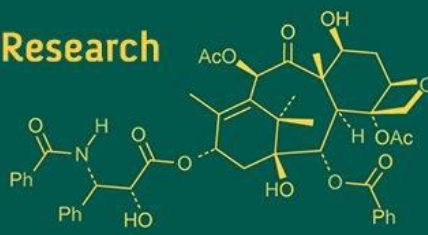


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Venkat Reddy K
Professor, College of Food Science and Technology, Jayashankar Telangana State Agricultural University, Rajendranagar, Telangana, India

Udaykumar N
Department of Processing and Food Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur, Karnataka, India

Sada Siva Rao K
Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

Hiregoudar S
Department of Processing and Food Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur, Karnataka, India

Sudhakar AC
Department of Fisheries, Main Agricultural Research Station, University of Agricultural Sciences, Raichur, Karnataka, India

Ramappa KT
Department of Processing and Food Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur, Karnataka, India

Devanand Maski
Department of Farm Machinery and Power Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur, Karnataka, India

Corresponding Author:
Venkat Reddy K
Professor, College of Food Science and Technology, Jayashankar Telangana State Agricultural University, Rajendranagar, Telangana, India

Economic evaluation of fish descaling machine

Venkat Reddy K, Udaykumar N, Sada Siva Rao K, Hiregoudar S, Sudhakar AC, Ramappa KT and Devanand Maski

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Abstract

Indian fisheries are one of the important sectors in terms of its contribution to the national economy. Among the post harvest processing operations of fish, fish descaling is one of the important operation. Manual descaling process may sometimes cause bruising of fingers and palms of the fish workers leading to infections. All the process is done in an unhygienic way. To address these difficulties, a roller type fish descaling machine (FDM) was developed for the needs of small fish farmers and vendors of inland fisheries sector. FDM consists of scalp roller assembly with different kinds of rollers for conveying the fish and descaling it, shaper bracket assembly to hold the fish tightly against the rollers, electric motors, chain and sprocket assembly for power transmission and a supporting frame. Economic evaluation of the FDM was carried out with Rohu fish (*Labeo rohita*) for selected speed levels of conveyor and descaling rollers. The production cost of the machine was estimated about ₹ 2,05,000 with operational costs of ₹ 5.57 kg⁻¹. Considering ₹ 20 kg⁻¹ charged for descaling operation, the net profit that might be earned for descaling fish using the machine per year was found to be ₹ 2,31,763. Payback period calculated was 324 days with net returns per year as ₹ 93,663. The benefit cost ratio obtained was 1.36:1.

Keywords: Economic evaluation, fish descaling machine, manual descaling

Introduction

Indian fisheries are one of the important sectors in terms of its contribution to the national economy. It is providing food, nutrition, socio-economic development and livelihood to the large population of the country. In addition, country earns valuable foreign exchange by exporting fish and fish value added products (Anon., 2021a) ^[1].

The preliminary processing of fish consists of different steps such as evisceration, beheading, scaling, cutting of fins and belly flaps, slicing of whole fish into small parts or steaks and other operations based on the consumption like filleting, skinning, grinding of skinned fillets etc. These pre-processed products are sold or further processed to obtain value added products (Bykowski and Dutkiewicz, 1996) ^[2].

Among the post harvest processing operations of fish, fish descaling is one of the important operation. Scaling is the process of removal of scales on the fish skin. Many fresh water fish needs descaling and the fish vendors remove the scales manually using hand tools. They use different kinds of brushes or knives to remove the scales. The freshwater fishes prevalent in the Indian fish markets such as rohu, catla, mrigal, silver carp and grass carp have prominent scales and their manual descaling is very difficult (Bykowski and Dutkiewicz, 1996) ^[2].

Manual descaling process may sometimes cause bruising of fingers and palms of the fish workers leading to infections. All the process is done in an unhygienic way (Gaikwad *et al.*, 2017) ^[4]. Another drawback in manual fish scaling is difficulty in separating various fractions of the waste generated which has good commercial value in industries like animal feed, pharmaceuticals etc. Fish processing waste has potential to extract proteins, oils, bio active peptides, enzymes (Ghaly *et al.*, 2013) ^[5].

During the market survey, it was found that the reasons for non adoption of descaling machinery were the lack of locally made machines that suit their species or needs and relatively higher cost of equipment. Considering the above facts and the research gap, there is a need to develop and popularize an inexpensive, efficient and safe fish descaling machine indigenously suitable for small fish vendors, fish farmers, restaurants, hotels and hostels. The new machine development is focused to operate in a semi continuous manner to make the

descaling operation easy, convenient, reduce the drudgery, and collect the scales neatly to be disposed off safely by keeping working area tidy and hygienic or utilized for preparing value added products.

