



ISSN (E): 2277-7695
 ISSN (P): 2349-8242
 NAAS Rating: 5.23
 TPI 2022; SP-11(10): 32-36
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www.thepharmajournal.com

Received: 08-08-2022

Accepted: 11-09-2022

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Turmeric polishing machine for small scale processing

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Abstract

Turmeric (*Curcuma longa* L.) is an ancient spice derived from the rhizomes, belongs to the family Zingiberaceae. The methods of turmeric processing are viz., boiling, drying, polishing and grinding. Polishing of turmeric is a bigger problem for the turmeric producers. Rhizomes are generally polished to remove the outer dirty skins. In the traditional method, the polishing was carried out manually which is time consuming operation. To overcome this problem, a turmeric polisher for small scale processing was developed at C.A.E.T., Dapoli, during 2021-22. The paper presents the turmeric polishing machine. The phenomenon of abrasion used in polishing, which is caused by the friction between pointed structure of drum and turmeric. The performance of developed polishing machine checked at three different capacities (8, 10 and 12 kg) and three speeds (45, 60 and 90 rpm). At speed 60 rpm and 8 kg capacity the highest polishing percentage is obtained and it is 7.68%. The polishing capacity is high as compared to hand polishing, i.e., 30 kg per hour. Polishing machine is easy to operate and useful on farm polishing job. Hence machine polishing is recommended for turmeric processing.

Keywords: Turmeric, colour, polishing, capacity, abrasion, speed, etc.

1. Introduction

Turmeric (*Curcuma longa* L.) is also known as 'Golden Spice of India'. Turmeric has been used for centuries in India in Ayurvedic medicine, which integrates the medicinal properties of herbs with food. India is the largest producer, consumer and exporter of turmeric in the world. India dominates the world production scenario contributing 80% followed by China (8%), Myanmar (4%), Nigeria (3%) and Bangladesh (3%). All India turmeric production in 2020-21 is at 11.02 lakh tonnes. The major states producing turmeric in India are Telangana (3.13 lakh tonnes), Maharashtra (2.26 lakh tonnes) and Karnataka (1.30 lakh tonnes). Annual production of turmeric in Maharashtra in 2020-21 is 2.26 lakh tonnes and ranked 2 in India. Turmeric cultivated over 54,248 hectares (Anonymous, 2021)^[1]. Curcuminoids or commonly termed as curcumin are the main phytoconstituents found approximately 1-6% by dry weight in the form of diarylheptanoids (Niranjan *et al.* 2013)^[9] and responsible for the light-yellow colour of turmeric. Turmeric has healing properties. Besides flavouring food, use to purify the blood and skin conditions remedy is probably the most common use of turmeric in Ayurveda. The main organs that turmeric treats are the skin, heart, liver, and lungs. Turmeric contains moisture (70-80%) at the time of harvest which should be reduced to a safe limit for milling (10%) and storage (6%) (Sahay *et al.* 1996)^[14]. The post-harvest operations of turmeric are cleaning, boiling, drying, polishing and grinding. Dried turmeric rhizomes are generally polished to remove the unwanted impurities and transform to relatively smooth, bright and yellowish colour. Traditionally polishing can be done by hand rubbing or by beating the turmeric rhizomes in gunny bag. This operation is carried out manually, which is slow, tedious and labour intensive. The quality of turmeric powder depends upon the practices adopted in various post-harvest operations. Polishing of turmeric plays important role in quality enhancement. Arora *et al.* (2007)^[2] stated that washed turmeric rhizomes in a rotary machine were useful for maintaining quality of turmeric. At the rotational speed of 40 rpm for 20 minutes, the colour improved from dark yellowish brown to desirable olive yellowish colour with increase in the surface smoothness. Polishing drums are being used at many places for cleaning and polishing of various agricultural products. Turmeric is polished by abrasive hard surface and against rough perforated surface when the turmeric-filled drum rotates as well as by rubbing rhizomes against each other. Moghe *et al.* (2013)^[7] developed a turmeric polisher operated by human power. It has a flywheel and motor bicycle-drive mechanism with speed-increasing gear pair, a flywheel and torque-increasing gear pair that drove the process unit with square jaw. The dusts were spread with rotation and polluted the working environment.

Sukumaran and Satyanarayana (1999) [17] developed a mechanical turmeric polisher. It consists of 880 mm diameter mild steel drum with wire meshes wrapped one above the other. The turmeric polisher rested on ball bearings at the two ends on a rectangular stand having 600-700 kg/h capacity. It was operated by a 2-hp three-phase electrical motor. Powar *et al.* (2015) [12] evaluated performance of a turmeric polisher operated by 5 hp diesel engine, 35 hp tractor and electricity. All of them were made with octagonal metallic drum. Pal *et al.* (2008) [10] developed a pedal operated hexagonal drum polishing machine. The raw skin of polish turmeric spread in working environment. The low cost turmeric polisher for small scale processing is yet not available. Therefore, this study was undertaken to develop a low-cost turmeric polisher for farmers and to evaluate its performance.

