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Predict Head Rice Yield with Mechanical Strength of Kernels

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ABSTRACT

This research aims to study the strength of rough rice kernel by measuring breaking forces and to study relation between head rice yield and the average maximum breaking force. The bending test was designed with a distance between two supporting points of 3.5 mm. The loading head had a flat end with thickness of 1.5 mm. and the deformation rate was 1.5 mm/s. In the bending test, the test kernel was placed on the designed instrument in its flat position. The force required to break each kernel was directly read. To study the relation between the head rice yield and average breaking forces, the KDML105, PTT1, SPR3, and RD41 rice variety from Central, Northern, and North-Eastern regions of Thailand were used. The determination coefficient between the head rice yield and average breaking forces were at 0.946, 0.944, 0.749 and 0.928 respectively. The determination coefficient of all rice varieties was 0.776. Form the test, the bending force was closely related to the head rice yield.

Key words: head rice yield, bending test, kernel breaking force

INTRODUCTION

The economic value of rice is determined by the mill rice yield (MRY) and head rice yield (HRY). Rice breakage during milling process causes economic loss. HRY most used for estimating the market value as bidding or offering price. Postharvest are effected to HRY. The grain moisture content is the one of many factors. Li *el al*., [7] reported that the post drying conditions are effected to fissure kernel. Rapid drying cause holes in starch granules. Siebenmorgen *et al*., [12] in studying the effect of drying temperature and average breaking force of kernels shows the most fissures appeared within 24 hrs after drying and breaking force strong related to HRY with determination coefficient (R^2) from 0.804 to 0.915 across the three varieties.

In studies of HRY and bending strength, Lu and Siebenmorgen, [6] applied load up to the rough rices. They reported that the deformation in linearly related to bending force and average bending force of all kernels related to HRY. The correlation coefficients between HRY and average breaking force for rough rice of ‘Lemont’ was 0.979 and ‘Tebonnet’ was 0.932.

According to above reports Siebenmorgen and Qin, [11] found that percentage of strong kernels was closely related to HRY (R^2=0.895). They chose a breaking force of 20 N as the level that separated the two groups of kernels. This force level used to differentiate weak and strong kernels. Qin and Siebenmorgen, [11] showed the complete studies of which they found that harvest moisture content affected breaking force distributions. The strong correlations between HRY and the percentage of strong kernels were found for growing location/ variety lots having HRY of 45% to 65%. Not correlation for HRY greater than 65%.

For current study to research the relation between HRY and average breaking force of rough rices. Thai rice varieties were KHAO DOWK MALI 105 (KDML105), PATHUMTHANI 1 (PTT1), SUPHANBURI 3(SPR3), and PHITSANULOK 5(RD41) of different growing locations and moisture content. Objective was that the average breaking forces were direct information to predict HRY and fissure kernels during milling causing from weak kernels.

Materials and Methods

Sample Preparation:

Four long grain of Thai rice varieties, KDML105, PTT1, SPR3, and RD41 harvested in October to December 2011 with various harvest locations and moisture content. Clean rough rice (1kg) from each cultivar was dried by sunlight (RD41 not include). The rough rice (RD41) were drying by variation of temperature at 40, 50, 60, and 70 ˚c in the oven within 180, 120, 60, and 40 minutes respectively [2,12] which tempering within 12 hrs

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before milling. Rough rice of 125 g per each sample variety were randomly selected for milling. Another four hundred kernels from each sample were randomly selected for bending test individually with reliability level 95% [14].

Table 1: General information of rice samples, determination and correlation coefficients.

