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Research Article

ROLE OF PHYSICAL DIMENSIONS ON MILLING CHARACTERISTICS OF 17 INDIAN PADDY VARIETIES

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Abstract- Milling characteristics of 17 Indian paddy varieties were determined along with their physical dimensions namely length, width and thickness of paddy. Statistical analysis was conducted to correlate the physical dimensions with milling characteristics. The mathematical models were selected based on the statistical parameters such as R^2, RMSE and reduced- χ^2. Mathematical models were also developed to predict the broken yield of milled rice. The brown rice yield varied from 75.73-79.69%, where as the milling yield varied from 66.82-73.51% at constant time of polishing.

Keywords- Milling, Brown rice, Fissures, Dimensions

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Introduction

Paddy is one of the important cereal crops of India and has the biggest area under cultivation. India is one of the leading producers of rice. Rice is the basic food crop and being a tropical plant, it flourishes comfortably in hot and humid climate. More than 4000 varieties of rice are grown in India. The marketing value of rice as an agricultural product depends on its physical qualities after the harvesting. The percentage of whole grain is most important parameter for the rice processing industry. Broken grain has half the market value of head rice. Producing milled, polished rice with minimum breakage is a universal goal of rice mills. Head rice yield and degree of milling are the primary factors determining the milling quality of rice. Milling rice to a minimum acceptable degree of milling can maximize head rice yield and avoid economic loss due to over milling [7]. Based on the past literature, head rice yield increased with increasing kernel thickness, and then it reached a maximum and decreased. The breakage in the milled rice was greater for the thinner fractions. As milling time increased, head rice yield decreased, and degree of milling increased [2].Rice grain breakage has been attributed to varietal differences, milling equipment and various other factors. Studies carried out by some scientists have related the yield to milling and breakage characteristics, as influenced by grain and machine parameters. However, there are more than 10,000 varieties, which differ considerably in milling characteristics. The routine type research in which the same parameter is repeated for each variety is time consuming and monotonous without scientific inquisitiveness. Hence a study was carried out to develop the appropriate relationship between brown rice and milled rice with the physical dimensions of paddy. The objectives of this study were 1) to determine the effect of dimensions of grain on milling characteristics, 2) to determine the effect of degree of polishing on milled and head rice yield and 3) to determine the effect of defect of grain on per cent brokens.

Materials and Methods

Collection of material

Seventeen varieties of paddy developed by Acharya N.G. Ranga Agricultural University, Hyderabad, grown in India were selected for the present study. The varieties were namely; NLR92, BPT5204, BPT2716, BPT1061, BPT3291, BPT2231, BPT2270, BPT1768, BPT 2295, BPT2411, BPT2605, MTU1010, MTU1001, MTU3626, MTU7029, MTU1061 and NLR523.

Methodology

Moisture content was determined using the oven-drying method [1]. Dimensions were determined by using digital vernier callipers, shelling was conducted by rubber roll sheller, milling was conducted using abrasive rice polisher [4]. Fissures in rice kernels were determined using the purity work board. Brown rice yield (BRY), milling yield (MY), head rice yield (HRY), % fissures and % broken rice were calculated by the equations suggested by [4].

Mathematical modelling:

The mathematical models were selected based on the statistical parameters such as coefficient of determination (R^2), root mean square error (RMSE) and reduced-χ^2. Higher values of R^2 and lower values of RMSE and reduced-χ^2 indicate best relationship between the parameters.

Results and Discussion

The moisture content of all varieties of samples was maintained at 13±1% (dry basis). The different fractions of brown rice, husk, unhulled paddy and brokens were separated manually and the data is shown in [Table-1].

Milling characteristics

Brown rice yield

The brown rice yield of different varieties of paddy was experimentally determined by adjusting the roller clearance-setting equal to half of the kernel width. The highest brown rice yield was observed in case of BPT2270 variety, where as the lowest yield was recorded for MTU1010. This indicated that the variety differed in their characteristics including husk content. The husk content varied from 19.69-

Table-1 *Milling yield of different varieties of paddy.*

S. No	Variety	Yield, (%)							
		BRY	UHR	Husk	DP	MY	BY	HRY	Fissures
1	NLR92	77.61	0.46	21.93	08.46	72.35	20.14	60.04	20.0
2	BPT5204	77.23	0.23	22.54	10.11	71.64	22.63	59.45	25.0
3	BPT2716	79.37	0.53	20.10	08.05	72.93	19.32	57.84	10.0
4	BPT1061	78.40	0.70	20.90	10.01	71.76	20.36	62.74	10.0
5	BPT3291	78.09	0.38	21.53	12.50	68.23	22.25	61.76	35.0
6	BPT2231	78.36	0.62	21.02	08.69	72.51	18.99	58.81	15.0
7	BPT2270	79.69	0.62	19.69	10.40	73.51	22.14	55.31	25.0
8	BPT1768	77.72	0.43	21.85	12.08	69.23	19.32	60.91	15.0
9	BPT 2295	79.4	0.34	20.26	08.23	72.31	22.85	61.95	25.0
10	BPT2411	79.02	0.54	20.44	09.95	70.94	20.65	60.53	15.0
11	BPT2605	77.03	0.50	22.47	07.95	73.51	23.77	62.32	35.0
12	MTU1010	75.73	0.46	23.81	14.30	67.23	20.36	61.11	20.0
13	MTU1001	78.31	0.29	21.40	14.38	66.82	18.32	55.36	10.0
14	MTU3626	77.96	0.50	21.54	10.55	69.02	21.89	58.02	25.0
15	MTU7029	79.78	0.29	19.93	09.66	73.25	19.37	60.53	15.0
16	MTU1061	78.54	0.28	21.18	08.83	70.36	22.06	60.80	20.0
17	NLR523	79.40	0.32	20.28	10.49	69.62	19.32	60.83	15.0

