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SOME PHYSICAL PROPERTIES AND YIELD OF OFADA RICE

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ABSTRACT

Effect of processing parameters on physical properties of Nigeria local rice (Ofada) was evaluated and optimised using D- optimal of response surface methodology. The independent variables were soaking duration (1,2,3,4 and 5 days) and parboiling temperatures (100,110 and 120ºC), while responses include Head Rice Yield(HRY), brokenness, chalkiness, Thousand Grain Weight (TGW), sphericity, length, breadth and width. The results generated were analysed by ANOVA and regression analysis. Data obtained ranged between 50.28-74.67%, 2.03-21.27%, 0-19.20%, 254.02-276.35%, 52.47-60.54%, 5.48-6.31mm, 2.02-2.37 mm, and 2.82-3.05mm respectively. Soaking duration and parboiling temperatures significantly influenced the dependent variables at $p<0.05$. All the model equations were quadratic except Thousand Grain Weight (TGW) and sphericity. Coefficient determination (R^2) of generated models ranged between 0.8935-0.9893 and revealed that the models developed were adequate. Optimum soaking and parboiling were put at 2 days: 6hrs and 119ºC.
KEYWORDS: Ofada rice, soaking, parboiling, size, yield, models.

INTRODUCTION

Rice (*Oryza sativa*) is grown in all the ecological and dietary zones of Nigeria with different varieties possessing adaptation traits for each ecology ([13]). The growing importance of rice in the diet of Nigerians is evidenced by the importation of processed rice ([17]). Nigeria is the highest importer of rice in Africa, and the second highest in the World. Its annual rice demand is estimated at five million tonnes, out of which 2.2 million tonnes is produced locally. This was attributed partly as a result of population growth and consumer preference associated with opportunity cost of their time and cooking convenience ([9]). Observations have shown that there is preference for imported rather than for locally processed rice with the former possessing better processing and cooking qualities ([1]).

Ofada rice is one of the indigenous rice varieties emanated from South-West Nigeria. It is an unpolished short grain with red kernels which is not related to any other rice. A lot of potentials exist in its cultivation, processing and export. Consumers gave it preference for its unique taste and aroma. However, obsolete and inefficient processing technology leads to smelling and unappealing products. Offensive aromatic nature and poor physical characteristics of Ofada rice may be as a result of processing conditions: fermentation due to several days of soaking and the degradation of fatty acid content of the rice as a result of rancidity during the parboiling process and presence of inherent enzyme that produces objectionable odour.

The need to increase production and improve quality of locally produced rice to make it more competitive with imported rice cannot be over emphasized. Several factors have been found to account for this variable quality; the obvious one is the poor physical properties. It is common to find locally processed rice containing a lot of foreign matter, high level of chalky grains, broken and damage grains. These physical properties dictate often the price of rice at the market level ([6]). It is therefore possible through the use of appropriate processing condition to improve the quality of locally produced rice. Response surface methodology (RSM) is a collection of mathematical and statistical techniques that are useful for modelling and analysis of problems in which a response of interest is influenced by several variables with the objective of optimising and or predicting the response ([15]). The RSM is important in designing, formulating, developing, and analysing new scientific studying and products. It is also efficient in the improvement of existing studies and products ([3]). As soaking and parboiling influences these quality attributes, the major insight of this research work was aimed at employing the technique of response surface methodology to provide a guide to positioning optimum processing conditions in term of factors varied and its effect on physical characteristics of Ofada rice for other end uses of local rice.

MATERIALS AND METHODS

Short grain rice (Ofada) was used for the experiments. Paddy was purchased from Ofada town, Ogun State Nigeria, an area known for the largest production. 30 kilograms were used as samples. Each sample was subjected to treatment combination as shown in Table 1. The levels of variables were decided mainly from

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preliminary investigation on the processing methods of Ofada in the region. Soaking was done at ambient temperature of 29°C± 2°C for 1, 2, 3, 4 and 5 days. The soaked sample was steamed in an autoclave using the following conditions: 100°C, 110°C and 120°C. Parboiling duration and pressure was fixed at 15 minutes and 15 psi respectively. The parboiled paddy rice was tempered for 30 min to cool and air dried in an oven at 35°C and equilibrated to 12% moisture content.

