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Techno-Economic analysis of CAZRI Solar Dryer

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ABSTRACT

Apricot (*Prunus armeniaca* L.) is one of the major horticultural produce and an important source of income as well as livelihood in Ladakh, Himachal Pradesh and North-eastern part of India. However, it is also full of nutritional and functional health benefits. Despite all the advantages associated with the fruit, shorter shelf life is major hindrance in attaining its potential economic benefit to the farmers. Apricot drying is most common in these regions traditionally done by the farmers. Solar dryer developed by ICAR-Central Arid Zone Research Institute (CAZRI) at its regional station, Leh is helping in extending shelf life of apricot and its availability throughout the year. This study was carried out during 2017–19 aimed to estimate the techno-economic benefit on adoption of the dryer by individual farmer or processor. It is found that adopter need to make investment of ₹1.10 lakh in fixed capital and requires ₹1.22 lakh annually to process one metric tonnes of the fruit. The annual cost of production was determined as ₹133,000 with depreciation of ₹11,000 for project of 1 metric tonne fresh fruit. Estimates indicate that adopter could generate net income of ₹78,000 annually. Profitability analysis yielded net profit ratio, pay-back period, benefit-cost ratio and break-even point of 37%, 1.23 years, 1.52, and 123.50 kg, respectively.

Keywords: Apricot, Business and Economics, Farmer income, Ladakh, Solar dryer

Apricot (*Prunus armeniaca* L.) is a nutritious stone fruit belonging to Rosaceae family, grown in mid hill as well as dry temperate regions. It is considered to have immense medicinal values (Yigit *et al.* 2009). Apricot is primarily grown in Ladakh, Himachal Pradesh and north-eastern states of India. In Ladakh, it covers around 75% of agricultural area and is considered as second most important agro-produce. Despite having export potential with larger market, apricot is associated to have short–shelf life, limited consumer area and availability at peak season. It necessitates the search of technologies needed for extending the storage life and value addition, proper packaging, ease of transportation to potential market to harness its economic potential.

Drying is one of the techniques for extending the storage period and value addition with concentrate form of nutrition (Incedayi *et al.* 2016). Prakash *et al.* (2019) advocated necessity of suitable drying technology for apricot in the growing region to ensure remunerative price to the farmers. Solar energy is abundantly available in the country (Poonia *et al.* 2019a).

Apricot can be consumed as a dry fruit directly or used for fortification in different products processed for enriching the nutritional and sensory quality. Drying reduces the space for storage, packaging and transportation and leads to reduction in cost. Solar drying is preferred for retaining fruit quality, while keeping it safe from dust, dirt and organisms present in the environment with least operational cost (Purohit *et al.* 2006, Poonia *et al.* 2017). Solar energy is easily accessible to rural farmers with favourable economic and environmental concerns (Sharma *et al.* 2009). It has been proved to be a better alternative for high valued products. Additionally, the drying system has potential of generating employment opportunities in the local market. Economic evaluation for business model of making solar-thermal devices can also attract opportunity for entrepreneurs of cold arid region (Singh *et al.* 2020). Hence, this study is an attempt to analyze the economic potential of solar dryer developed by ICAR-Central Arid Zone Research Institute at regional research station, Leh.

MATERIALS AND METHODS

The study estimates the economic feasibility of the specified technology to enhance its adoption level among the targeted farming communities. Hypothesis behind is to utilize free time of family members for earning additional income and making processed apricots available for larger population throughout the year. The process follows the unit operations as Apricot fruit was harvested and collected either from the farms or procured from the local market. The fruit is subjected to gentle cleaning and sorting. Processors have option either to dry the whole fruit directly or cut