Materials and Methods

The fish De-scaling machine was developed with an objective to remove the scales of the fish, reduce human drudgery, avoid contamination and maintain hygiene for human consumption. The description of the developed descaling machine and economic evaluation of the machine is as follows.

Assembly of the fish descaling machine

The main assembly and fabrication was carried out in the workshop of the College of Agricultural Engineering, Kandi, Sangareddy. The individual components were fabricated as per the designed specifications. Standard components like chain, bearings, sprockets, motors, VFDs were procured from the market. Supporting frame was fabricated as per the specifications and was placed on a hard

and even surface. The designed components were fabricated or procured from the market and kept ready for assembly of the machine. The assembled fish descaling machine is depicted in Fig.1 and the specifications of the developed machine are given in Table.1.

The developed machine was evaluated for the economics of operation. The methodology used for estimation of cost is depicted as follows:

Economics of the developed fish descaling machine

The economics of the developed fish descaling machine were studied by calculating the cost of fabricating machine, cost of operation, payback period, benefit-cost ratio and net present worth.

Cost of fish de-scaling machine

The cost of the developed machine was calculated by considering the actual quantity of the raw material used in the fabrication of the designed machine including transportation and labour charges.



Fig 1: Assembled fish descaling machine a) Top view b) Front view c) Side view

Table 1: Components and specifications of the developed fish descaling machine

Particulars	Material of construction/ make	Specifications	Quantity (Nos.)
Electrical motors	Rotomotive make	One hp, three phase, 1400 rpm	2
Variable Frequency Drive units	Schneider electric	1 hp, three phase	2
Sprockets	Mild steel	13 teeth, Hub – 37 mm Ø	16
Chain (Single row roller)	Carbon steel, SAE – 1045	Heavy duty – 12 B, Pitch – 20 mm Ø	2
Bush	PP	8.5 mm Ø	22
Bearing block with 11 holes	EN8- Unalloyed medium carbon steel	795 × 65 mm	1
Bearings (Deep groove ball type)	SKF make, chrome steel with cast iron	Model No. SKF 6004-ZZ	13
Conveyor roller	SS 304, fabricated part	-	8
Primary descaling roller	SS 304, fabricated part	-	2
Secondary descaling roller	SS 304, fabricated part	-	1
Shafts for Conveyor Roller and Primary Descaling roller	SS 304, fabricated part	216 mm	10
Secondary Descaling roller shaft	SS 304, fabricated part	236 mm	1
Frame support, 875 × 610 × 1005 mm, length × width × height	MS pipe, fabricated part	40 × 40 mm square tubing of 2 mm thick, m	1

Cost of operation

The cost of operation of the developed fish de-scaling machine was calculated by straight line method described by Ojha and Micheal (2009) [6]. The following assumptions were made before calculating the cost of operation.

- No. of working days per year = 300
- No. of working hours per day = 8 h
- No. of labour required per day = 2 Nos.
- Life of the developed machine = 10 years

- Salvage value of the machine = 10% of initial cost
- Insurance = 1% on initial cost
- Rate of interest = 10% of initial cost
- Tax = included in the cost
- Housing = 2% of initial cost
- Repairs and maintenance = 10% of initial cost

The expected returns for the machine were estimated based on the descaling charges of

₹ 20 per kg weight of raw material. In the fixed cost, annual depreciation, annual interest on investment and taxes were computed by using the following equations.

$$\text{Annual depreciation (Rs.)} = \frac{\text{Initial investment} - \text{Junk value}}{\text{Life in years}} \dots(1)$$

$$\text{Interest} = \frac{\text{Initial investment} + \text{Junk value}}{2} \times \frac{\text{Interest rate}}{100} \dots(2)$$

$$\text{Total cost} = \text{Fixed cost} + \text{Operating cost} \dots(3)$$

Payback period

Payback period is the amount of time taken to recover the cost of an investment. Payback period of the developed fish descaler in terms of number of years was computed by using the following equation (Reddy *et al.*, 2004) [7].

$$\text{Payback period} = \frac{\text{Investment}}{\text{Net annual return}} = \frac{I}{E} \dots(4)$$

Where,

P- Payback period, years

I- Investment, ₹

E- Annual net return, ₹

Benefit cost ratio

Benefit cost ratio was estimated by using the equation suggested by Reddy *et al.* (2004) [7].

