DEVELOPMENT OF A CLEANING AND GRADING MACHINE TO IMPROVE THE QUALITY OF MILLED RICE (*Oryza sativa* L.)

BY

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CERTIFICATION

I certify that this work was carried out by Mr. A. A. OKUNOLA in the Department of Agricultural and Environmental Engineering, University of Ibadan.

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ABSTRACT

Locally processed rice (*Oryza sativa* L.) is characterized with high percentage of broken grains and impurities which impair the quality and reduces the market value. Reducing the proportion of broken rice and impurities after milling remains a challenge. There is therefore a need to develop a machine which cleans and grades the rice kernels based on quality. The objective of this work was to develop a cleaner - grader to improve the quality of milled rice.

The physical and aerodynamic properties of six rice cultivars (ITA 150, FARO 44, FARO 52, NERICA 1, IGBEMO 1 and IGBEMO II) were determined using ASAE Standards. Based on these properties, a three sieve oscillating cleaner - grader machine was developed. Samples from the six rice varieties were milled using No 1 rice huller and milling characteristics were evaluated according to NIS 230 Standards. The machine was tested to determine cleaning performance index and grading efficiency of the rice cultivars. The tilt angle of the top and bottom sieves were fixed at 2 and 15^{o}, the intermediate sieve was set at 2, 4 and 6^{o} and the blower was inclined at 0 and 5^{o}. Data were analysed using ANOVA and descriptive statistics.

The moisture content of the rice cultivars during milling varied from 10.7 to 12.5% and 11.0 to 13.6% in the raw and parboiled paddy respectively. The mean angle of repose was $29.3^{o} \pm 0.4$ and the mean co efficient of friction was 0.3 ± 0.01. The spherical mean ranged from 2.9 to 3.5 mm and was significantly different ($p<0.05$) in Igbemo II cultivar when compared with other cultivars. The sphericity was within 0.41 to 0.5; the bulk density ranged from 1.34 to 1.38 gcm^{-3}, while the terminal velocity varied from 4.8 to 6.4

ms^{-1}.The machine was developed to operate at a fan speed of 240 rpm, air velocity of 4.8 ms^{-1} with aperture diameter of 3, 5.5 and 7 mm for bottom, intermediate and top sieves respectively. The head rice yield ranged from 22.3 to 34.1% and 44.8 to 55% for the raw and parboiled milled respectively. The percentages of broken grains obtained during milling of raw and parboiled rice were further reduced by 41.5 and 64.8% respectively with the use of the machine. The cleaning performance index of the machine ranged from 0.6 to 0.9; the highest occurred at a tilt angle of 4^o and blower inclination of 5^o for raw ITA 150. The grading efficiency ranged from 61.4 - 84.8% and 69.0 to 94.5% for raw and parboiled milled rice respectively. The highest values of 84.8% and 94.5% were obtained in raw FARO 44 at a tilt angle of 2^o and in parboiled ITA 150 at a tilt angle of 6^o respectively with blower inclination of 5^o.

The use of the cleaning and grading machine after milling has substantially reduced broken kernels of locally processed rice in the raw and parboiled milled rice thereby enhancing the quality.

Key words: Rice, Terminal velocity, Cleaning and grading machine, Cleaning performance, Grading efficiency.

487 words

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DEDICATION

This work is dedicated to Jesus Christ, my lord who is the brightness of God's glory and the express image of his person.

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LIST OF ABBREVIATIONS

Symbol/ Abbreviation	Meaning	Unit
a	acceleration	ms^{-2}
Ap	projected area	m^2
A	Cross sectional area	m^2
Bp	Bad Product	g
Br	Bad reject	g
CPI	Cleaning performance index	
C_{dmax}	Belt maximum centre distance	m
C_{dmin}	Belt minimum centre distance	m
C	drag co-efficient	unit less
Co	Co-efficient of opening	unit less
dd/dt	velocity	ms^{-1}
d^2d/dt	acceleration	ms^{-2}
ρ_f	density of fluid	kg/m^3
ρ_a	density of air	kg/m^3
ρ_p	mass density of particle	$1g/m^3$
Ø	diameter	mm
D	diameter of hole	mm
d	thickness of wire	mm
Egr	efficiency of separating whole grain	%
E	modulations of elasticity	N/M^2
Ebc	Efficiency of separating broken/chaff	%
Eg	efficiency of grading whole grain	%
FAO	Food and Agriculture Organization	
Fr	Drag force	N
FGIS	Federal Grain Inspection service	
Fg	Gravitational force	N
F_A, F_B, F_C, F_D, F_E	Resultant forces on shaft	N

F	Feed	g
G	Torsional modulus of rigidity	N/m^2
GT	Gelatinization temperature	
g	acceleration due to gravity	m/S^2
GP	good product	g
GR	Good reject	g
HYV	High yield variety	%
HRY	Head rice yield	%
HP	Horse power	kw
I	least second d moment area	m^3
IRRI	International Rice Research Institute	
$(LWT)^{1/3}/L$	Sphericity	
$(LWT)^{1/3}$	Spherical mean	
LV	local variety	
L	Length or major diameter	mm
L/W	Length/width	unit less
L/T	Length/Thickness	unit less
MC	Moisture content	% wet basis
MOG	Material other than grain	
m	mass of particle	g or kg
Mt	Torsional moment	Nm
Mb	Maximum bending moment	Nm
NCRI	National Cereals Research Institute	
Np	Permissible speed	rpm
Nc	critical speed	rpm
N	Brower speed	rpm
NIS	Nigeria industrial standard	
R	Radius of eccentricity	m
r.p.m	revolution per minute	
Q_A	Actual air discharge	
Q_T	Theoretical air discharge	m^3/s

Θ	angle of wrap	
Pe	Critical load	kg
S	Distance	m
Φ	Sphericity	unit less
S.D.	Standard deviation	
T	Thickness/Minor diameter	mm
T	time	s
USDA	United States Department of Agriculture	
μ	Co-efficient of friction unit less	
UG	Undersized grain	g
UM	Unmilled grain	g
Vt	Terminal velocity	m/S^2
WG	Whole grain	g
W	width/intermediate diameter	mm
W/T	width/thickness	unit less
ω	angular velocity	rad/s
WARDA	West African Rice development agency	
y	deflection	m