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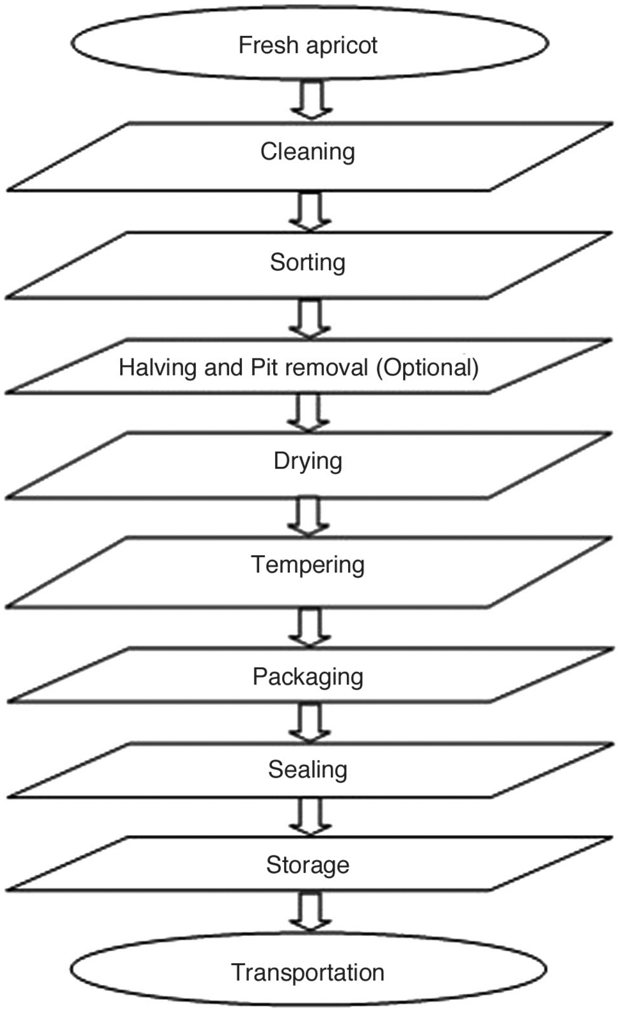

Fig 1 Process flow chart for preparation, storage and transportation of dried apricot.

into two halves and remove pits before drying. Drying is performed in the CAZRI solar dryer until attaining safe limit for moisture content of the fruit. The dried fruits were tempered for equilibration of moisture and cooling at room temperature. Subsequently, the fruit is sealed in the desired size of packaging material. Dried fruits are stored in the container or transported to the market place with higher demand. Thus, the fruit has been processed following the unit operations as mentioned in Fig 1. Processed fruits can be consumed directly or used as one of the ingredients in different products processed at industry or domestic levels.

The basis and presumption of the study included following points: the project profile needs 45 man-day assuming rate of labour at ₹300/man-day. Salaries/wages are based on prevailing rates during preparation of the report and likely to vary with time and place. The quoted rate of raw material is based on the prevailing rates during preparation of report and likely to vary with time, place and supplier with whom agreement is made. Gestation period of 3–4 months is required for implementing the project. It includes technical know-how, technology transfer, market survey and tie-ups with stakeholders (farmers and shopkeepers), site selection, registration, financing, procuring materials (containers, knives etc.) for drying, installation of dryer, staff recruitment, procuring fresh apricot fruit and trial production etc.

Table 1 Implementation schedule and paths of scheduling the activities for commencement of apricot drying

Implementation schedule		
Activity	Description	Duration (Days)
A (1-2)	Technical know-how and technology transfer	10
B (2-3)	Site selection	07
C (2-4)	Registration and Financing	15
D (4-5)	Recruiting staff	07
E (5-6)	Market surveys and tie-ups with stakeholders	10
F (5-7)	Procuring materials (containers, knives etc.) and installing dryer	20
G (7-8)	Procuring, washing, sorting, cutting and pitting of apricot	03
H (8-9)	Trial production	05
Paths of scheduling the activities for commencement of apricot drying		
Paths	Activities	Remarks
1-2-3---4-5-6---7-8-9	ABDEGH	----
1-2-3---4-5-7---8-9	ABDFGH	----
1-2-4-5-6---7-8-9	ACDEGH	----
1-2-4-5-7-8-9	ACDFGH	Critical path (60days)

RESULTS AND DISCUSSION

Detailed implementation schedule has been kept under consideration for apricot drying project through CAZRI Solar dryer. In Table 1, the duration of each of the activities has been enlisted to find the paths before commencing the project. The critical path of implementation has been identified as 1-2-4-5-7-8-9 (ACDFGH) as depicted from Table 1 and Fig 2. It indicates that it will require 60 days for commencement of the commercial production.

