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RESEARCH ARTICLE

Design and fabrication of chilli paste grinder

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ABSTRACT

The traditional method of chilli paste processes essentially consist of two main unit operation namely blending of raw material and cooking of the chilli paste, accompanied by manual stirring. The transferring of blended food for cooking adds clean-up work and tends to waste time and energy. Substantive continuous stirring during the cooking process is essential, but time and labour consuming. In this study, a process design of the chilli paste machine has been developed with the aim to combine both the process of blending and agitated cooking in single application. A new design of machine called chilli paste machine has been successfully built with the intention to overcome the issues present in making chilli paste. It comprises of blade which enables blending and stirring of chilli paste during blending and cooking process, respectively. A heating plate is installed for the heating of the chilli paste the whole operation is controlled by a simple mechanism of Miniature Circuit Breaker. (M.C.B.) and Switches which enables the temperature control. The prototype machine was tested to ensure the performances of the machine design are met. The ready to serve batch of chilli paste was successfully produced using this newly designed machine.

KEY WORDS : Blending, Stirring, Heating, Chilli paste, Miniature circuit breaker (M.C.B), Switches

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INTRODUCTION

Chilli is one of the most important commercial crops of India. It is grown almost throughout the country. There are more than 400 different varieties of chillies found all over the world. Its botanical name is "*Capsicum annuum* L.". The world's hottest chilli "Naga Jolokia" is cultivated in hilly terrain of Assam in a small town Tezpur, India. Chilli occupies an important place in Indian diet. It's among the spices consumed per head; dried chilli fruits constitute a major share. Currently, chillies are used throughout the world as a spice and also in the making of beverages and medicines. If some varieties of chillies are famous for red colour because of the pigment 'capsanthin,' others are known for biting pungency attributed to 'capsaicin.' India is the only country which is rich in many varieties with different quality factors. Chillies are rich in vitamins, especially in vitamin A and C. They are also packed with potassium, magnesium and iron. Chillies have long been used for pain relief as they are known to inhibit pain messengers, extracts of chilli peppers are used for alleviating the pain of arthritis, headaches, burns and neuralgia. It is also claimed that they have the power to boost immune system and lower cholesterol (Gisslen, 2007).

Chilli paste is served in Asian cooking as a popular condiment. It is used as an ingredient in soups, stews and also main dishes. The chilli pastes can add flavour and heat in any dishes (Russell, 2013). As a method of preservation, chilli paste is such a product that cans retainits colour and flavour in a semisolid form that is convenient to use (Ahmed *et al*., 2002). Moreover, chilli paste is mostly served hot as a side dish for main food dishes among the peoples of South East Asia.

The traditional method of chilli paste processing consists essentially of two unit operations, which are mechanical and preservation carried out separately using different food processing equipment and cooking utensils. These two-step processes take up a lot of time and man-power. The transfer of blended food for cooking adds work in terms of cleaning up and the process wastes time and energy. Further, careful manual stirring during the cooking of chilli paste might be inadequate for a number of reasons, such as inattention due to other related cooking tasks. The choky smell released during the cooking process also tends to provoke an uncomfortable feeling in the people who perform the manual stirring. As a result of these distractions, the continuous stirring of chilli paste is extremely difficult to achieve by hand. In order to eliminate the problems faced during the making of chilli paste, a food processing machine that is capable of performing both blending and agitated cooking operations either simultaneously or consecutively in a single appliance is necessitated Peng (2007).

In this study, the objective is to design a blender-cooker machine that automatically functions both as a blender structure and a cooker structure. The present design aims to provide an automated chilli paste maker, which combines blending and agitated cooking into one single appliance in order to overcome the issues that are present in the traditional method of making chilli paste. Another objective of the present design is to provide a blender-cooker machine with appropriate blades which are able to perform appropriately in both blending and stirring operations. More specifically, the blades should work efficiently as a cutting blade in the blending operation and as a stirring blade in the cooking operation, respectively.