Varieties	Location	MC	MRY	HRY	ABF	R^2	r
KDML105	LAMPANG	12.6	64.9	27.6	22.5	0.946	0.973**
	NAKHONSAWAN	11.8	65.1	27.2	22.1		
	PATHUMTANI	12.4	68.0	53.0	28.9		
	SURIN	10.5	67.1	39.7	25.9		
	KHONKAEN	13.3	65.7	39.2	26.9		
PTT1	AYUTTHAYA	10.7	68.8	45.6	27.7	0.944	0.972*
	ANGTHONG	11.1	67.8	43.6	25.0		
	CHAINAT	9.7	63.4	49.3	29.8		
	SAKONNAKHON	12.3	62.9	40.8	20.8		
SPR3	SARABURI	11.3	70.5	63.3	30.5	0.749	0.867
	AYUTTHAYA	11.5	72.4	65.1	30.0		
	LOPBURI	10.7	71.6	66.4	34.8		
	PATHUMTANI	13.4	71.1	42.4	24.1		
	CHIANGMAI	12.4	70.1	42.7	27.3		
RD41	LAMPANG	14.3(Drying at 40˚c.)	64.0	41.9	25.9	0.928	0.946*
		14.2(Drying at 50˚c.)	64.7	43.8	25.2		
		14.3(Drying at 60˚c.)	63.7	33.6	23.3		
		14.3(Drying at 70˚c.)	60.8	28.2	22.0		

MC = Milling moisture content (%, w.b.)
MRY = Mill rice yield (%)
HRY = Head rice yield (%)
ABF = Average breaking force (N)
R^2 = Determination coefficient (HRY vs ABF)
r = Correlation coefficient(HRY vs ABF)
*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
(Adapted from Siebenmorgen and Qin, 2005)

Milling Tests:

Dry rough rice (125g) from each samples were milled. Brown rice were first resulted and milled for 30 second with a 720 g weight and placed 30 cm out on the lever arm from the centerline of the milling chamber. Head rice was separated from mill rice then calculated the HRY.

Bending Tests:

Bending tests (also known as flexural test) were conducted with an INSPEC, Model IPX800 to measured and showed the breaking force. The bending test showed in fig. 1. The distance between two supporting points was set at 3.5 mm. The loading head had a flat end with a thickness of 1.5 mm. and width of 10 mm. The deformation rate was set at 1.5 mm/s [8,6,1615,3,5,13,9]. The experiment design was appropriate for long grain Thai rice cultivars.

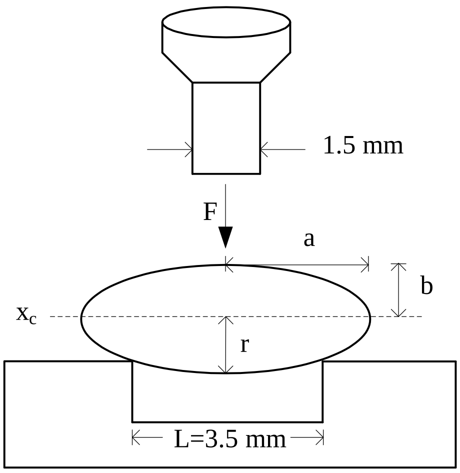

Fig. 1: Bending test dimension.

Fig. 1 showed the schematic of bending test on rough rice which assume that the rice kernel was ellipse and finding by equation. [4]

$\sigma_x = FLr/(4I_c)$

where σ_x is the bending stress (N/m^2), F is the bending force or breaking force (N.), L is the base

width (m.), r is the distance from edge to neutral axis (m.), I_c is the Moment of inertia at the neutral axis x_c, and $I_c = (\pi ab^3)/4(m^4)$.
Random selected rough rice from each samples were breaking test on bending. Average breaking forces were calculated to find relation with the HRY.

Results and Discussion

The results from experiments. HRY was related to average breaking force to rough rice of KDML105, PTT1, SPR3 and RD41. The determination coefficients (R^2) were 0.946, 0.945, 0.749 respectively (Fig. 2). Determination the correlation coefficients (r) in Table1 found that almost were significant at the 0.01 level or 0.05 levels. However, R^2 of SPR3 was lower (R^2=0.749) caused from other postharvest factor including relative humidity, drying condition, moisture content, harvest location, etc. [10,1].