The techno-economic analysis of ICAR-CAZRI solar drier devised for production target of drying 1 MT of apricot fruit is worked out. Dry apricot fruits are in demand as whole as well as halved without stones. Total apricot fruits quantity is divided equally under category of whole and halved as per assumed market demand. Stones in the fruit yields apricot kernels called giri and their shell and all the parts are supposed to be in use. Prakash *et al.* (2019) described utility and commercial importance for different parts of apricot. Apricot fruit was reported with 8.01–15.1 g containing 12.7–22.2% stone of 1.78–1.92 g

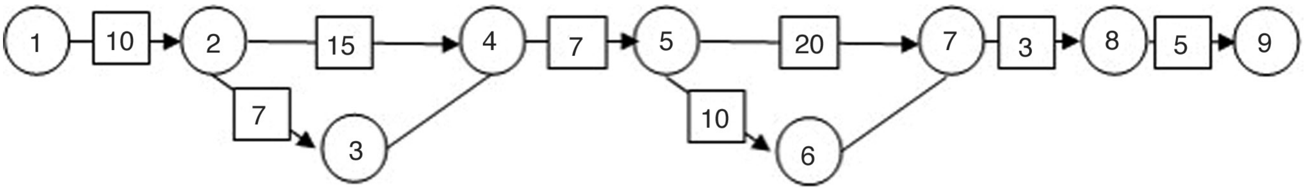

Fig 2 Diagram of scheduling the activities for commencement of apricot drying.

with 30.7–33.7% kernel recovery from 45.6–46.3% crude oil present in kernels (Gupta *et al.* 2012). Kate *et al.* (2014) reported fruit containing 22–38% kernels with commercially important oil up to 53.4%. Targais *et al.* (2011) reported oil from sweet kernels edible and that from bitter kernels with religious, medicinal and cosmetic values. Hence, the whole and halved fruits were subjected to drying, while keeping equal quantity (500 kg) in both the forms.

Mass balance of whole fruit: Mass balance was performed for whole fruit (with stone), while assuming the total quantity of whole fruit (T1) = 500 kg subjected to drying

Initial moisture of stone containing fresh fruit of apricot (I1)

= 2.64 kg/kg dry matter

= 2.64 kg/kg = (2.64 × 100/ 3.64) % wet basis = 72.5% wet basis

= 0.725 wet basis fraction

Final moisture of stone containing apricot fruit = 0.17 kg/kg (=F_1, Say)

Moisture removal (MR_1)

= Dry matter in whole fruit × (I_1, kg/kg – F_1, kg/kg)

= T_1 × (1 – I_1, wet basis fraction) × (2.64 – 0.17) kg

= 500 × (1 – 0.725) × (2.64 – 0.17) kg

= 339.6 kg

Dry apricot = T_1 – MR_1

= (500 – 339.6) kg = 160.4 kg

Mass balance of fruit halves (without stone): Mass Balance was performed separately for half fruit (without stone), while assuming total quantity of fruit (T_2) = 500 kg halved with removal of pits before subjecting it for drying.