2. Materials and Method

The traditional and improved methods of turmeric processing *viz.*, boiling, drying, polishing and grinding were studied. In the traditional method turmeric boiled in water. Open sun drying method used for turmeric drying. In the traditional method of polishing, dried turmeric put in sack and biting on concrete surface. After polishing turmeric was ground between two stones. In the improved method of turmeric processing, steam was used for boiling. A recirculatory dryer was used for the drying of turmeric. The dried rhizomes were polished in developed turmeric polisher.

2.1 Development of turmeric polishing machine

Turmeric polisher was designed for small scale processing. The schematic view of turmeric polisher was shown in fig.1. The polisher was fabricated in workshop of C.A.E.T., Dapoli during period of 2021-22. The raw materials used for fabrication of turmeric polishing machine were: polishing drum, M.S. angle, belt, shaft, bearing, pulleys, motor, nut-bolts, handle etc. The developed turmeric polishing machine was shown in fig.2.

The polishing machine for turmeric was developed on the basis of different engineering inputs like rpm of motor, capacity of polishing drum, feed rates, speed of polishing drum, etc. The different components of the polishing machine were developed in the workshop.

2.2 Design consideration for development of turmeric polishing machine

Development work of turmeric polishing machine was undertaken in a view of proper polishing and minimum wastage of turmeric. Dried rhizomes size, feeding rate, motor speed and material holding capacity were important parameter to achieve high polishing efficiency of machine. Following points were considered for development of turmeric polishing machine.

1. Turmeric feed rate should be upto 10 kg/per batch.
2. Polishing drum should be 50% empty for proper polishing.
3. Speed of the power operated polishing machine should be low.
4. It should be safe and easy to operate.
5. Maintenance of machine should be low.

2.3 Material for development of turmeric polishing machine

2.3.1 Main frame

Main frame of turmeric polishing machine was fabricated

from mild steel square pipe of size 30 mm x 30 mm x 2.5 mm. Length, Width and height of the fabricated main frame is 800 mm, 550 mm and 600 mm respectively.

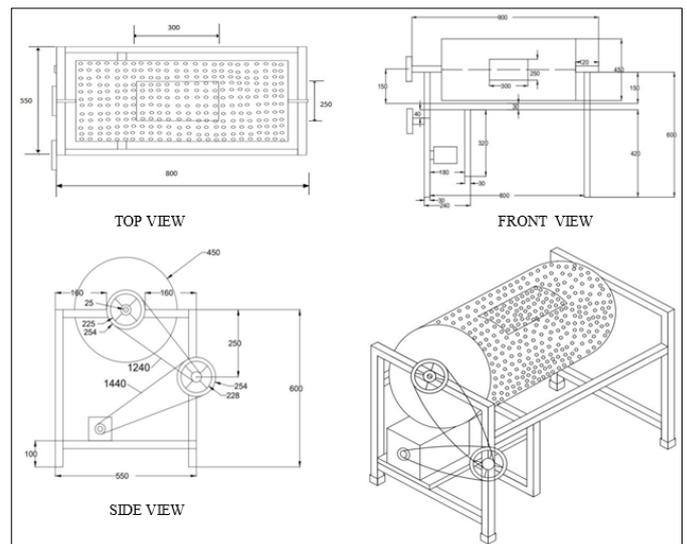


Fig 1: Schematic view of turmeric polisher (All dimensions are in mm)

2.3.2 Polishing drum

Fabrication was polishing drum was done as per dimensions given in design. The diameter and length of drum are 450 mm and 660 mm respectively. Diameter of shaft is 25 mm and length is 900 mm. This shaft was passed through the ball bearing of size 31.75 mm internal diameter provided on the frame. Shaft was inserted through the hole at centre of drum. There is a small gate opening of length 300 mm and width 250 mm for feeding and discharging of turmeric. It is easy to open and close the drum while feeding and discharging of turmeric. The shape and size of dried turmeric rhizomes were considered while determining capacity of polishing drum. The drum was filled at 50% of its capacity and 50% empty space required for proper polishing. Therefore mass of turmeric was 10 kg to achieve high polishing percentage.