EXPERIMENTAL PROCEDURE

The raw materials used are the basic ingredients of chilli paste grinder and chilli paste, including steel, red chillies (*Capsicum annuum*), water and palm oil (cooking oil) were procured from the local market of Allahabad. The machine was fabricated in the local workshop of Kydganj, Allahabad.The experimental techniques, steps and methods adopted during the developing machine of present investigation will be elaborated in this paper.

Construction of chilli grinder :

The first activity of the design process was to design a plan of a new machine that combined both blending and cooking chilli paste. At this stage, two important points were identified, which were (i) to identify the problems faced during chilli paste processing and (ii) to identify the design specification. Fig. A shows the processing of chilli paste described in unit operations that should be undertaken. The problem was to eliminate the use of two unit operations which were the blender and cooking apparatus. The target was to design a machine that could perform the two operational processes in a single appliance either simultaneously or consecutively.

Planning

↓

Analysis

↓

Design

↓

Fabrication

↓

Performance evaluation

Fig. A : Flow chart for the fabrication of chilli grinder and cooker

Based on an understanding of the problem definitions, the target design specification of the machine was generated as given in Table A.

Table A : Parts and materials used in fabrication of machine

Sr. No.	Parts	Material used
1.	Main body	Stainless steel
2.	Motor	Caste iron and copper
3.	Motor shaft	Stainless steel
4.	Supporting frame or Base support	Cast iron
5.	lever	Stainless steel
6.	container	Stainless steel
7.	Jerk preventer	Rubber
8.	spring	Hardened steel
9.	heater	Glass and nicrome wire
10.	Main body cover	Stainless steel
11.	Spring base	Stainless steel
12.	Supporting legs and frame work	Cast iron
13.	Handle	Stainless steel
14.	Nuts and bolts	Cast iron and stainless steel
15.	Blades	Stainless steel
16.	Heat resistor	Plaster of paris and caste iron
17.	Container cover	Stainless steel
18.	Key lock system	Mild steel

Unit operation in chilli paste making and cooking process :

In performing both blending and cooking operations simultaneously, the machine design should have a size reduction (or liquefaction) section of solid ingredients and a heating section accompanied by a stirring section of the semi-liquid paste. These three important component parts play an important role in the machine operations and ensure that the input ingredients undergo the required processing steps in order to produce the targeted output, a chilli paste with the desired consistency which is ready to be served and safe for consumption.

Beside of these some other parts will be also used in chilli paste grinder :

– Three meter core cable along with 15 Ampere plug top for single phase motor or 3 meter four core cable for

