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PERFORMANCE EVALUATION OF ATTRITION MILL USED IN THE FINGER MILLET PROCESSING INDUSTRIES

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Abstract— **Experiment was conduct to evaluate the performance of attrition mill used in the finger millet processing industries in South India. The treatments of the experiment include three plate clearances (0.3, 0.5 &0.7 mm), three plate speeds (450, 600 &700 rpm) and three feed rates (90, 100 & 115 kg\hr). The experiment was conducted in Factorial Completely Randomized Design (FCRD), having plate clearance, feed rate and plate speed as treatments and analyzed statistically. GPU-28 variety of cleaned finger millet having 10 per cent moisture (w.b) was used as feed material to find out the performance of attrition mill. The study indicated that at 0.3 mm plate clearance, 100 kg/hr feed rate and 600 rpm plate speed combinations; milling efficiency of the attrition mill was 85 per cent. The flour samples after milling were sieved using BS 30 sieves and analyzed for fineness of flour at different plate clearances, plate speeds and feed rates. It was observed that the fineness modulus of 2.04 was recorded at 0.3 mm plate clearance, 100 kg/hr feed rate and 600 rpm plate speed combinations.**

KEY WORDS: ATTRITION MILL, FINGER MILLET, MILLING EFFICIENCY, FINENESS MODULUS.

I. INTRODUCTION

Finger millet [Eleusine coracana (L.) Gaertn.] commonly known as Ragi, is one of the important small millet crops in red soil areas of southern India. This millet contains 7-9 % protein, 15-20 % dietary fibre and 2-3.5 % minerals; besides, it is a very good source of calcium, and several other micronutrients. The kernels of finger millet are smaller in size and brick red in colour. The colour of finger millet is confined to the seed coat only as its endosperm is milky white and is floury texture in nature to which seed coat is rigidly attached. Because of these peculiar morphological features peeling the seed coat causes fragmentation of the endosperm matter into flour. Hence, the millet is invariably pulverized into flour with plate or disc mill (attrition mill) before using it for making different finger millet food products. In case of cereals like wheat, the nature of pulverizers used to make the flour are known to influence the physico- chemical properties and accordingly, the wheat is pulverized depending upon the end use of the flour (Saxena and Rao, 1997). The particle distribution and its proportion in the flour depend on the nature of pulverizers used. This kind of information on the quality parameters of finger millet flour is required to identify suitable end uses of the finger millet flour. Further, the presence of anti-nutritional compounds like phytic acid, phenolics particularly tannins and oxalic acid reduce bioavailability of minerals, resulting in reducing the nutritional quality of finger millet (Reddy et al. 1982). According to Elyas et al. (2002) the processing of millet for the product manufacturing reduces anti – nutritional factors, thereby resulting bioavailability of nutrients. Hence, there is need to evaluate whether the existing attrition mills used in the finger millet processing industries fulfills the required quality parameters to use the flour of the finger millet for various end uses.

II. MATERIAL AND METHODS

. The experiment was conducted at a finger millet processing industry in Bengaluru. The attrition mill used by the industry consists of one stationary and one rotating cast steel plate positioned vertically and operated by 2 hp electric motor. The finger millet grains were fed into the hopper, from where it passes on to the screw conveyor to deliver the feed material in between the two plates. The cast steel plates containing radial grooves allow the grind flour to pass out through the outlet due to centrifugal action. The treatments of the experiment include three plate clearances (0.3, 0.5 &0.7 mm), three feed rates (90, 100 & 115 kg\hr) and three plate speeds (450, 600 &700 rpm). The experiment was conducted in Factorial Completely Randomized Design (FCRD), having plate clearance, plate speed and feed rate as treatments and the data was analyzed statistically. GPU-28 variety of cleaned finger millet having 10 per cent moisture (w.b) was used as a test grains to find out the performance of attrition mill. Fifty-four sample bags containing one kg each were separately weighed and used for experiment (9 samples each for plate clearance, plate speed and feed rate). Graphs were plotted showing milling efficiency against plate clearance, plate speed and feed rate.

