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Research Paper :

Economic evaluation of solar tunnel dryer for drying peeled prawns

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ABSTRACT

Fish is a very important food due to high protein content and nutritional value. Being a perishable product, preservation is essential. Drying is one of the efficient and cheap methods for food preservation. Besides the preservation purposes, the demand for dried fish has also been driven by the flavour of the products. In comparison to sun drying, minimum spoilage and microbial infestation, improved and more consistent product quality is obtained in solar drying. The economic evaluation of solar tunnel dryer was done in comparison with open sun drying methods. The cost economics of dried peeled prawns was proved better for solar tunnel dryer than open sun dried method. Thus, solar tunnel dryer can be proposed as a suitable alternative to the local method of drying fish.

Key words : Economics, Tunnel, Dryer, Peeled, Prawns

Fish is a very important foodstuff in most of the countries, due to its high protein content and nutritional value. Being a perishable product, especially in hot climates and tropical areas where cold preservation techniques are often missing, drying is one of the efficient and cheap method for food preservation. Fish salting/brining, open sun drying or smoking, are traditional techniques for improving preservation and storage. Besides the preservation purposes, the demand for dried fish has also been driven by the flavour of the products. Japan, Hong Kong, Singapore, Malaysia and Hawai prefer dried squid, anchovy, sardines and cuttle fish (Dey, 1984). The sun dried salted fish like seer, tuna, perches, anchovies, bombay duck and other dried marine products are exported to Sri Lanka, South East Asian countries, Mauritius and the UK. The low cost incurred in employing traditional sun drying methods and convenience of utilizing petroleum based fuels for post harvest processing serves as a major impediment to the widespread deployment of solar dryers. Compared to sun drying, solar dryers can generate higher air temperatures and lower relative humidities, which improves drying rates and lower final moisture content of the drying material. This method has several advantages such as less spoilage and less microbial infestation, thus leads improved and more consistent product quality. Solar drying can also be a feasible alternative to those natural convection dryers that use wood or agricultural waste products as fuel.

Jain *et al*. (2004) conducted the economic analysis of forced convection type solar dryer for drying of groundnuts, ginger and garlic in comparison to an electrically operated tray type mechanical dryer. The benefit cost ratio for the solar dryer and mechanical dryer was found to be 1.56 and 1.18, respectively. Seveda *et al.* (2004) techno-economic analysis of walk in type semi-cylindrical shaped tunnel dryer with two chimneys and exhaust fan. was carried out by using different economic indicators such as net present worth (NPW), benefit-cost ratio (B-C ratio), pay back period and compared with electrical drying system. They observed that commercial solar tunnel dryer is techno-economically better than electrical drying system. Reddy *et al.* (2004) explained the method of analyzing cost economics of a project by using economic indicators. The capital investment, income statement and expenditure statement are made to calculate the economic indicators. The detailed procedure to calculate the economic indicators (*i.e.* net present worth, benefit-cost ratio, pay back period and internal rate of return) should be followed to decide feasibility of project.

METHODOLOGY

The solar tunnel dryer mainly consists of a cover of U.V. stabilized polyethylene sheet of 200 μm fixed on the cladding material with the help of zig-zag springs. The dryer is large enough that one can enter inside to load and unload the raw fish to be dried. The floor of the solar tunnel dryer is constructed with cement concrete and painted black for absorbing more solar radiation to increase the temperature inside the dryer. The supports for the chimney, door and exhaust fan were welded. The north wall was placed at north side of solar tunnel dryer

to minimize energy loss. The technical specifications and isometric view of solar tunnel dryer (100 kg/batch) are shown in Table 1 and Fig. 1, respectively.

Economic analysis of solar tunnel dryer for drying peeled prawns (Fig. 1) :

The economics of drying operation changes as per the dryer used as well as other factors. The economics was calculated separately for drying of peeled prawns (*Parapaeneopsis stylifera*) by solar tunnel dryer and open sun drying system. Drying was continued till the moisture content of the fish tended to a value of safe moisture content (*i.e.* 16 % w.b.). The different economic indicators for the economic analysis of the fish business for drying of peeled prawns in the solar tunnel dryer are described here

Net present worth/ Net present value

$$NPW = \frac{P_1}{(1+i)^{t_1}} + \frac{P_2}{(1+i)^{t_2}} + \cdots\cdots + \frac{P_n}{(1+i)^{t_n}} - C_0$$

where, P_1= Net cash flow in first year; i= Discount rate; t= Time period; C_0= Initial cost of the investment

Benefit- cost ratio (B-C Ratio):

It was calculated by comparing the present worth of costs with present worth of benefits.

$$B - C \text{ Ratio} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+r)^n}}{\sum_{t=1}^{n} \frac{C_t}{(1+r)^n}}$$

