % of machine purchase price per year.

Labour wages

Rs. 400/ day is finalised for labour wages.

Electricity

The total electricity consumption is recorded and overall electric charges are computed based on these measurements.
Total electricity charge = 4 Rs/h

So, total operating cost = Repair and maintenance cost + labour charges + electricity cost and total cost of developed hybrid dryer = Total ownership cost +

Table 1. Result for cost economics of infrared assisted air impingement hybrid dryer

Ownership cost (Rs/h)		Operating cost (Rs/h)	
Depreciation,	0.72	Labour cost	50
Interest	0.53	Electricity	4
Housing, shelter	0.16	Repair and maintenance	0.8
Total ownership cost	**1.41**	**Total Operating cost**	**54.8**
Total cost (Rs/h)	56.21		
Overhead charges (Rs/h)	14.05		
Profit (Rs/h)	17.56		
Custom hiring charge	87.82		
Breakeven point (h/year)	124.68		
Average net annual profit (Rs)	96,418.4		
Payback period (year)	0.24		

Total operating cost

Breakeven point (BEP): This is the point where; total cost is equal to total revenue from the use of machine. Here, there is no profit and no loss. It can be calculated using the following formula as

$$BEP = \frac{\text{Annual fixed per year}}{\text{Custom hiring charge} - \text{Operating cost}}$$

Here,

Custom hiring charge = Total cost + Overhead charge + Profit

Over head charge = 0.25*Total cost

Profit = 1.25 * Overhead charge

Payback period

It is the time frame required for total cash inflows generated by using the dryer to equal the investment cost of purchasing the machine. The earlier the payback period the quicker the return on investment.

It can be calculated using the following formula.

$$\text{Payback period} = \frac{\text{Initial cost of machine}}{\text{Average net annual profit}}$$

Average net annual profit can be calculated as,

Average net annual profit = (Custom hiring charges – Operating cost)*Annual use

Results

Cost economic analysis was computed considering the total ownership cost, total operating cost, overhead charge, profit, custom hiring charge (Table 1).

Breakeven point even was computed to find the no. of hour per year where the total running expenses were equal to the total revenue from its use. Payback period was calculated from the total cash inflow generated by using the dryer to the total investment cost purchasing the machine.

Conclusion

Total initial cost of the developed hybrid dryer was Rs. 23,580. The machinery cost, breakeven point, payback period is found to be 56.21 Rs. /h, 124.68 h/year, 0.24 year respectively. This detail analysis of infrared assisted hybrid dryer will be helpful to food product developer in deciding to go with technology or not. Moreover, this can be concluded that, due to low breakeven point, the financial stability and profitability will be high. The payback period is also short. Hence, it is a more attractive investment as it reduces the exposure to uncertainty and volatility in future cash flows.

References

Anand, S. and Barua, M. K. 2022. Modeling the key factors leading to post-harvest loss and waste of fruits and vegetables in the agri-fresh produce supply chain. *Computers and Electronics in Agriculture.* 198: 106936.

Chua, K.J., Mujumdar, A. S., Chou, S. K., Hawlader, M.N.A. and Ho, J.C. 2000. Convective drying of banana, guava and potato pieces: effect of cyclical variations of air temperature on drying kinetics and color change. *Drying Technology.* 18(4-5): 907-936.

Hyson, D.A. 2011. A comprehensive review of apples and apple components and their relationship to human health. *Advances in Nutrition*. 2(5): 408-420.

Marfil, P.H.M., Santos, E.M. and Telis, V.R.N. 2008. Ascorbic acid degradation kinetics in tomatoes at different drying conditions. *LWT-Food Science and Technology.* 41(9): 1642-1647.

Mongpraneet, S., Abe, T. and Tsurusaki, T. 2002. Accelerated drying of welsh onion by far infrared radiation

under vacuum conditions. *Journal of Food Engineering*. 55(2): 147-156.

Nag, R.H., Sharma, P.K., Mani, I., Kushwaha, L.H., Yadav, R., Chakraborty, D., Sarkar, S.K. and Kushwah, A. 2023. Cost-Economic Evaluation of Leafy Vegetable Harvester versus Conventional Harvesting: A Comparative Study. *International Journal of Environment and Climate Change.* 13(9): 3145-3153.

Oyenihi, A.B., Belay, Z.A., Mditshwa, A. and Caleb, O.J. 2022. An apple a day keeps the doctor away: The potentials of apple bioactive constituents for chronic disease prevention. *Journal of Food Science.* 87(6): 2291-2309.

Riadh, M.H., Ahmad, S.A.B., Marhaban, M.H. and Soh, A.C. 2015. Infrared heating in food drying: An overview. *Drying Technology.* 33(3): 322-335.

Vega-Gálvez, A., Ah-Hen, K., Chacana, M., Vergara, J., Martínez-Monzó, J., García-Segovia, P. and Di Scala, K. 2012. Effect of temperature and air velocity on drying kinetics, antioxidant capacity, total phenolic content, colour, texture and microstructure of apple (var. Granny Smith) slices. *Food Chemistry.* 132(1): 51-59.