Performance evaluation of a Porridge (Hammer) Mill.

Author: Er. Medha Vyas

Abstract: - Rapid growth in the human population not necessitates enhancing production but also requires proper storage of surplus. Proper food storage is of paramount importance in the present scenario of increasing incidences of localized food shortage. Besides this nutritious mixed porridge is a resource of protein, fiber, and highly energetic food product consume and liked by everyone whether a child and old age person who require more protein and energy. Therefore, the present study was made on the development of nutritious mixed porridge at a small-scale level using cereal and pulses. The obtained result on various parameters like grinding percentages, sieve size analysis, fineness modulus.

Index terms: - fineness modulus, grinding percentage, hammer mill, machine performance, milling, sieve size analysis, wheat.

INTRODUCTION

Food scarcity is not only a major problem in our country but also prevails in the world. The main reason for this problem is decreasing availability of agricultural land and day by day increasing population. Besides this malnutrition, a state of improper nutrient balance in the body; affects health. A vast majority of the population in developing and underdeveloped countries do not have adequate nutrition to sustain a healthy life. In India, protein-energy malnutrition is still a major problem in all the segment of the population.

Porridge is also known as Dalia, Cracked wheat, Bulgar, Facia, Lapsi, and Ogi. It is a wheat product made from whole wheat kernels that are crushed or cut into smaller pieces. Porridge is a typical means of preparing cereal crops-based food products for the table. Porridge is a traditional food in much of Northern Europe and Russia.

Wheat (*Triticum aestivem*) is an important source of energy and protein in the diets of the population in developing countries (Hira *et al.*, 1991). The world's total annual production of wheat is 469 million metric tons (FAO, 2011). Wheat is one of the most widely cultivated crops in the world. It is a staple food for a large segment of the world population.

Besides this, it is a general fact that food products based on either cereals or pulses alone are nutritionally inferior. Therefore, the present study was planned to develop a nutritious porridge, by mixing wheat and soybean in various combinations.

In this context, the present study is undertaken with the milling characteristics of the porridge machine.

REVIEW OF LITERATURE

This chapter deals with the review of research work so far carried out in the porridge milling field.

2.1 Hammer mill

El-Shal et.all has evaluated the effects of operational parameters in the performance of a prototype hammer mill taking into consideration hammer mill capacity, efficiency, particle size distribution (fineness degree), power, energy requirement, and operational cost. The obtained results reveal that it is recommended to use the hammer mill at drum rotational speed about 2250 rpm (33.56 m/s), grain moisture content of 10%, concave clearance of 5 mm, and hammer thickness of 5 mm to produce pelleting feed by increasing the percentage of finely milled corn (FMC) and decreasing coarse milled corn (CMC).

Vetrimani (1990**);** showed that very fine grinding makes foods dusty and lower palatability. However, fine grinding may be desirable when pelleting is to follow.

Hassan (1994); found that increasing drum speed from 1460 to 2930 and 3910 rpm gave a decrease of 59.1 and 67.9% in grinding energy. The increase of the grain moisture content from 5.4 to 8.1 and 11.4% gave an increase of 20.1 and 49% in grinding energy. He added that the fine grinding percentage was obtained at lower grain moisture content and higher drum speed. Besides, as to the fineness degree of grinding (medium and coarse) an opposite trend results comparing with the fine grinding.

EL- Gayar and Bahnas (2002) studied the factors affecting the production of garlic power such as three hammer tip speeds (13.82, 18.43, and 23.04m/s), two feed rates (27.00and 43.2 kg/h), two-screen hole diameters (1 and 2mm) and two drying methods (natural and artificial) using a hammer mill. They indicated that the highest milling capacity was obtained at 23.04m/s hammer tip speed and the highest milling efficiency was obtained at 13.82m/s hammer tip speed and the milling efficiency takes the opposite trend of the milling capacity.

Independent variable			**Measuring parameters**
S. No.		**Level**	
1	Feed rate(kg/h) 90,180,270 and 360	3	1) Milling characteristics Grinding percentage and Average particle size
2	Screen sizes 3mm and 7mm	2	

Hegazy *et al.* (2002) indicated that increasing hammer revolving speeds from 1000 to 2500 rpm (16.6 to 41.5 m/s) cause a corresponding increase in machine productivity.