Profitability index:

$$PI = \frac{NPV}{C_0} = \frac{1}{C_0} \sum_{i=1}^{n} \frac{C_r}{(1+i)^n}$$

where, PI = Profitability index; NPV= Net present value of cash flows; C_0 = Initial capital expenditure; C_r = Total capital required for the project

Table 1 : Technical specifications of solar tunnel dryer for fish (100 kg/ batch)

Sr. No.	Particulars	Specifications	Material
1.	Collector area, sq. m	37.5 (3.75 m width x 10 m length)	--
2.	Drying tray area, sq.m.	2.5 (1.6 m x 1.6 m)	Al. wire mesh
3.	Number of trays	04 on each trolley	MS angle
4.	Number of trolleys	3 Nos., width 1.67 m, Length 3.12 m	----
5.	Height of tunnel, m	2.0	--
6.	Chimney, m	3 Nos., Ø 0.30 m, Length 0.50 m	20 SWG MS
7.	Fresh air vent area, sq.m	0.05	--
8.	Exhaust fan, single phase	2 Nos, Brushless AC, 410 Wp, 1400 rpm	---
9.	Door	1.75 m x 1.75 m	MS angle
10.	North wall	Height 1.55 m, Length 10 m	GI sheet

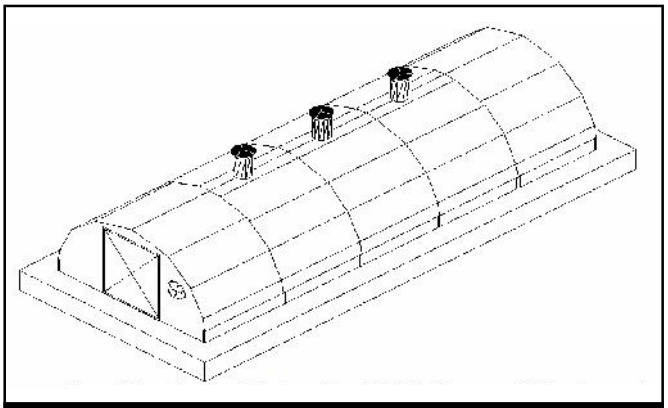

Fig. 1 : Isometric view of Solar tunnel dryer (100 kg/batch) Economic analysis of solar tunnel dryer for drying peeled prawns

Payback period:

Payback period= Amount of loan/ Average net returns

Internal rate of return:

It is the discount rate at which the present values of the net cash flows are just equal to zero, *i.e.* NPW = zero.

$$\left[\begin{matrix}\text{Internal rate}\\ \text{of return}\end{matrix}\right] = \left[\begin{matrix}\text{Lower}\\ \text{discount}\\ \text{rate}\end{matrix}\right] + \left[\begin{matrix}\text{Difference between}\\ \text{the two discount rates}\end{matrix}\right] \times \left[\frac{\begin{matrix}\text{Present worth of the}\\ \text{cash flow at the lower}\\ \text{discount rate}\end{matrix}}{\begin{matrix}\text{Absolute difference}\\ \text{between the present}\\ \text{worths of the cash flow}\\ \text{at the two discount rates}\end{matrix}}\right]$$