$$\text{Benefit-Cost ratio} = \frac{\text{Discounted return}}{\text{Discounted cost}} \dots(5)$$

The discounted cost and discounted return were calculated by using the following equations. Assuming, an increase in annual operational cost of the machine as 2% due to the probable hike in the repair and maintenance cost.

$$\text{Discounted return} = \sum_{t=1}^n \frac{B_t}{(1+r)^t} \dots(6)$$

$$\text{Discounted cost} = \sum_{t=1}^n \frac{C_t}{(1+r)^t} \dots(7)$$

Where,

B_t - Returns for year t , ₹

C_t - Cost of production for year t , ₹

t - Economical life, years

r - Discount rate, fraction

Net present worth

Net present worth or Net Present Value (NPW) is the present worth of cash flow stream of the operation. It was calculated by using the following formula (Reddy *et al.*, 2004) [7].

$$\text{NPW} = \frac{P_1}{(1+i)^{t_1}} + \frac{P_2}{(1+i)^{t_2}} + \dots + \frac{P_n}{(1+i)^{t_n}} - C \dots(8)$$

Where,

P- Net cash flow, ₹

i - Discount rate, fraction

t - Time period, years

C - Investment, ₹

Results and Discussion

The fish descaling machine was fabricated and evaluated for different speeds of descaling and conveying rollers. The economics of the machine for optimized parameters was evaluated on different metrics like cost of operation, payback period, net returns, Benefit-cost ratio, net present worth as follows.

Cost of operation

The evaluation of the machine was carried out for optimizing the operational speeds. During the evaluation of the machine, the capacity of the machine was taken as 50 kg per hour. The cost of operation included were fixed costs and operational costs of

₹ 35,788 and ₹ 6,32,450, respectively with the life of descaling machine assumed as 5 years. The total cost of operation per annum was ₹ 6,68,238. Considering 300 working days and 8 working hours per day, the cost of operation was found to be ₹ 5.57 kg⁻¹. The cost of descaling the fish was found to be ₹ 278 per hour. Considering ₹ 20 charged per kg for fish descaling operation, the expected returns per day was found to be ₹ 3,000 resulting in an annual income of ₹ 9,00,000 for 300 days. The net profit that might be earned for fish descaling operation using the machine was found to be ₹ 2,31,763. Delfiya *et al.* (2019) [3] reported that manual fish scaling requires ₹ 15 and operating cost of a drum type descaler they developed was calculated as ₹ 4.76 and ₹ 9.52 per kg in case of Tilapia and Pearl spot, respectively and stated that ₹ 5.5 could be saved by using the machine in case of Pearl spot. The cost of operation of ₹ 5.57 kg⁻¹ determined in the present study was in close agreement with the cost of operation estimated by the earlier investigator. The details of the Cost of manufacturing the machine and operational costs, Annual cost of operation of the fish descaling machine and Calculation of economics of fish de-scaler operation are given in Table 2, 3 & 4 respectively.

Payback period

Payback period was calculated on the basis of investment made to the net returns. It was the ratio of investment made on the machine to net annual returns made from the descaling operation. It was found to be 0.9 years or 324 days.

Net returns

Net returns of the developed descaling machine was obtained by deducting the value of estimated cost from estimated returns and was found to be ₹ 4,68,313 for a period of 5 years with an average net returns per year as ₹ 93,663.

Benefit-cost ratio

The benefit-cost ratio (B-C), calculated based on the discounted returns and discounted costs was found to be 1.36:1.

Table 2: Cost of manufacturing the machine and operational costs

Sl. No.	Cost details	Amount (₹)
A	Cost of manufacturing the fish descaling machine	
1	Hardware material	120000
2	Labour for fabrication work, (Two 2) workers used @Rupees 1000/- per day of 8 hours for 30 days) (2 × 30 × 1000)	60000
3	Electricity charges for 30 days, 5 kWh per day of 8 hours ₹ 10/- per kWh (30 × 5 × 10)	4500
4	Machining different precision parts like rollers, shafts, bearing block on CNC machines and other precision equipment	20000
	Total production cost of the de-scaling machine (A)	2,04,500
B	Operational cost calculation	
1	Salvage value (A × 10/100)	20450
2	Depreciation (This is defined as the price that equipment can be sold for at the time of its disposal) (A - Salvage value/ 10)	18405
3	Interest (multiply the interest rate times the average annual investment) ((A+Salvage value)/2) × (10/100)	11247.5
4	Insurance (A × 1/100)	2045
5	Housing (A × 2/100)	4090
6	Repairs and maintenance (A × 10/100)	20450
7	Taxes -Included	0