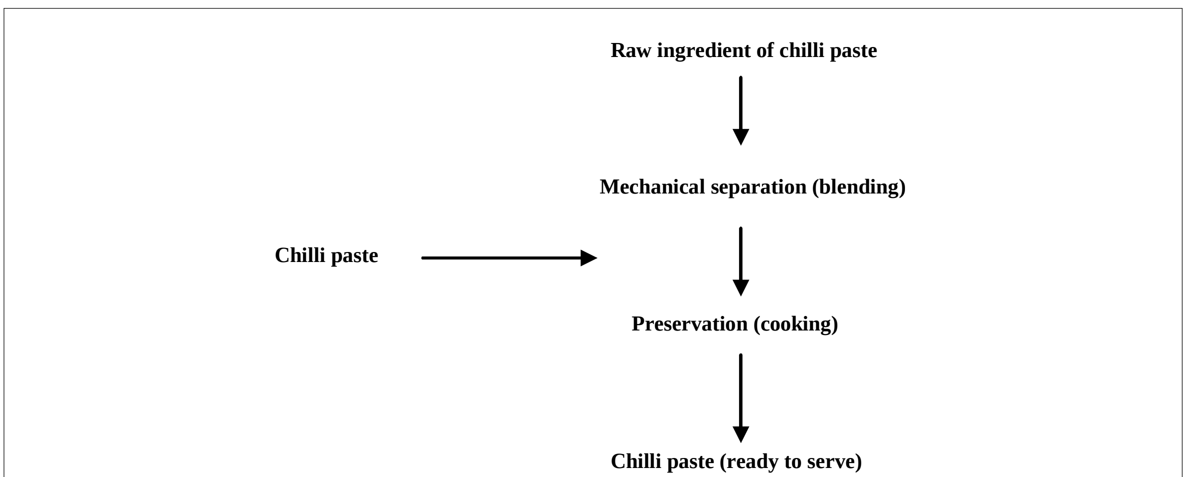


Fig. B : Flow chart for the preparation of chilli paste from chilli grinder

three phase electric motor.

– Indicator for indicating the electricity with a resistance.

Operational processes of chilli grinder :

The machine operation starts with both blending and heating operations in parallel. The setting for blade assembly speed parameters is made before the machine operation. Two temperature parameters play an important part in determining the quality of the end product (chilli paste). The first controlled temperature (T_1) is the temperature at which the blending operation ends, for which the particle size distribution of the suspended solid ingredient (chilli) greatly depends on the temperature. During the blending operation, the blades are rotated at high speed in order to utilize the sharp cutting surfaces along the leading edges of the blades for liquefying the solid ingredients, accompanied by heat. When the T_1 is achieved and detected by the temperature sensor (thermometer), the rotation of the blades stops. The blade assembly takes five seconds to prepare for the following cooking operation.

The cooking operation starts with the rotation of the blades in a clockwise direction where the wing flaps on the blade edges work to induce an upwardly directed axial flow of the semi-liquid food. Heat transfer from the heating plate is continued until the second predetermined temperature (T_2) is achieved. The second temperature (T_2) determines the cooking time of the foodstuff during cooking operations. The cooking method employed in the present design is pan-frying. The end products should not contain any free water in its cooked state. Once there is no free water in the chilli paste, the temperature of the chilli paste will be increased to 100°C and at this time, the foodstuff will be in a well-cooked state, where the oil from the paste floats to the top.

Therefore, 100°C can be used as the second temperature (T_2) parameter to control the cooking operation of the machine and ensure that the chilli paste is well-cooked at that particular temperature.

Performance evaluation :

The following parameters to be under taken :

The product losses :

The percentage of product losses will be calculated by using the following formula (Willard *et al.*, 1971).

$$y_1 = \frac{W_1 - W_2}{W_1 \times t} \times 100$$

where; y_1 = product losses (%/min), W_1 and W_2 = initial weight of chilli taken and final weight of chilli, respectively (gram), and t = time taken to prepare the chilli paste (min). The analogue scale with ±1 gram accuracy.

Capacity of paste preparation :

The paste preparation capacity of the chilli paste making and cooking machine will be calculated by using the following formula (Pyler, 1988).

$$\text{Paste preparation capacity} = \frac{\text{Mass of chilli paste in kg}}{\text{Time (sec.)}}$$

Load justification (BIS, 2004) :

The load justification method is calculated by the following formulas

$$K = \frac{Gd4}{8nD}$$

where, K= spring constant.

G = young modulas of spring

d = wire diameter (inch).

n = number of active coils.

D= mean coil diameter.

$$\text{Rate} = \frac{\text{Load}}{\text{Distance travelled}}$$

Load = rate x distance travelled

Volume of can (BIS, 2004) :

The volume of can method is calculated by the following formula.

Volume of can = $\pi r^2 h$

Motor power verification (BIS, 2004) :

The motor power verification is calculated by the following formulas

$$\text{Speed of motor (RPS)} = N = \frac{\text{Speed in revolution per minute}}{60}$$

$$N_{re} = \frac{NDa^2\rho}{\text{Hardness}}$$

where, N = revolution per second.