Table 2 : Cost incurred in drying prawns

Sr. No.	Particulars	Solar tunnel dryer				Sr. No.	Particulars	Open sun drying			
		Qty	Unit	Rate	Amount			Qty	Unit	Rate	Amount
1.	Land	100	m^2		62250	1	Drying yard				10000
2.	Building storage, packing	150.00	m^2		30000	2	Building storage, packing	150.00	m^2		12000
3.	Solar tunnel dryer				55500	3	Shed				3000
4.	Shed				5000	4	Electric fitting				1000
5.	Packing machine	1.00	unit	500	500	5	Packing machine	1.00	Unit	500	500
6.	Electric fitting				3000	6	Tub	2.00	Unit	263	526
7.	Fencing				11000	7	Bucket	2.00	Unit	46	92
8.	Tub	2.00	unit	263	526	8	Wooden board	2.00	Unit	110	220
9.	Bucket	2.00	unit	46	92	9	Sitting board	2.00	Unit	27	54
10.	Wooden board	2.00	unit	110	220	10	Plate	6.00	Unit	25	150
11.	Sitting board	2.00	unit	27	54	11	Chair	2.00	Unit	180	360
12.	Plate	6.00	unit	25	150	12	Table	2.00	Unit	448	896
13.	Chair	2.00	unit	180	360	13	Wooden box	3.00	Unit	4250	12750
14.	Table	2.00	unit	448	896	14	Ice Box	4.00	Unit	255	1020
15.	Wooden box	3.00	unit	4250	12750	15	Crate	6.00	Unit	270	1620
16.	Ice Box	4.00	unit	255	1020	16	Fan	1.00	Unit	760	760
17.	Crate	6.00	unit	270	1620	17	Balance	1.00	Unit	2655	2655
18.	Fan	1.00	unit	760	760		Capital cost				47603
19.	Balance	1.00	unit	2655	2655						
	Capital Cost				188353						
1	Packing bags	8.00	Packets	50	4800	1	Packing bags	5.00	Packets	50	2500
2	Operation Maintenance	--	--	--	2000	2	Operation Maintenance	--	--	--	43200
3	Repair at end of 5^{th} year	--	--	--	5000	3	Repair at end of 5^{th} year	--	--	--	10000
4	Ice slap	270.00	nos.	25	6750	4	Ice slap	180.00	nos.	25	10000
5	Transportation	--	--	--	2000	5	Transportation	--	--	--	4500
6	Stationary		per month	200	2400	6	Stationary		per month	200	1350
7	Pesticides		per month	100	1200	7	Pesticides		per month	100	200
8	Water charges		per month	250	3000	8	Water charges		per month	250	1200
9	Insurance, Taxes @ 2%				3767.06	9	Insurance, Taxes @ 2%				2836.66
10	Raw material cost, Yearly	13500	kg	75	1012500	10	Raw material cost	9000	Kg	75	675000
11	Labour charges @ (3+1+2) for peeling, packing and drying inspection respectively	810	labour charges / batch	80	64800	11	Labour charges @ (2+1+3) for peeling, packing and drying inspection respectively	540	labour charges/ batch	80	43200
						12	Land rent				12000
	Variable cost				1108217.1		Variable cost				843186.7

RESULTS AND DISCUSSION

The findings of the present study are presented in Table 2, 3, 4, 5 and 6.

Economic evaluation:

The total cost of construction of solar tunnel dryer has been estimated as Rs. 55,500/-. The cost incurred on drying includes the fixed cost and variable cost. The following parameters have been considered to carry out economic analysis:

– The life of solar tunnel dryer and drying platform for open sun drying is 20 years. Both the systems could be used effectively for 270 days in a year (Table 2).

– The exhaust fan of solar tunnel dryer runs on an average of 6 hrs in a day. This is only when the relative humidity inside the dryer exceeds 45 per cent.

– Since, the solar tunnel dryer is essentially walk in type of a dryer, therefore, out of 37.5 m^2 floor area 20% of it is kept for movement in solar tunnel dryer for carrying out operations.

– The standard discount rate is assumed 10 per cent.

– Selling price of dried peeled prawns is Rs. 500/ kg. This is based on market rate. The 8% processing losses were considered in open sun drying method. The market price will be increased by 10% since better quality will be maintained.

– The moisture content of raw material 70-80 per cent needs to reduce to 15-20 per cent. Hence, the total weight of dried peeled prawns that return per annum is 22.30 per cent of total weight of raw whole prawns.

– The by product *i.e.* prawns shells can be used as organic fertilizer and sold at Rs.12/kg. The total weight of dried prawns shells that return per annum is 27 per cent of total weight of raw whole prawns.

– The loan amount includes the sum of total fixed cost and total variable cost. For solar tunnel drying of peeled prawns loan of Rs. 1300000/- and in case of open sun drying loan of Rs. 800000/- was considered for running the drying business.

It is clear from Table 6 that the net present value of investment made in solar dryer for drying of peeled tiny prawns under solar tunnel dryer and in open sun drying system were Rs. 20,86,165/- and Rs. 85,822/-, respectively. The pay back period for solar tunnel dryer and open sun drying was found to be 2.84 and 7.01, respectively. The benefit cost ratio, profitability index and Internal rate of return calculated for solar tunnel dryer and open sun drying are 1.21, 11.08, 23.90 and 1.02, 1.80, 11.15, respectively.

Table 3 : Production of peeled prawns and byproduct

Particulars	Solar tunnel dryer	Open sun drying
Yearly batches	Requires 18-20 hrs for drying. Hence, 135 batches	Requires 4 days for drying. Hence 90 batches
Yearly fish utilization	Each batch with 100 kg fish. Therefore 13500 kg of prawns for drying per year.	Each batch with 100 kg fish. Therefore 9000 kg of prawns for drying per year.
Yearly Recovery of peeled prawns	Considering 45% of peeled prawn recovery per batch. Hence, yearly 6075 kg peeled prawns	Considering 45% of peeled prawn recovery per batch. Hence, yearly 4050 kg peeled prawns
Yearly weight loss due to moisture	Considering 28% of weight loss due to moisture per batch. Hence, yearly 3780 kg weight loss due to moisture	Considering 28% of weight loss due to moisture per batch. Hence, yearly 2045.25 kg weight loss due to moisture. Additional 8% was process loss due to insect infestation etc.
Yearly production of fertilizer	By utilizing shell waste for production of organic fertilizer @27 kg per batch yearly 3645 kg of fertilizer could be produced	By utilizing shell waste for production of organic fertilizer @27 kg per batch yearly 2430 kg of fertilizer could be produced