III. FINENESS MODULUS OF FINGER MILLET FLOUR

The flour obtained at different plate clearances, feed rates and plate speeds, was analyzed for its fineness modulus. The samples (250 g each) were dried in a oven at 105°C. The dried samples having 10 per cent moisture (w.b) is placed in the top-most sieve and the whole set of 9 sieves is placed on a sieve shaking machine and shaken for 5 minutes. The British Standard Sieves used for different fractions consists of a set of 9 sieves and a pan. The fractions retained on each sieves were weighed adding the weight fraction retained above each sieve and dividing the sum by 100 determined the fineness modulus. Graph was plotted showing fineness of flour obtained against plate clearance, plate speed and feed rate.

IV. Results and Discussion

A. Milling Efficiency

The data on milling efficiency of the attrition mill analyzed statistically are presented in Table 1.

B. Plate clearance

The data in Fig.1 shows that as the plate clearance increased from 0.3 mm to 0.7 mm the milling efficiency of the attrition mill decreased gradually irrespective of feed rates and plate speeds. The milling efficiency was highest (85 %) when the plate clearance was 0.3 mm, feed rate was 100 kg\hr and plate speed was 600 rpm. The milling efficiency was reduced to 61.70 per cent when the plate clearance increased to 0.7 mm at the same feed rate (100 kg\hr) and plate speed (600 rpm) as compared to that recorded at 0.5 & 0.7 mm clearance, 90 & 115 kg \ hr feed rates and 450 & 700 rpm plate speeds.

C. Milling loss

The data in Fig.2 indicates that as the plate clearance increased from 0.3 mm to 0.7 mm the milling loss of the attrition mill increased gradually irrespective of feed rates and plate speeds. The lowest milling loss (15 %) was recorded when the plate clearance was 0.3 mm, feed rate was 100 kg\hr and plate speed was 600 rpm. It was highest (38.30 %) when the plate clearance was 0.7 mm at the same feed rate (100 kg\hr) and plate speed (600 rpm) as compared to that recorded at 0.5 & 0.7 mm plate clearance, 90 & 115 kg \ hr feed rates and 450 & 700 rpm plate speeds.

D. Recovery of flour

The data in Fig.3 reveals that as the plate clearance increased from 0.3 mm to 0.7 mm the recovery of flour of the attrition mill decreased gradually irrespective of feed rates and plate speeds. The recovery of flour was highest (85 %) when the plate clearance was 0.3 mm, feed rate was 100 kg\hr and plate speed was 600 rpm. Recovery of flour was reduced to 61.70 per cent when the plate clearance was increased to 0.7 mm at the same feed rate (100 kg\hr) and plate speed (600 rpm) as compared to that recorded at 0.5 & 0.7 mm plate clearance, 90 & 115 kg \ hr feed rates and 450 & 700 rpm plate speeds. The data recorded in this study is on far with the data of Ramakumar et al.(1997), where they stated that 100 kg\hr feed rate with 0.3-0.5 mm plate clearance found optimum to obtain 86 per cent milling efficiency using burr mill at 10.70 per cent grain moisture (w.b).

E. Interaction (plate clearance, feed rate and plate speed)

The data on interactions of plate clearance, feed rate and plate speed are presented in Table 1. It was observed that, the maximum milling efficiency (85 %) was recorded at 0.3 mm plate clearance, 100 kg/hr feed rate and 600 rpm plate speed combinations (C1F2S2) followed by 82.20 per cent at 0.5 mm plate clearance at the same feed rate (100 kg/hr) and plate speed (600 rpm) combinations (C2F2S2) and 62.30 per cent at 0.7 mm plate clearance, 100 kg/hr feed rate and 700 rpm plate speed combinations (C3F2S3). The study further indicates that milling loss was the least (15 %) at 0.3 mm plate clearance of C1F2S2 combinations followed by 17.80 per cent at 0.5 mm plate clearance of C2F2S2 combinations and 37.70 per cent at 0.7 mm plate clearance of C3F2S3 combinations.

F. Fineness Modulus

The data on fineness modulus of the attrition mill analyzed statistically are presented in Table 2.