BRY= Brown rice yield; UHR= Unhulled rice; DP= Degree of polish; MY= Milling yield; BY= Brokens yield; HRY= Head rice yield

23.81%. A small amount of paddy remained unhulled during shelling. The percentage of unhulled paddy varied from 0.23-0.62% among all the 17 varieties. The yield of brown rice was depending upon the some physical dimensions of paddy. Therefore the correlation of individual dimensions of different varieties of paddy were analysed with per cent yield of brown rice, first through linear regression and then up to third order polynomial. The R^2 values of the regression analysis revealed that the width and thickness of paddy had a profound influence on brown rice yield. Other parameters length, length/width, width/thickness and fissures did not influence the yield as seen from the R^2 values [Table-2]. The effect of width (W) and thickness (T) of paddy on brown rice yield was supported by the fact that during shelling, the clearance was set equal to half of width of paddy [6].The following models fit the relationship between brown rice yield and physical dimensions.

$$BRY= 3.6638W+69.44 \quad (R^2= 0.813; RMSE=0.482; Reduced\text{-}\chi^2=0.232) \quad [1]$$

$$BRY= 5.8349T+67.814 \quad (R^2= 0.810; RMSE=0.485; Reduced\text{-}\chi^2=0.235) \quad [2]$$

From the [Eq-1] and Eq-2], higher values of width and thickness of paddy resulted in higher brown rice yield. This was due to the fact that high value of width and thickness resulted more solid matter [6]. However, applicability of these models was limited to the range of experiment because the above models will give some values of brown rice yield even at zero value of width and thickness of paddy. Higher order polynomial regression did not indicate any improvement in relationship between brown rice yield and paddy characteristics [Table-2].

Milling yield

The total milling yield varied from 66.82-73.51% with an average of 70.89%. The maximum degree of polishing was observed in MTU1001 (14.38%) which had the lower milling yield. However the trend was not uniform for all varieties of paddy, in some cases, the lower degree of polish results lower yields. Therefore, the regression analysis was conducted to correlate the degree of polish, using the following model, which represents the experimental data satisfactorily.

$$MY= -0.9414DP+80.566 \quad (R^2= 0.744; RMSE=1.146; Reduced\text{-}\chi^2=1.313) \quad [3]$$

The brokens in milled rice varied from 18.32-23.77% for different varieties of paddy. There was no definite trend between degree of polish and brokens, BPT2716 variety exhibited lower degree of polish had higher percentage brokens (19.32%) , where as the variety MTU1001 showed higher degree of polish had lower percentage of brokens (18.32%). These results were similar to the results obtained by [6]. This indicated that other than degree of polish, the variety and fissure content of paddy influenced the per cent brokens. The effect of various physical dimensions on milling yield was studied through linear and polynomial relations. In all cases up to the third order, the R^2 values were lower than 0.500 [Table-2]. Therefore no definite relationship between physical dimensions and milling yield.

Effect of per cent fissures of brown rice on per cent brokens

The causes of breakage of rice grains have been reported to be influenced by the properties of the grains and also by the conditions under which the grain is milled ([3] and [5]). The properties of the grains are strongly influenced by the variety, the moisture content and the condition to which the grains are subjected to from time to time, till they reached maturity in the field [6]. [Table-1] shows the amount of fissured kernel present in brown rice for individual varieties. The fissured kernels varied from 10-35%. The relationship between brokens and fissure content was explained by the linear regression analysis

$$BY=0.1784F+17.293 \quad (R^2= 0.739; RMSE=0.855; Reduced\text{-}\chi^2=0.730) \quad [4]$$

Where F= Fissures

Table-2 *Coefficient of determination of milling yield and grain dimensions relationship.*

Parameters	Brown rice yield			Milled rice yield			% Brokens		
	1	2	3	1	2	3	1	2	3
Length, mm	0.016	0.192	0.378	0.043	0.053	0.095	0.015	0.045	0.079
Width, mm	0.813	0.833	0.836	0.249	0.251	0.316	0.007	0.018	0.019
Thickness, mm	0.810	0.812	0.812	0.075	0.197	0.199	0.018	0.019	0.037
Length/Width	0.525	0.526	0.547	0.282	0.283	0.283	0.009	0.088	0.089
Width/Thickness	0.124	0.442	0.458	0.468	0.468	0.473	0.009	0.014	0.031
% Fissures	0.099	0.094	0.109	0.006	0.008	0.019	0.739	0.748	0.817
Degree of Polish	----	----	---	0.744	0.747	0.751	0.095	0.101	0.168

1) Linear fitting 2) Second order polynomial 3) Third order polynomial

Conclusions

From the above study, it has been observed that brown rice yield varied from 75.73-79.69%, and milling yield varied from 66.82-73.51% at constant time of polishing. The brokens in milled rice varied from 18.32-23.77% for different varieties of paddy. The fissured kernels varied from 10-35%. Width and thickness of paddy had profound effect on the brown rice yield where as length of paddy grain least influenced the brown rice yield. Width and thickness were linearly related to the brown rice yield. Higher order polynomial regression did not indicate any improvement in relationship between brown rice yield and paddy characteristics. There was no definite relationship between physical dimensions and milling yield of paddy but, degree of polish affected the milling yield. Other than degree of polish, the variety and fissure content of paddy influenced the brokens percentage. The relationship between brokens and fissure content was explained by the linear regression analysis.

Conflict of Interest: None declared

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