D_a =Diameter of blade revolution

ρ = Density

$P = c' \times {}^\circ \times D_0^5 \times N^3$

where, $c' = N_p$ = power number

ρ = Density

D_0= diameter of the can.

N=speed of motor (RPS)

P= power

$$\text{Horsepower} = \frac{\text{Power}}{746}$$

EXPERIMENTAL FINDINGS AND ANALYSIS

This paper deals with the results obtained from the different experiments of the present investigation such as design, fabrication and performance evaluation of machine. Efforts have been made to develop grabs to describe the different product losses, capacity related with time. The findings have been suitably explained with logical regions wherever possible. The findings also have been discussed in the light of theories and with the literature support to the possible extent.

Performance evaluation of fabricated chilli grinding and cooking machine :

Product loss :

The product losses were determined by taking different sets of experiments and it was found that the product loss

Table 1 : Product loss (%)

Sr. No.	W_1	W_2	W_1-W_2	Product loss (%)
1.	250	249	1	0.40
2.	300	297	3	1.00
3.	450	454	6	1.33
4.	500	493	7	1.40
5.	750	739	11	1.46
6.	850	837	13	1.53
7.	1000	983	17	1.70
8.	1250	1228	22	1.76

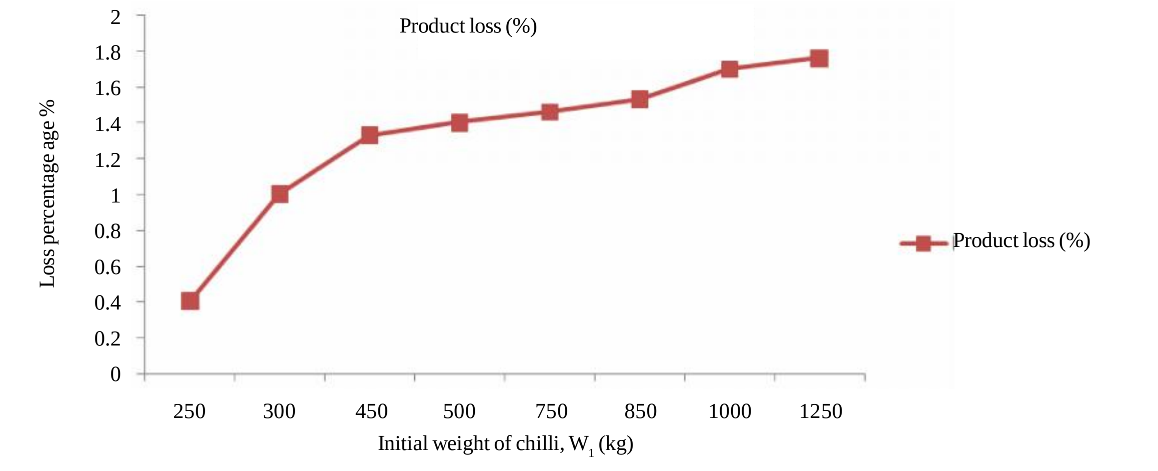


Fig. 1 : **Product Loss specification**

were varies from 0.4 to 1.7 per cent. The average product loss was 1.275 per cent. The loss is due the oil used during the cooking of the chilli paste leads to sticking of chilli paste in the can lid and the blades.

Paste preparation capacity :

The Paste preparation capacity of fabricated machine was calculated and it was found that it varies from 0.000141 kg/sec to 0.000321 kg/sec. The average capacity was 0.000249 kg/sec.