MATERIAL AND METHOD

All the experiments for the performance evaluation of a porridge mill and the development of nutritious mixed porridge were conducted in the product development laboratory of the Department of Post Harvest Process and Food Engineering, College of Agricultural Engineering, JNKVV Jabalpur.

3.1 Materials

3.1.1 Wheat

For the preparation of the nutritious mixed porridge wheat (variety Sharbati) was procured from the local market. All the foreign materials present in the raw material were removed. Cleaned grains were then ground in a vertical hammer mill.

3.2 Experimental plan

3.2.1 Experimental plan for the performance evaluation of porridge mill

Proposed research work was carried out at the Food Processing Laboratory of Post Harvest Process and Food Engineering, College of Agricultural Engineering, JNKVV, Jabalpur (M.P.). All the experiments were replicated thrice.

Table 3.1 Experimental plan of a milling

3.2.2.2 Experimental plan for the preparation of porridge

3.3 Equipment and instrument used

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3.3.1 Hammer mill

Hammer mills work on the principle that most materials will crush, shatter, or pulverize upon impact. Porridge hammer mill is a fixed type hammer mill, provided with a 5hp motor. The prepared sample was inserted from the top of the casing; at different feed; is broken by rotating hammer and fall out the screen at the bottom. Hammer is rotated at fixed rpm, strike and grind the material until it becomes small enough to pass through the bottom screen. The collected sample was prepared for grading.

3.3.2 Grader

Milled grits prepared for grading; by using a three-stage grader, in which 3mm, 2.5mm, and 1mm diameters openings are provided.

3.3.3 Digital Weighing Balance

Digital electronic balance (Model: CY-3600, Manufactured by-Citizen, India) with measuring scale showing maximum- 360g and minimum-20mg.

3.3.4 Digital Venire Caliper

It was used to measure the longitudinal and lateral dimensions of the porridge. (Aerospace digital venire caliper, range 0-150mm).

3.3.5 Tachometer

It is used for measuring the speed of the motor shaft. It has a range that varies from 20-5000rpm.

3.4 Determination of Measuring Parameters

3.4.1 Milling Characteristics

3.4.1.1 Grinding Percentages

The grinding percentage was determined by recovery of the sample, in terms of percentages (%), as per the recommendation of porridge; which was determined by sensory analysis based on the particle size.

3.4.1.2 Sieve Size Analysis (Particle Size Distribution)

The particle-size distribution (PSD) is also known as grain size distribution or sieve size analysis. This was carried out for the determination of recovery of desired size sample. Sieve size analysis was measured by the method as recommended by Singh and Sahay.

3.4.1.3 Fineness Modulus

Fineness modulus (FM) is defined as an empirical figure obtained by adding the total percentage of the sample of an aggregate retained on each of a specified series of sieves and dividing the sum by 100. This was measured by the method as recommended by Ranganna.

$$Dp = 0.135 \times 1.366^{fm}$$

Where:

fm: Finesse modulus

Dp: average particle size diameter (mm)

RESULTS AND DISCUSSION

The present investigation entitled "Performance Evaluation of a Porridge Mill and Development of Nutritious Mixed Porridge" was carried out in the Department of Post Harvest Process and Food Engineering, College of Agricultural Engineering, J.N.K.V.V., Jabalpur. The obtained results are presented in the following sections.

4.1 Milling characteristics

Nutritious mixed porridge of wheat and soybean was prepared by using a hammer mill operating at a constant speed of 1380 rpm and 90, 180, 270, and 360 kg/h feed rate. Screens of size 3.5 and 7 mm were fitted at the outlet of the hammer mill. The ground samples were graded by passing through the grader having sieves with 3, 2.5, and 1mm openings.