Table 4 : Annual total returns in solar tunnel dryer and open sun drying method

Sr. No.	Particulars	Solar tunnel dryer				Open sun drying			
		Qty	Unit	Rate	Amount	Qty	Unit	Rate	Amount
1.	Dried peeled prawns	3007.13	kg	550	1653918.75	1844.37	kg	500	922185
2.	Total organic fertilizer kg	3645 kg	kg	12	43740	2430.00	kg	12	29160
	Total (iii)				1547302.5				951345

Table 5 : Present worth of total cash inflow and outflow for drying of peeled prawns using solar tunnel dryer

Year	Solar dryer					Open sun drying				
	Cash outflow	P W of cash outflow	Cash inflow	P W of cash inflow	NPW	Cash outflow	P W of cash outflow	Cash inflow	P W of cash inflow	NPW
1	1295843	1178039.09	0.00	0.00	-1178039.09	796543.00	724130.00	0.00	0.00	-724130.00
2	1425990	1178504.13	1697658.75	1403023.76	224519.63	898273.33	742374.66	951345.00	786235.54	43860.88
3	1406490	1056716.75	1697658.75	1275476.15	218759.39	891873.33	670077.64	951345.00	714759.58	44681.94
4	1386990	947332.83	1697658.75	1159523.77	212190.94	885473.33	604790.20	951345.00	649781.44	44991.23
5	1370490	850966.46	1697658.75	1054112.52	203146.05	888073.33	551423.67	951345.00	590710.40	39286.73
6	1347990	760905.21	1697658.75	958284.11	197378.89	872673.33	492601.35	951345.00	537009.45	44408.10
7	1328490	681725.43	1697658.75	871167.37	189441.94	866273.33	444535.19	951345.00	488190.41	43655.22
8	1308990	610653.50	1697658.75	791970.34	181316.84	859873.33	401137.26	951345.00	443809.46	42672.21
9	1289490	546869.64	1697658.75	719973.03	173103.39	853473.33	361956.01	951345.00	403463.15	41507.14
10	1110492	428142.74	1697658.75	654520.94	226378.20	856073.33	330053.33	951345.00	366784.68	36731.35
11	1107494	388169.89	1697658.75	595019.04	206849.14	840673.33	294650.87	951345.00	333440.62	38789.74
12	1107496	352882.36	1697658.75	540926.40	188044.04	834273.33	265825.19	951345.00	303127.84	37302.64
13	1107498	320802.72	1697658.75	491751.27	170948.55	827873.33	239805.42	951345.00	275570.76	35765.34
14	1107500	291639.36	1697658.75	447046.61	155407.24	821473.33	216319.60	951345.00	250518.87	34199.27
15	1110502	265845.35	1697658.75	406406.01	140560.66	824073.33	197276.60	951345.00	227744.43	30467.83
16	1107504	241025.14	1697658.75	369460.01	128434.87	808673.33	175990.88	951345.00	207040.39	31049.51
17	1107506	219114.16	1697658.75	335872.73	116758.58	748940.00	148173.79	951345.00	188218.54	40044.75
18	1107508	199195.05	1697658.75	305338.85	106143.80	748940.00	134703.44	951345.00	171107.76	36404.32
19	1107510	181086.73	1697658.75	277580.77	96494.04	748940.00	122457.67	951345.00	155552.51	33094.83
20	1110512	165070.53	1697658.75	252346.16	87275.62	748940.00	111325.16	951345.00	141411.37	30086.21
21	0	0.00	1697658.75	229405.60	229405.60	0.00	0.00	951345.00	128555.79	128555.79
	Total	10864687.08		13139205.40	2274518.32	Total	7229607.93		7363032.98	133425.05

Table 6 : Economic indicators for drying peeled prawns

Sr. No.	Indicator		By solar tunnel dryer	By open sun drying
1.	Capital investment	=	188353.00	47603.00
2.	NPW at 10% D.R.	=	2274518.32	133425.05
3.	NPV at 10% D.R.	=	2086165.32	85822.05
4.	BCR	=	1.21	1.02
5.	Profitability index	=	11.08	1.80
6.	Pay Back Period	=	2.84	7.01
7.	IRR	=	23.90	11.15

Conclusion:

The cost economics of dried peeled prawns was proved better for solar tunnel dryer than open sun dried method. Thus solar tunnel dryer can be proposed as a suitable alternative to the local method of drying fish.

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