G. Plate clearance

Plate clearance had significant difference on fineness modulus of flour. The data in Fig.4 indicates that as the plate clearance increased from 0.3 to 0.7 mm, the fineness modulus of flour increased gradually irrespective of feed rate and plate speed. Higher the value of fineness modulus, lower will be the fineness of flour. It is clear from the figure that the least fineness modulus (2.04) was recorded when the plate clearance was 0.3 mm, at 100 kg\hr feed rate and 600 rpm plate speed. It was increased to 3.43 when the plate clearance increased to 0.7 mm at the same feed rate (100 kg\hr) and plate speed (600 rpm) as compared to that recorded at 0.5 & 0.7 mm plate clearance, 90 & 115 kg\ hr feed rates and 450 & 700 rpm plate speeds.

H. Feed rate

Feed rate also had significant influence on fineness modulus. The data in Fig.4 indicates that as the feed rate increased from 90 kg\hr to 115 kg\hr the fineness modulus of the attrition mill increased gradually irrespective of plate clearance and plate speeds. The lowest fineness modulus (2.04) was recorded when the feed rate was 100 kg \hr at 0.3 mm plate clearance and plate speed of 600 rpm. It was highest (3.66) when the feed rate was 115 kg\hr at the plate speed of 450 rpm and plate clearance of 0.7 mm as compared to the rest of the treatments under study.

I. Interaction (plate clearance x feed rate x plate speed)

Lower the value of fineness modulus, higher will be the fineness of flour. Among the treatments, 0.3 mm plate clearance, 100 kg/hr feed rate and 600 rpm plate speed (C1F2S2) combinations found better fineness of flour recording least fineness modulus (2.04) followed by 2.16 at 0.3 mm plate clearance 100 kg/hr feed rate and 700 rpm plate speed (C1F2 S3) combinations as compared to the rest of the treatments under study.

V. Conclusion

Milling adds value to the finger millet grains. By milling, the processor is adding value to the finger millet in terms of its acceptability, marketability and profitability. The finger millet is generally pulverized using attrition mill or bur mill and the pulverized flour is used for making various finger millet based food products. The performance of attrition mills used in the finger millet processing units in the south India was evaluated to find out the milling efficiency and the fineness of finger millet flour obtained for various end uses. GPU-28 variety of finger millet having 10 per cent moisture content (w.b) was used for the evaluation study. From the study it can be concluded that;

(i) Milling efficiency of the attrition mills used for milling finger millet was 85 per cent at 0.3 mm plate clearance, 100 kg/hr feed rate and 600 rpm plate speed combinations, followed by the milling efficiency of 82.20 per cent at 0.5 mm plate clearance 100 kg/hr feed rate and 600 rpm plate speed combinations.

(ii) Milling loss was the least (15.00 %) at 0.3 mm plate clearance, 100 kg/hr feed rate and 600 rpm plate speed combinations, followed by 17.80 per cent at 0.5 mm plate clearance, 100 kg/hr feed rate and 600 rpm combinations.

(iii) Least fineness modules of 2.04 was recorded at 0.3 mm plate clearance, 100 kg/hr feed rate and 600 rpm plate speed combinations indicating better fineness of flour, followed by fineness modulus of 2.16 at 0.3 mm plate clearance, 100 kg/h feed rate and 700 rpm plate speed..

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LIST OF TABLES

TABLE.1

Treat ments	Fineness modulus		
	Plate speed (450 rpm)	**Plate speed (600 rpm)**	**Plate speed (700 rpm)**
	S1	**S2**	**S3**
C1F1	2.48	2.18	2.22
C1F2	**2.36**	**2.04**	**2.16**
C1F3	2.65	2.22	2.38
C2F1	2.51	2.47	2.53
C2F2	2.40	2.38	2.38
C2F3	2.70	2.62	2.67
C3F1	3.51	3.46	3.52
C3F2	3.44	3.43	3.34
C3F3	**3.66**	**3.64**	**3.62**
F test	*	*	*
SEM±	0.0101	0.0014	0.1109
CD at 5%	0.0303	0.0043	0.3324

Note:
C1, C2, and C3 denote 0.3, 0.5 and 0.7 mm plate clearances respectively.
F1, F2 and F3 denote 90,100 and 115 kg/h feed rates respectively.
S1, S2 and S3 denote 450, 600 and 700 rpm plate speeds respectively.
*Denotes significant at 5 % level.