Mass of turmeric is calculated as

$$M = \pi r^2 l \times \rho \quad \dots (1)$$

Where,

M = Mass of turmeric in drum,

R = Radius of drum = 0.225 m,

l = Length of drum = 0.66 m,

M = Density of turmeric = 577 kg/m³

2.3.3 Design of belt drive

Motor power is transmitted with the help of V-belt drive. V belt drive was used to achieve a desirable speed of polishing machine. Power was transmitted from motor to shaft through four pulleys, to achieve desirable speed. One pulley mounted on the electric motor as main drive, second and third pulley on frame and fourth pulley was mounted on polishing drum shaft. In this case, pulley was fitted on shaft which becomes a final drive shaft for changing the speed of polishing machine which adjusts the speed of final drive shaft.

Following equations are used to design V belt drive (Sahay *et al.* 1996) [14]. Velocity ratio of V belt drive for two pulleys can be expressed as,

Velocity ratio,

$$\frac{N_1}{N_2} = \frac{D_2}{D_1} \dots(2)$$

Belt length (L),

$$L = 2C + 1.57(d_1 + d_2) + \frac{(d_2 - d_1)^2}{4C} \dots(3)$$

Where,

d_1, d_2 = Diameter of the pulleys 1 and 2 respectively, mm

N_1, N_2 = Speed of the pulleys 1 and 2 respectively, rpm

L = Length of the belt, mm

C = distance between the Centre's of two pulleys, mm

Considering the availability of pulleys, 152.4 mm, 228.6 mm and 304.8 mm size pulleys were used in the experiment.

2.3.4 Power transmission system

A 0.5 hp single phase electric motor was fixed on one side at the base of the frame as shown in fig.2. For speed reduction belt and pulley arrangement was used. The power from electric motor was transmitted through belt and pulley to shaft on main frame.

Table 1: Specifications of turmeric polishing machine

Sr. No.	Parameter	Dimension
1.	Frame	800 x 550 x 600 mm
2.	Polishing drum	450 mm diameter x 660 mm length
3.	Shaft	900 mm length
4.	Electric motor	0.5 hp single phase
5.	Pulley	31.75, 254, 76.2, 228.6 mm
6.	Belt	Rubber belt
7.	Speed of drum	60 rpm
8.	Holding capacity	10 kg

2.4 Working principle

The phenomenon of abrasion used in polishing. During rotation of polishing drum, polishing was done by rubbing the turmeric against the inside pointed structure of drum. The outer skin rubbed by polishing and fell through the perforation of the drum. The holding capacity of the turmeric polisher was generally kept 50% of volume of the polishing drum to allow turning and proper mixing of dried rhizomes during polishing.

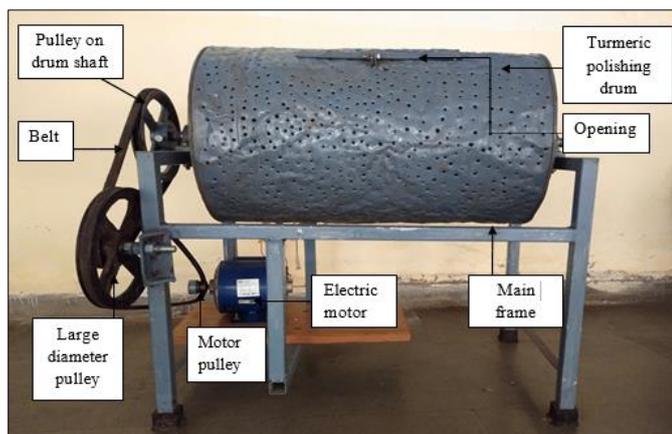


Fig 2: Developed turmeric polishing machine

3. Performance evaluation of developed turmeric polishing machine

The performance of electric motor operated turmeric polishing machine was evaluated for on the basis of different performance parameter described by Powar *et al.* (2015) [12].

For performance evaluation of turmeric polishing machine, polishing of turmeric was done at three different capacities (8, 10 and 12 kg) at three different speeds (45, 60 and 90 rpm).

3.1 Polishing percentage

The mass of turmeric lost in the polishing from an input quantity was taken as polishing percentage and was calculated as:

$$\text{Polishing percentage} = \frac{W_r - W_p}{W_r} \times 100 \dots(4)$$

Where,

W_r = Weight of raw turmeric, kg.

W_p = Weight of polished turmeric, kg.

3.2 Feed capacity per batch: The measured quantity of turmeric was loaded in the polishing drum up to of full capacity of polishing drum and noted as feed capacity of the batch.

3.3 Speed of polishing

For determination of speed of polishing drum the no. of revolution per minute was noted by tachometer.

4. Results and Discussion

4.1 Polishing percentage

The results were obtained from polishing turmeric was given in Table 2 by considering 15 min as operational time. The replications were taken in three different capacities (8, 10 and 12 kg) and at three different speeds (45, 60 and 90 rpm). Following results were obtained when turmeric was polished for three capacities and at three different speeds.