Stone weight (St) = 20% of the fruit weight

= 500 × 0.2 = 100 kg

Giri weight in the stone (G) = 30% of stone weight

= 100 × 0.3 = 30 kg

Shell weight in the stone

= Stone weight (St) – Giri weight (G)

= 100 – 30 = 70 kg

Fresh fruit moisture without stone = 4.80 kg/kg = (I_2, say) and

Dry fruit moisture without stone = 0.11 kg/kg = (F_2, say)

Initial moisture of apricot flesh before after drying (I_2)

= 4.80 kg/kg = (4.8 × 100/5.8) % wet basis = 82.76% wet basis

= 0.8276 wet basis fraction

Final moisture of apricot flesh after drying (Final) = 0.11 kg/kg

Moisture removal (MR_2)

= Dry matter in flesh of apricot fruit × (I_2, kg/kg – F_2, kg/kg)

= (T_2 – St) × (1 – I_2, wet basis fraction) × (4.80 – 0.11) kg

= (500 – 100) × (1 – 0.8276) × (4.8 – 0.11) kg

= 323.4 kg

Weight of dry apricot = T_2 –St – MR_2

= (500 – 100 – 323.4) kg = 76.6 kg

Financial Analysis of the project consisted of estimating the fixed capital, working capital, initial investment (in 1st year) and cost of production (per annum). Fixed capital deals with the initial capital were required irrespective of the variation in the production level. However, their capacities matched with the expected level of production. It was estimated as ₹110,000 in the present study (Table 2). The working capital projected in Table 2 revealed requirement of ₹122,000 as expenditure for making the project operational. It was based on one metric tonne capacity of the system. Thus, the business model requires a sum of ₹232,000 as initial investment. The annual expenditure was determined as the sum of working capital and depreciation annually with the assumption of 10% depreciation on fixed capital. It was estimated as ₹133,000.

Profitability calculations dealt with the sales revenue earned from the project annually, profit per annum (Annual Cash Benefit), net profit ratio, pay-back period (PBP), accounting rate of return, net present value (NPV), benefit cost ratio (BCR) and break–even analysis.

Net Profit Ratio (NPR): It was determined as the percentage of net profit relative to the gross income.

NPR= [Net Profit × 100/Gross income] = G × 100/E

= [78,100 × 100/211,100]

= 37.0%

Pay-back period (PBP) indicates time period required to recover the investment cost.

PBP = Initial investment or fixed cost (A)/Annual Cash Benefit (F)

= 110,000/89,100

= 1.23 years

Barnwal and Tiwari (2008) reported it as 1.25 years for photo-voltaic dryer with thermal energy in grape drying. The same was revealed as 1.42 and 3–4 years, respectively, for optimally tilted solar dryer (Poonia *et al.* 2019) and optimum mode dryer (Hossain *et al.* 2005).

Accounting rate of return exhibits percentage of net income earned as the ratio with the investments made over project life.

Accounting rate of return=Average Net Income/ Investment over the life of the Project

Table 2 Investment and revenue generation

Cost estimation for fixed capital expenditure			
Description	Quantity (Nos.)	Rate (₹/unit)	Value (₹)
Dryer	05	20,000.00	100,000.00
Storage container	10	200.00	2,000.00
Miscellaneous	01	8,000.00	8,000.00
	Total (A)		110,000.00
Cost estimation for working capital expenditure			
Components of working capital			Value (₹)
Raw material			
Apricot fruits (1000 kg)			100,000.00
Packaging material (60 Nos.)			3,000.00
Labour# (45 man-day)			13,500.00
Transport and Sales expenses			3,000.00
Miscellaneous expenses			2,500.00
Total Expenses on working capital per annum (B)			122,000.00
Initial investment for executing the business model			
Description			Value (₹)
Fixed Capital			110,000.00
Working capital per annum			122,000.00
Initial Investment (C)			232,000.00
Annual expenditure for executing the business model			
Description			Value (₹)
Working capital per annum			122,000.00
Depreciation$ on Fixed Cost @10%			11,000.00
Cost of Production (D)			133,000.00
Annual sales revenue			
Production	*Quantity (kg)*	*Price (₹/kg)*	*Revenue (₹)*
Dry apricot (Whole fruit)	160.4	800.00	128,320.00
Dry apricot (Half fruit)	076.6	800.00	61,280.00
Apricot giri	030.0	600.00	18,000.00
Apricot seed shell	070.0	50.00	3,500.00
Sale Realization (gross income) per annum (E)			211,100.00
Annual profit realization (Cash Benefit)			
Sale realization (Gross income) per annum (E)			211,100.00
Working capital per annum			122,000.00
Profit per annum (F) = Gross income – Working capital per annum			89,100.00
Depreciation @10%			11,000.00
Net Profit per annum (G) = F- Depreciation			78,100.00
Rate of return			
CAZRI Solar Drier			Remarks
Annual Cash Benefit (₹)		79,100	G
Initial investment (₹)		1,10,000	A
Salvage value (₹)		0	Assumption
Net investment (₹) (2–3)		110000	
Expected life of the project (Years)		10	
Average net investment (₹) (4/5)		11000	Result
Average net income (₹) (1–6)		68100	
Average rate of return (%)		61.91	
Estimation of the BC (Benefit-Cost) ratio			
Discounted cost incurred for the project (₹)			935220
Discounted benefit received from the project (₹)			1416457
NPV of the project			481237
B:C Ratio			1.515