Table 3: Annual cost of operation of the fish de-scaling machine

Sl. No.	Cost details	Amount (₹)
C	Fixed costs	
1	Annual depreciation	18405
2	Annual interest @ 10%	11247.5
3	Insurance @ 1%	2045
4	Housing @ 2%	4090
5	Taxes - included	0
	Total Fixed costs (C)	35787.5
D	Operating costs per annum	
1	Repairs and maintenance @ 10%	20450
2	Labour charges – 2 × 300 × 1000	600000
3	Energy/electricity charges per annum (Assuming 4 kWh consumption per day for machine operation and lighting @₹ 10 per unit) - 4 × 300 × 10	12000
	Total operating costs (D)	632450
	Total processing and operational costs (C+D)	668237.5

Table 4: Calculation of economics of fish de-scaler operation

Sl. No.	Cost description	Amount (₹)
1	Hourly cost of operation (Rupees per hour) = Total operation cost / (No. of working days per annum × working hours per day)	278
2	Capacity of the descaler (kg h ⁻¹)	50
3	Expected cost of descaling (Rupees per kg)	5.57
4	Assume charges for descaling (Rupees per kg)	20
5	Effective number of hours in fish descaling operation	3
6	Expected returns (rupees per day) (capacity × number. of working hours × cost for descaling process) (50 × 3 × 20)	3000
7	Expected returns per year (Rupees per year) (300 working days)	900000
8	Profit (₹) (Expected returns – Total operational cost)	231762.5
9	Total production cost of the descaler(₹)	2,04,500
10	Total operational cost of the descaler per annum (₹)	668237.5
11	Life of descaler (in years)	10
12	The discount rate for the descaler was assumed as (%)	12
13	Increase in operational cost of the descaler due to change in maintenance and repairs (%)	2

Net Present Worth (NPW)

It was the difference between the present value of cash inflows and the present value of cash outflows over a period of time. The Net Present Worth was found to be ₹ 1104734 for a period of 5 years.

Manual descaling operation was laborious, unhygienic and requires the skill to handle the tool to remove the fish scales. It was observed that on an average in manual operation, one person takes about 2 minutes for descaling a fish of size 500 g (Gaikwad *et al.*, 2017) ^[4], i.e. around 15-20 kg per hour.

With a capacity of about 66.4 kg h⁻¹, the fish descaling machine developed in the present study, could descale a similar fish in about 1 minute. Therefore, the developed machine would be beneficial for the fisher folks, unemployed rural youth and small entrepreneurs. Adoption of the machinery would greatly improve the utilization of fish by-products like fish scales effectively by cleanly collecting them. Improvement in hygiene in fish processing and surroundings were envisaged as one of the foremost advantage of using the machine. All these advantages might

result in increased value addition to the fish and new customers for the fish meat and additional income to the

vendor. The details of the calculation of economics of the machine for 5 years is given in Table 5.

Table 5: Economics of the machine for five years

Life (year)	Estimated cost (₹)	Discounted cost (₹) @ 12%	Estimated return (₹)	Discounted return (₹) @ 12%	Net return (₹)
0	668237.50	668237.50	-	-	-
1	681602.25	596640.63	900000.00	803571.43	218397.75
2	695234.30	532714.84	918000.00	819642.86	222765.71
3	709138.98	475638.25	936360.00	836035.71	227221.02
4	723321.76	424677.01	955087.20	852756.43	231765.44
5	737788.20	379175.90	974188.94	869811.56	236400.75
Total	4215322.98	3077084.14	4683636.14	4181817.99	1136550.66
Mean	702553.83	512847.36	936727.23	836363.60	227310.13

The payback period, Benefit cost ratio and Net present worth of the machine are given below:

- 1) Payback period (Investment / Net returns) in years = 0.9
- 2) Benefit cost ratio (Discounted return / Discounted cost) = 1.36:1
- 3) Net present worth (Discounted return - discounted cost) = ₹ 1104734

Conclusions

The cost of the machine was found to be ₹ 2,04,500. The total cost of operation per annum was ₹ 6,68,238. Considering 300 working days and 8 working hours per day, the cost of operation was found to be ₹ 5.57 kg⁻¹ and ₹ 278 h⁻¹. Considering ₹ 20 kg⁻¹ charged for descaling operation, the net profit that might be earned for descaling fish using the machine was found to be ₹ 2,31,763 per annum. Payback period calculated was 324 days with net returns per year as ₹ 93,663. The benefit cost ratio obtained was 1.36:1.

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