PHYSICAL PROPERTIES

Size Characteristics: Linear dimensions of grains were measured with digital vernier callipers having 0.01 mm accuracy. Grain length, breadth and width were measured in five replicates of fifty kernels per sample.
Thousand Grain Weight: This was carried out by counting 100 kernels and weighing them in an electronic balance and then multiplied by 10 to give the mass of 1000 grains ([6]).
Sphericity (φ): ([8]) mathematical expression was used for sphericity determination

$$Ø = \frac{\sqrt[3]{LWT}}{L} \qquad \ldots\ldots\ldots\ldots \qquad 1$$

Where; Ø = shericity

L= Length of grain; W= Width of grain; T= Thickness of grain (breadth)

Head Rice Yield:. The parboiled rice was shelled and milled using laboratory miller, which separates whole and broken grains. The head rice yield (HRY %) was calculated as percentage of whole milled grains respect to the parboiled rough rice, the average value of the duplicates was calculated.

Percentage Chalky and broken Rice: The percentage rice chalkiness and brokenness were calculated from five replicates of 100g samples, according to the method outlined by ([17]).

Statistical Analysis

All the experimental procedures were repeated in triplicate unless otherwise stated. The data collected were processed using a statistical package, Design Expert 6 (Stat ease Inc; Mineapolis USA, version). The software was used for the analysis of variance (ANOVA), mathematical modelling, regression analysis, predicted output and optimisation. The optimisation of the processing conditions was tailored toward assessing levels of soaking period and parboiling temperature which will minimise chalkiness and brokenness, increase head rice yield, increase in size characteristics of Ofada rice especially the sphericity.

Table 1: Effect of Soaking and Parboiling on Physical Properties of Ofada Rice

Run	A:Soaking	B:Parboiling	Length	Breadth	Width	TGW	HRY	Brokenness	Chalkiness	Sphericity
	Days	0C	mm	mm	mm	%	%	%	%	%
1	3	100	5.91	2.12	2.96	26.61	63.96	16.32	1.02	56.42
2	3	120	6.01	2.11	2.97	26.44	71.05	2.99	0	55.77
3	5	110	6.2	2.09	2.85	26.01	69.21	2.87	1.63	53.71
4	1	100	5.48	2.19	2.9	26.92	50.28	21.27	19.2	59.58
5	5	120	6.31	2.06	2.89	26.4	70.03	2.03	0.81	53.08
6	5	100	5.99	2.08	2.87	25.85	58.97	15.58	8.21	55.00
7	1	100	5.53	2.28	2.96	27.64	54.35	19.61	14.36	60.43
8	1	120	6.01	2.37	3.05	25.4	73.91	3.03	2.54	58.49
9	1	120	5.92	2.28	3.01	25.63	74.67	2.92	3.99	58.07
10	3	110	5.94	2.15	2.97	26.6	70.44	4.32	0.59	56.56
11	5	120	6.28	2.02	2.82	26.42	72.38	2.90	0	52.47
12	1	110	5.64	2.36	2.99	25.8	62.1	3.41	2.37	60.54

RESULTS AND DISCUSSION

Effect of soaking and parboiling on size characteristics

The range of length, breadth and width recorded were 6.31.- 5.48mm, 2.37-2.02mm, and 3.05-2.85mm respectively. The longest length was made at 120°C parboiling temperature and 5 days of soaking period while the shortest was at 100°C parboiling and 1 day of soaking.([11]) recorded parboiled rice length ranged from 7.0 -9.0mm and width 2.02-2.06 mm while (10) recorded 7.04mm for length. The variation observed may be in agreement with the result of ([12]) that parboiled rice expanded less in length but more in breadth.

However, the result obtained was in agreement with the findings of ([5]) that recorded the mean length 6.95 for Ofada rice. Hence, Ofada rice is classified as short grain base on its size characteristics.

Figure 1 showed respond surface plot of length as affected by soaking period and parboiling temperature. Linear response surface model satisfactorily explained the mathematical expression between the length and the treatments. Lack of fit test at 95% confidence level for the predictive model was non- significant. The model satisfy lack of fit test and significant at $p<0.05$. The estimated R- squared value was 0.9246.. This means that the model is appropriate for predicting the length of Ofada rice as influenced by soaking periods and parboiling temperatures. The model equation is shown in equation 2.

$$Length= +6.21+0.40*S-0.034*P-3.50E-003*S^2 \quad \text{..} \quad 2$$

P- Parboiling temperature (°C)

S- Soakind duration (days)