Table 2: Calculation to find turmeric polish percentage

Sr. No.	Capacity per batch, kg	Speed, rpm	Polishing percentage, (%)
1	8	45	7.35
2	10	45	6.72
3	12	45	6.04
4	8	60	7.68
5	10	60	7.24
6	12	60	6.875
7	8	90	7.15
8	10	90	6.95
9	12	90	6.26

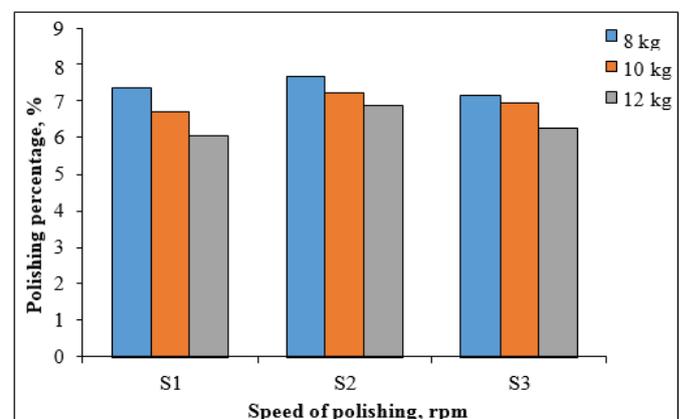


Fig 3: Polishing percentage of turmeric

It was observed at capacity 8 kg and speed 60 rpm polishing percentage of turmeric was highest and it was 7.68%. The 12 kg capacity with speed 90 rpm which gives polishing percentage was 6.26% which was less compared to other

experiments. The polishing percentage at speed 60 rpm was higher as compared to other experiments. As speed increased up to 90 rpm then polishing percentages was to be decreased up to 6.26%.

4.2 Comparative study of hand polishing and power operated polishing machine

The machine polishing was suitable for large quantity of turmeric processing. The time required for machine polishing

was less as compared to hand polishing. The high quality of turmeric polishing was obtained in machine polishing. The polishing capacity of machine was high as compared to hand polishing, i.e., 30 kg/per hour. The cost of polishing in hand polishing is very low as compared to machine polishing. The power source required for machine polishing in the form of electric energy and for hand polishing human power is required.

Table 3: Comparison between hand polishing and machine polishing

Sr. No.	Parameter	Hand polishing	Machine polishing
1	Quantity processed, kg	10	50
2	Weight of turmeric per batch, kg	4	8
3	Operating time per batch, min	30	15
4	Labor requirement, person	1	1
5	Capacity, kg/hr	8	30
6	Quality of polishing	Low quality	High quality
7	Test result– polishing percentages	Low	High
8	Energy source	Human power	Electric energy
9	Cost of polishing	Very low	Moderate cost
9	Remark	Not suitable for on-farm polishing job	Useful for on-farm polishing job

4.3 Cost estimation

The economics are worked out by considering it as a farm level project of turmeric processing. The total development

cost of turmeric polishing machine was found to be Rs. 13980/- which included material cost Rs. 11650/- as well as the fabrication cost Rs. 2330/-.

Table 4: Cost of material required for fabrication

Sr. No	Material	Specification	Price
1	Polishing drum	Length=66 cm, Dia.=45 cm	1250/-
2	M.S Metal square pipe	Material: MS, 30*30 mm	1800/-
3	Shaft	Length=90 cm, Dia.=2.5 cm	800/-
4	Ball Bearing	2 no.	700/-
6	Pulleys	4	1200/-
7	V – belt	2	600/-
8	Nut and Bolt	8	250/-
9	Wooden plywood	1 No	300/-
10	0.5 hp Single phase motor	1 No	4500/-
11	Miscellaneous		250/-
Total material cost			11650/-
Fabrication cost, (20% of material cost)			2330/-
Total cost of machine			13980/-

5. Conclusions

The developed turmeric polishing machine was successfully polished the turmeric. It gives uniform colour and it was suitable for small scale processing. The developed turmeric polishing machine was capable of polishing 8 kg dried turmeric in 15 minutes. It was observed at capacity 8 kg and speed 60 rpm polishing percentage of turmeric was highest and it was 7.68%. The 12 kg capacity with speed 90 rpm which gives polishing percentage was 6.26% which was less. This polishing method gives high quality of turmeric and time saving as compared to traditional method. The polishing percentage between 6-8% and time required for polishing was 15 minutes. The polishing capacity of machine was high as compared to hand polishing, i.e., 30 kg/hr. Polishing machine was easy to operate and handle. Thus it was useful on farm polishing job. Machine polishing gives high service to the farmer to do their work more efficiently. Hence machine polishing was recommended for turmeric processing.

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