Table 2 : Paste preparation capacity of fabricated machine

Sr. No.	Mass of the chilli paste (kg)	Time taken in chilli grinding (sec)	Paste preparation capacity(kg/sec)
1.	0.255	1800	0.000141
2.	0.499	2280	0.000218
3.	0.744	2700	0.000275
4.	0.988	3420	0.000288
5.	1.233	3840	0.000321

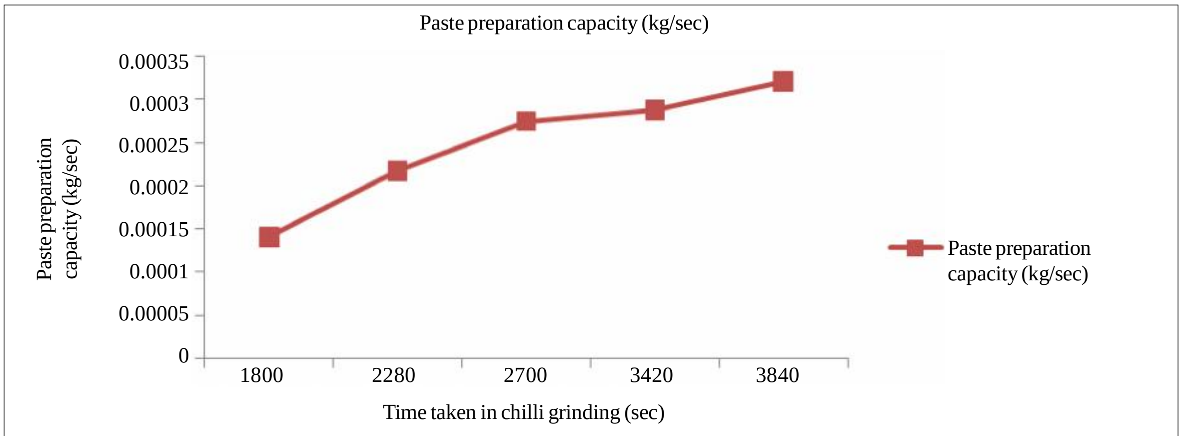


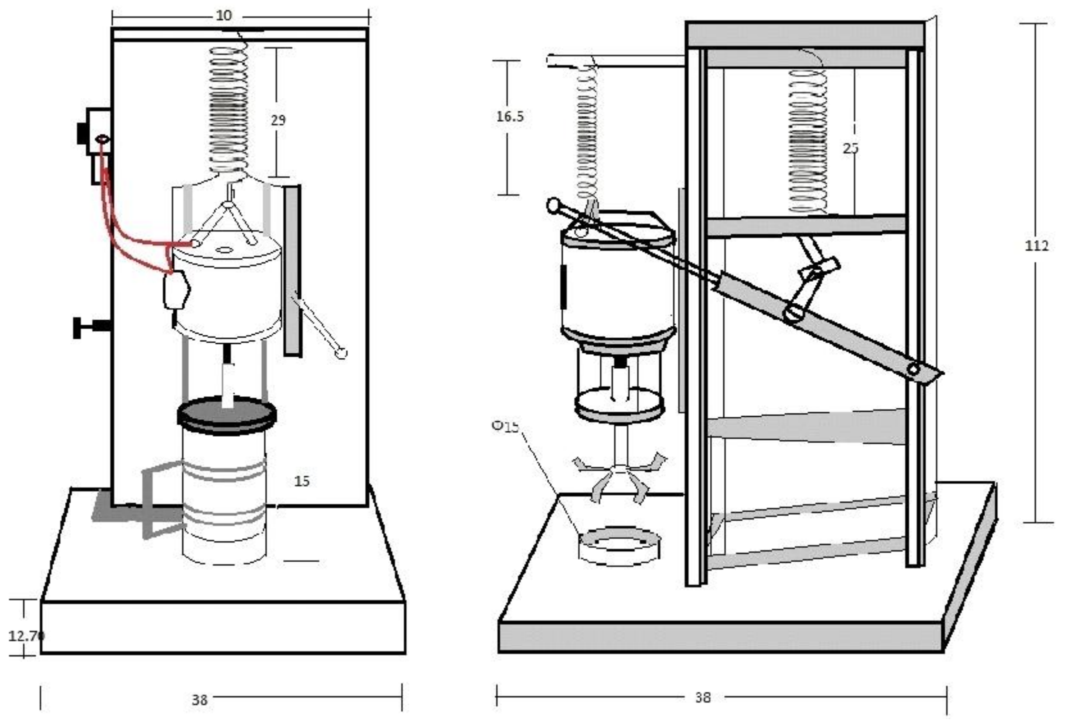
Fig. 2 : **Performance specification**

Cost analysis :