4.1.1 Particle size analysis

Table 4.1 reveals that the percentage recovery of the coarse porridge was 9.9 and 4.6 at 360 kg/h and 90kg/h feed rate, respectively. The percentage recovery of fine porridge having size 1-2.5 mm ranges from 56.1 to 40.2. The percentage recovery of medium porridge obtained at different feed rates ranged from 35 to 26.6. From table 4.1 it is clear that the maximum percentage recovery of fine porridge was 56.5 at a 180 kg/h feed rate. At 90 kg/h feed rate the percent recovery of fine porridge was maximum (40.2) followed by the medium porridge (35.0) and fine porridge (20.1). From the table, it is also evident that at any feed rate the percentage recovery of the fine porridge was maximum. The percentage recovery of the fine porridge at 90, 180, 270, and 360 kg/h feed rate were 40.2, 56.5, 56.1, and 44.9, respectively. No specific trend was observed in the percent recovery of the coarse, medium, and fine porridge at selected feed rates. The percentage recovery of the flour decreased from 20.1 to 13.7 as the feed rate increased from 90 to 360 kg/h

Table 4.1 Effect of feed rate on percentage recovery of the coarse, medium, and fine porridge at 3.5 mm sieve opening of hammer mill

Sieve size of grader (mm)	Feed rate (kg/h)			
	90	**180**	**270**	**360**
Coarse porridge (3-3.5 mm)	4.6	0.2	0.7	9.9
Medium porridge (2.5-3 mm)	35.0	26.6	28.8	31.5
Fine porridge (1-2.5 mm)	40.2	56.5	56.1	44.9
Flour (up to 1mm)	20.1	16.7	14.4	13.7
Total recovery of porridge, (%)	99.4	98.5	98.7	97.5
Loss, (%)	0.6	1.5	1.3	2.5

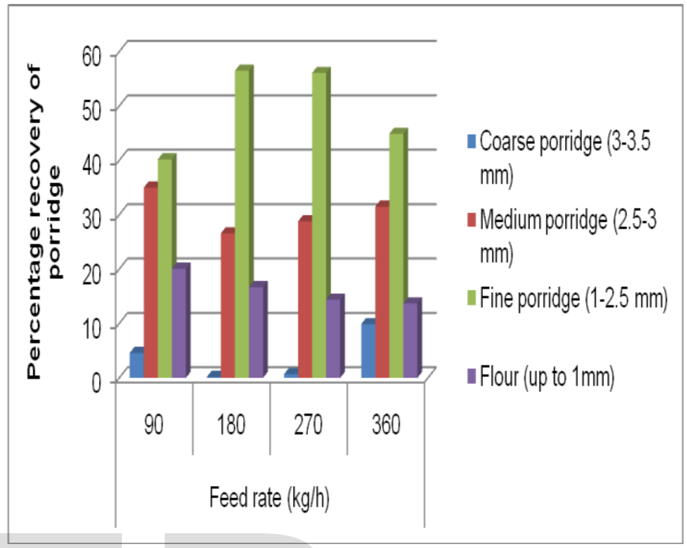


Fig. 4.1 Effect of feed rate on percentage recovery of the coarse, medium, and fine porridge at 3.5 mm sieve opening of hammer mill.

From Table 4.2 it is clear that the percentage recovery of the coarse porridge was 18.3 and 4.6 at 360 kg/h and 90 kg/h feed rate, respectively. The percentage recovery of fine porridge having size 1 to 2.5 mm ranges from 58.2 to 36.5. The percentage recovery of medium porridge obtained at different feed rates ranged from 36.3 to 20.8. From table 4.2 it is clear that the maximum percentage recovery of fine porridge was 58.2 at a 270 kg/h feed rate. At 90 kg/h feed rate the percent recovery of fine porridge was maximum (42.7) followed by the medium porridge (36.3) and flour (16.4). From the table, it is also evident that at any feed rate the percentage recovery of the fine porridge was maximum. The percentage recovery of the fine porridge at 90, 180, 270, and 360 kg/h feed rate were 42.7, 56.3, 58.2, and 36.5, respectively. No specific trend was observed in the percent recovery of the coarse, medium, and fine porridge at selected feed rates. At

90 kg/h feed rate, percentage recovery of flour was 16.4 and it decreased to 14.8 at 180 kg/h feed rate. However, the percentage recovery decreased to 10.4 and further to 12.3 at 270 and 360 kg/h feed rate respectively.