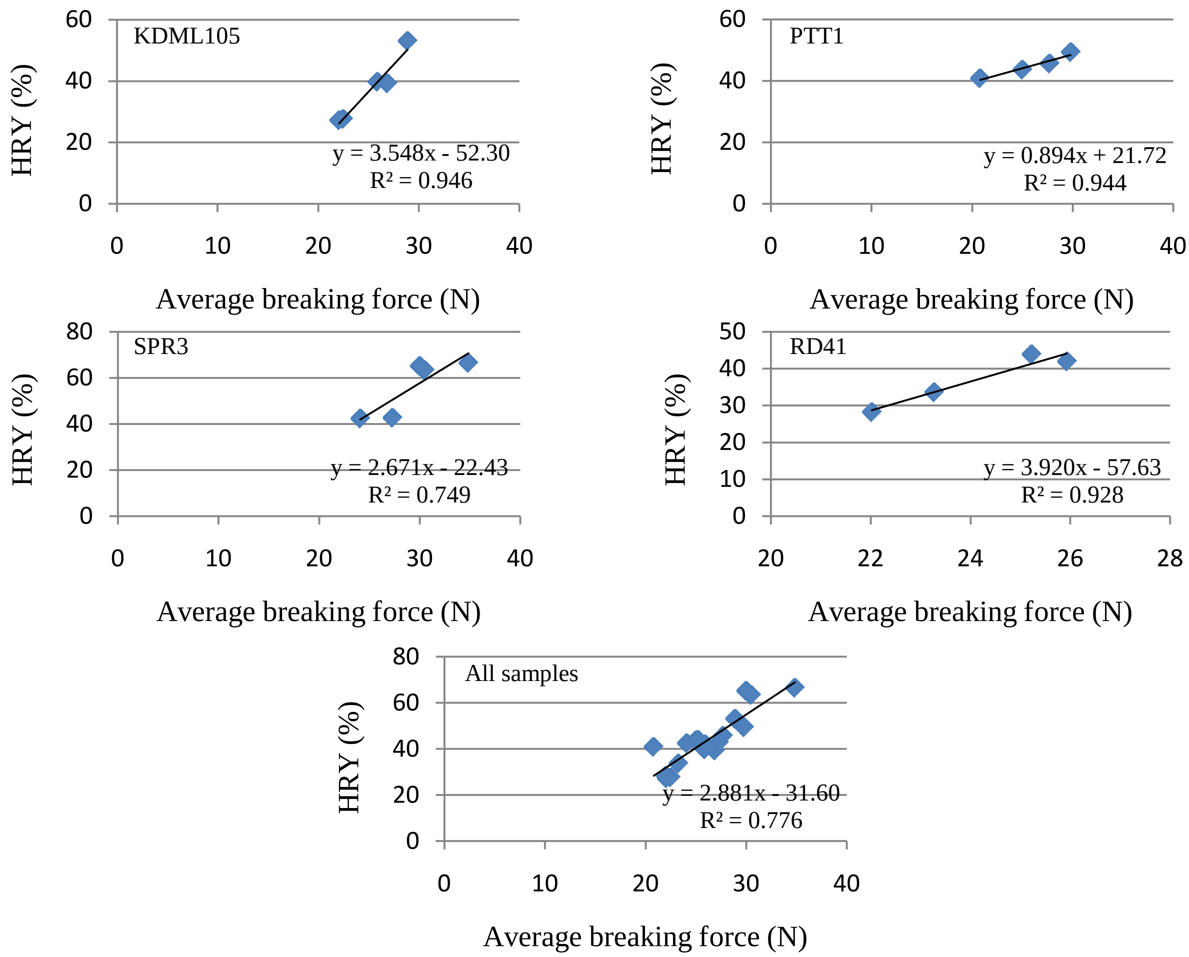

Fig. 2: Relation between HRY and average breaking force.

The relation of all samples were R^2=0.776 and r=0.881** showed the closely related. Therefore the result conducting the average breaking forces were predicted the HRY.

Conclusions:

HRY was closely related to average breaking force. Determination and correlation coefficients were showed significant for KDML105, PTT1 and RD41. Although the correlation coefficient of SPR3 was not significant (r=0.876) but determination coefficient showed much relation (R^2=0.749). The overall average breaking forces were the information to predict HRY. To improve mechanical properties of kernels is to decrease fissure kernels due to milling process. This would cause increasing the economic value of rice.

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