Note: Assumed that fixed capital will be potentially operational for 10 years. Charges at ₹300 per man-day. Life of solar drier considered 10 years, for discounting time value of money rate 8% considered in the analysis. Maintenance cost 2% of initial capital investment included in the analysis.

Net Present Value (NPV): It is the difference between the present worth of the benefit stream and present worth of cost stream (Zamalloa *et al.* 2011). The decision criterion is if NPV is positive then the investment made on the solar dryer is economically viable.

Benefit:Cost ratio (BCR): It is the ratio of present worth of the benefit to present worth of cost. For a project to be viable if BCR is more than one, the investment made on the solar dryer can be considered as economically viable (Rymbai *et al.* 2012, Panwar *et al.* 2014, Kumar *et al.* 2019).

Break-even analysis: Break-even analysis is carried out to foresee the minimum production level to be maintained in adverse condition (Sathiadhas *et al.* 2009, Kangotra and Chauhan 2014). Break Even Point (BEP) of the project indicates weight of the fresh apricot that must be processed without incurring any loss or gaining profit. The revenue generated is used to maintain the cost incurred due to depreciation or variable cost of production. Thus,

BEP = [Fixed cost/(Sales price per unit – Variable cost per unit)]

= [Annual depreciation on fixed cost/annual cash benefit (F)

= [(₹11,000)/(₹89, 100/MT)]

= 123.5 kg

The profitability calculation of the business model yielded annual sales (gross) and net profit realisation as ₹211,100 and ₹78,100 (Table 2). It was found with favourable values of net profit ratio as 37% with pay-back period of 1.23 years. The average rate of return of the project was obtained as 61.91%. This model was estimated with benefit-cost ratio of 1.515. The break-even analysis revealed minimum production level of 123.5 kg without realising any profit or loss in running the project.

The solar dryer developed at Central Arid Zone Research Institute, Regional Research Station, Leh is one of the potential technologies to increase income of the farming community. The fruit is supposed to cover greater market because of its nutrition and health benefits. It needs techno-economic analysis before adoption by local farmers. Economics of the dryer was required to ensure enhanced income, considering utilization of labour available in the family. Hence, the dryer was studied for financial feasibility as economic gain of farmers. Implementation of scheduling the project was found as 60 days for critical path identified before commencement of the regular work. Economic analyses carried out in terms of annual profit, net profit ratio, payback period, benefit-cost ratio and break-even point clearly exhibited its potential in increasing the income of farmers. The system is likely to create additional employment opportunities for the makers of solar dryer in the local market.

REFERENCES

Barnwal P and Tiwari G N. 2008. Grape drying by using hybrid photovoltaic-thermal (PV/T) greenhouse dryer: an experimental study. *Solar energy* **82**(12): 1131–44.

Gupta A, Sharma P C, Tilakratne B M K S and Verma A K. 2012. Studies on physico-chemical characteristics and fatty acid composition of wild apricot (*Prunus armeniaca* L.) kernel oil. *Indian Journal of Natural Products and Resources* **3**(3): 366–70.