Total manufacturing cost was the sum of the elemental costs which are as follows :

Table 3 : Cost analysis

Material costs	8000.00 INR
Direct labor costs	14000.00 INR
Overhead costs	500.00I NR
Other costs	2500.00 INR
Total costs	25000.00 INR



Front view of chilli paste grinder

Side view of chilli paste grinder

All dimension are in cm.

Conclusion :

A new chilli paste making machine was successfully designed and fabricated with combination feature of blending and cooking element. This machine processes the raw ingredients into chilli paste that is ready to serve. The machine performs blending and agitated cooking automatically without any manual input at the stage of changing from the blending to cooking operation. The blades that are fixed in the machine do not require to be changed during the whole operation (blending and cooking operation). The whole operation is controlled by the miniature circuit breaker and the switches which allows for the automated control at the desired temperature and speed parameters. The present machine has eliminated the need of transferring of blended food in the blender or food processor to the pan for cooking as well as saves time and labor by eliminating the need of manual stirring by hand. It is expected that this newly designed machine could replace the traditional way of chilli paste as it simplifies the tasks involving in making chilli paste.

Appendix :

Calculation during projects

– Weight of motor with attachments = 10.76 kg
– Material of spring = hardened steel
– Load justification

$$K = \frac{Gd4}{8nD}$$

where, K= spring constant.
G = young modulas of spring
d = wire diameter (inch).
n = number of active coils.
D= mean coil diameter.

Values :

G = 30000000
d =0.5 cm or 0.1968 inch.
n = 33
D = 2.6772

Calculation :

$$K = \frac{30000000 \times (0.1968)^4}{8 \times 33 \times (2.6772)^3}$$

$$= \frac{45000.944}{5065.78}$$

$$= 8.88$$

$$Rate = \frac{Load}{Distance\ travelled}$$

Load = rate x distance travelled
= 8.8815 x 11
= 97.71 pounds/inch or,
= 44.32 kg.

Volume of can :

Volume of can = $\pi r^2 h$

= $3.14 \times (6.05)^2 \times 15$
= 1723.97 cm^3

Motor power verification :

Power number = N_p= c'=1.05 (for N_{re} > 300)
Diameter of blade revolution D_a =11.6 cm
Hardness = 3.50
Density = 621 kg / m^3 = 0.621 g / cm^3
N = revolution per second

$$N = \frac{Speed\ in\ rpm}{60}$$

$$= \frac{1440}{60}$$

= 24 revolution per sec.

$$N_{re} = \frac{NDa^2\rho}{Hardness}$$

$$= \frac{24 \text{ x } (11.6)^2 \text{ x } 0.621}{3.05}$$

$$= 572.99$$

$$\mathbf{P = c' \text{ x } ^\circ \text{ x } D_0^5 \text{ x } N^3}$$

$$P = 1.05 \text{ x } 0.621 \text{ x } (24)^3 \text{ x } (11.6)^5$$

$$P = 1893235200 \text{ g.cm}^2/\text{s}^3$$

$$P = 1893235200 \text{ x } 10^{-7} \text{ kg.cm}^2/\text{s}^3$$

$$P = 189.32 \text{ kg.cm}^2/\text{s}^3$$

P = 189.32 J/Sec or 189.32 Kw.

$$\textbf{Horsepower} = \frac{\textbf{Power}}{\textbf{746}}$$

$$\text{Horsepower} = \frac{189.32}{746}$$

$$= 0.2501 \text{ Hp}$$

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