Table 4.2 Effect of feed rate on percentage recovery of coarse, medium, and fine porridge at 7mm sieve opening of hammer mill

Sieve size of grader (mm)	Feed rate (kg/h)			
	90	180	270	360
Coarse porridge (3-3.5 mm)	4.6	2.9	10.6	18.3
Medium porridge (2.5-3 mm)	36.3	26.0	20.8	32.8
Fine porridge (1-2.5 mm)	42.7	56.3	58.2	36.5
Flour (up to 1mm)	16.4	14.8	10.4	12.3
Total recovery of porridge, (%)	99.2	99.4	98.3	98.2
Loss, (%)	0.8	0.6	1.7	1.8

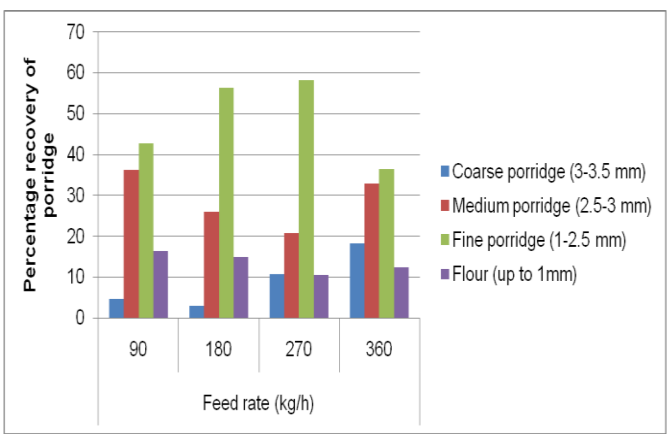


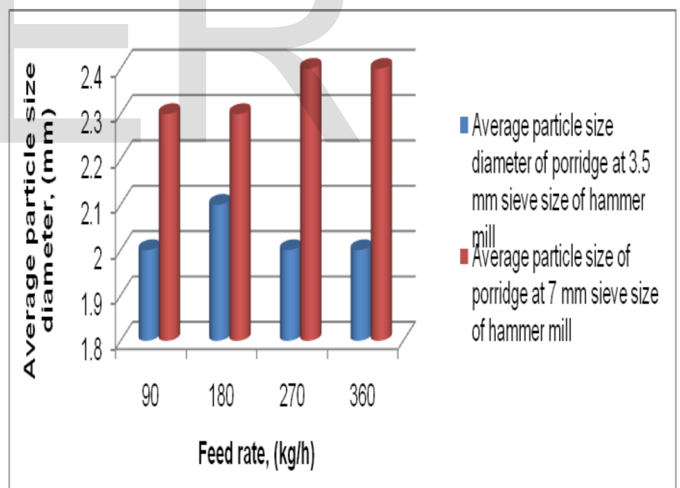
Fig.: Effect of feed rate on percentage recovery of coarse, medium, and fine porridge at 7mm sieve opening of hammer mill.

Effect of feed rate and screen size on the fineness modulus (average particle size diameter) of porridge

Table 4.3 evidenced that among all feed rates average particle size diameter was nearly the same. It is ranged from 2.0 to 2.4 mm. highest average particle size diameter of 2.4mm was found at 270 and 360 kg/h for 7mm sieve size. For 3.5 mm sieve size, it was found highest at 180kg/h.

Table: 4.3 Effect of feed rate and screen size on the fineness modulus (average particle size diameter) of porridge

Feed rate, (kg/h)	Average particle size diameter (mm) at different sieve size (mm) of hammer mill	
	3.5	7
90	2.0	2.3
180	2.1	2.3
270	2.0	2.4
360	2.0	2.4



- Among all storage periods, 3.5 mm screen size at 270 kg/h shows the maximum recovery of desired fine porridge grinding percentage.
- Since 270 kg/h shows a higher mean value at screen size 3.5 mm, hence it is suggested that for recovery of fine porridge feed rate 270 kg/h may be used for further experimentation rather than that of other combinations.

- For medium and coarse porridge recovery 360kg/h at 7mm screen size shows higher recovery.
- In case of flour recovery, 90 kg/h at 3.5 mm screen size could be used.
- The value of fineness modulus was almost the same for all feed rate and screen size.

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