Hossain M A, Woods J L and Bala B K. 2005. Optimisation of solar tunnel drier for drying of chilli without color loss. *Renewable Energy* **30**(5): 729–42.

Incedayi B, Tamer C E, Sinir G O, Suna S and Copur O U. 2016. Impact of different drying parameters on color, β-carotene, antioxidant activity and minerals of apricot (*Prunus armeniaca* L.). *Food Science and Technology* **36**(1): 171–78.

Kangotra A and Chauhan S K. 2014. Economic viability of button mushroom cultivation in Himachal Pradesh, India. *Indian Journal of Agricultural Research* **48**(2):134–39.

Kate A E, Lohani U C, Pandey J P, Shahi N C and Sarkar A. 2014. Traditional and mechanical method of the oil extraction from wild apricot kernel: a comparative study. *Research Journal of Chemical and Environmental Sciences* **2**(2): 54–60.

Kumar N, Malik D P and Kumar R. 2019. An economic analysis of Mango (*Mangifera indica* L.) cultivation in Haryana. *Indian Journal of Economics and Development* **15**(2): 282–88.

Panwar N L, Kothari S and Kaushik S C. 2014. Cost-benefit and systems analysis of passively ventilated solar greenhouses for food production in arid and semi-arid regions. *Environment Systems and Decisions* **34**(1): 160–67.

Poonia S, Singh A K, Santra P and Jain D. 2017. Performance evaluation and cost economics of a low cost solar dryer of ber (*Zizyphus mauritiana*) fruit. *Agricultural Engineering Today* **41**(1): 25–30.

Poonia S, Singh A K, Santra P and Jain D. 2019a. Development and performance evaluation of high insulation box type solar cooker. *Agricultural Engineering Today* **43**(1): 1–10.

Poonia S, Singh A K, Santra P and Jain D. 2019b. Economic analysis of inclined solar dryer for drying of fruit and vegetables. *International Journal of Agriculture Sciences* **11**(20): 9154–59.

Prakash O, Jain D, Nikumbhe P H, Srivastava S and Raghuvanshi M S. 2020. Significance, status and scope of apricot in India: a review. *International Journal of Chemical Studies* SP-**8**(6): 05–11.

Purohit P, Kumar A and Kandpal T C. 2006. Solar drying vs. open sun drying: A framework for financial evaluation. *Solar Energy* **80**(12): 1568–79.

Rymbai D, Singh R, Feroze S M and Bardoloi R. 2012. Benefit-cost ratio analysis of pineapple orchard in Meghalaya. *Indian Journal of Hill Farming* **25**(1): 9–12.

Sathiadhas R, Najmudeen T M and Prathap S. 2009. Break-even analysis and profitability of aquaculture practices in India. *Asian Fisheries Science* **22**: 667–80.

Sharma A, Chen C R and Lan N V. 2009. Solar-energy drying systems: A review. *Renewable and Sustainable Energy Reviews* **13**(6-7): 1185–210.

Singh A K, Poonia S, Jain D, Mishra D and Singh R K. 2020. Economic evaluation of a business model of selected solar thermal devices in Thar desert of Rajasthan, India. *Agricultural Engineering Unternational: The CIGR Journal* **22**(3): 129–37.

Targais K, Stobdan T, Yadav A, Singh S B. 2011. Extraction of apricot kernel oil in cold desert Ladakh, India. Indian journal of traditional knowledge. *Indian Journal of Traditional Knowledge* **10**(2): 304–06.

Yigit D, Yigit N and Mavi A. 2009. Antioxidant and antimicrobial activities of bitter and sweet apricot (*Prunus armeniaca* L.) kernels. *Brazilian Journal of Medical and Biological Research* **42**(4): 346–52.

Zamalloa C, Vulsteke E, Albrecht, J. and Verstraete W. 2011. The techno-economic potential of renewable energy through the anaerobic digestion of microalgae. *Bioresource Technology* **102**: 1149–58.