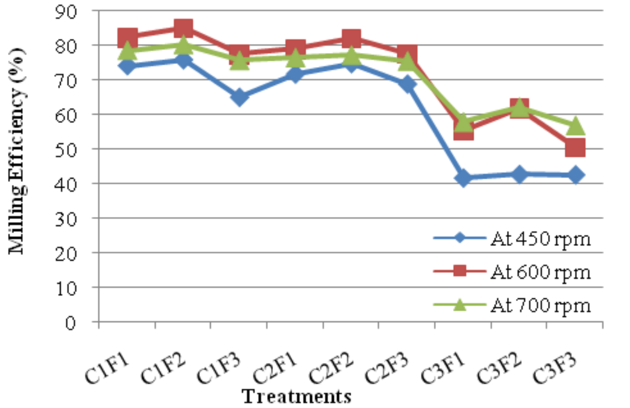

Fig.1: Effect of plate speed, plate clearance and feed rate on Milling efficiency (%)

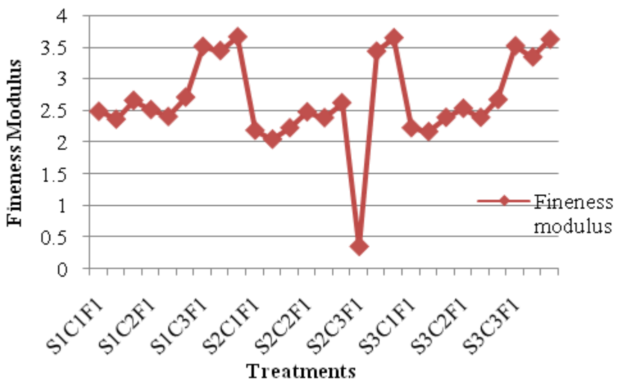

Fig 4:Effect of plate clearance and feed rate on fineness modulus of finger millet flour at different plate speeds

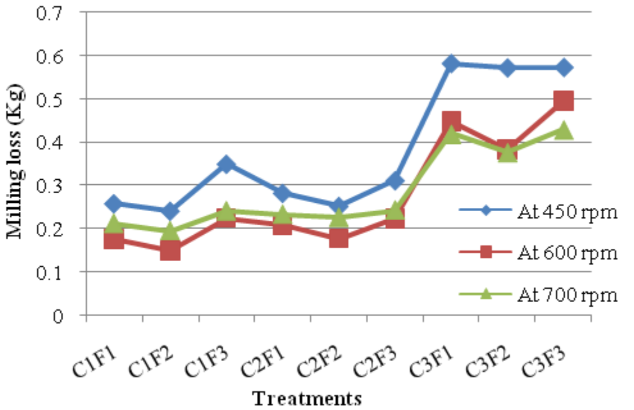

Fig.2: Effect of plate speed, plate clearance and feed rate on Milling loss (kg)

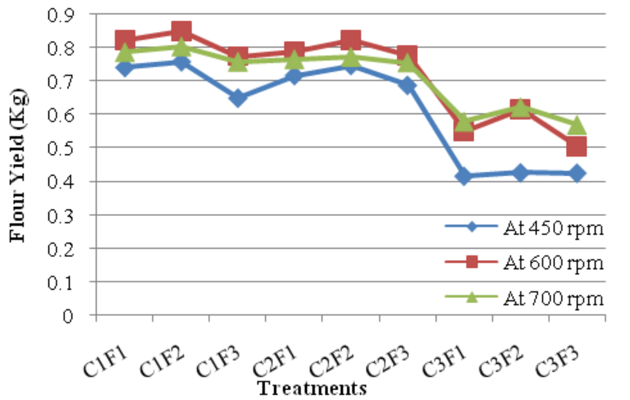

Fig.3: Effect of plate speed, plate clearance and feed rate on Flour Yield.