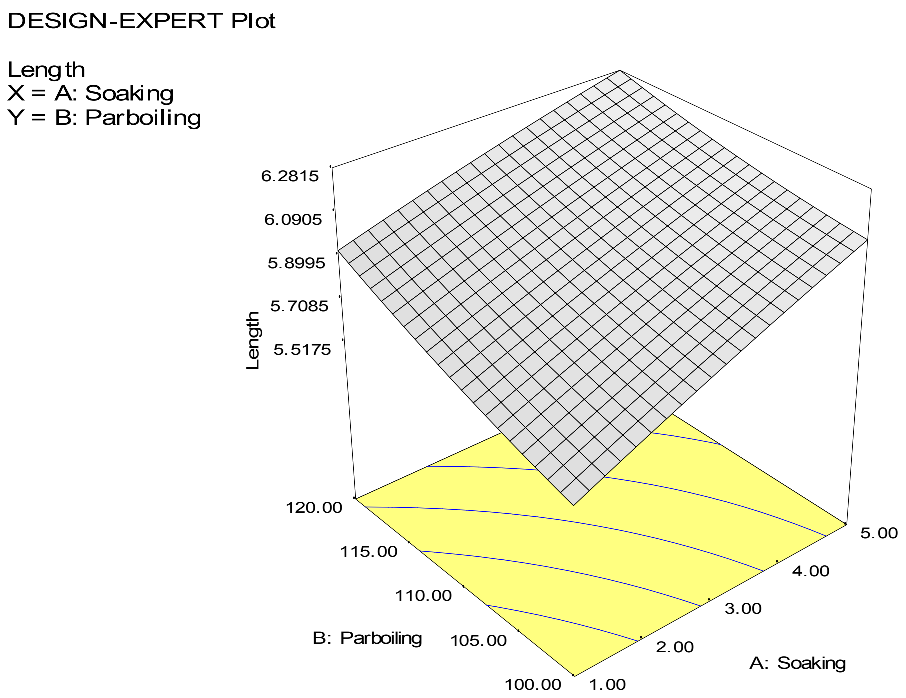

Figure 1: Effect of soaking and parboiling on length

Figure 2 revealed the response surface plot of breadth against the soaking duration and parboiling temperatures. Quadratic model best describe the mathematical expression. Prob>F less than 0.05 indicate that the model terms are significant with the model equation expressed in equation 3 below

$$Breadth=-4.12+0.03*S+0.12*P+0.02*S^2-4.92E-004*P^2-1.62E-003*S*P \quad \text{--------------} \quad 3$$

P- Parboiling temperature (°C)

S- Soakind duration (days)

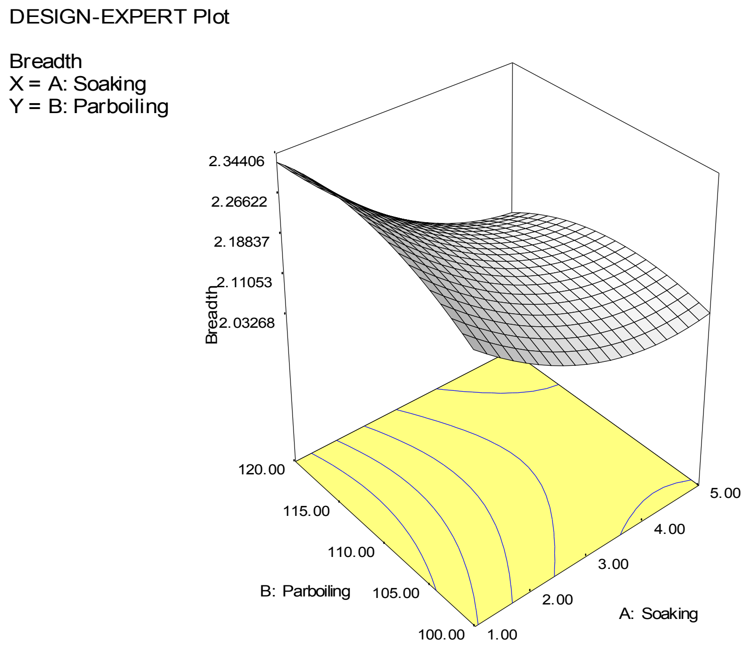

Figure 2: Effect of Soaking and Parboiling on the breadth of Ofada rice

The predictive model equation for width is given in equation 4 below. The result of the width of rice obtained ranged from 2.85-3.05. The lowest width was obtained at 5 days of soaking and 110°C of parboiling temperature which is preferable since consumers demand more for long rice ([17]). [16] recorded 1.83mm for Sazandegi variety while the result of Patindol ranged 2.02-2.06 mm for KDML105, although the result obtained were influenced by processing/treatment adopted. The response surface plot is given in fig. 3.

$$Width= +2.22+0.20*S+7.20E\text{-}003*P-0.012*S^2-4.88E\text{-}006*P^2-1.45E\text{-}003*S*P \quad .... \quad 4$$

P- Parboiling temperature (°C)

S- Soakind duration (days)

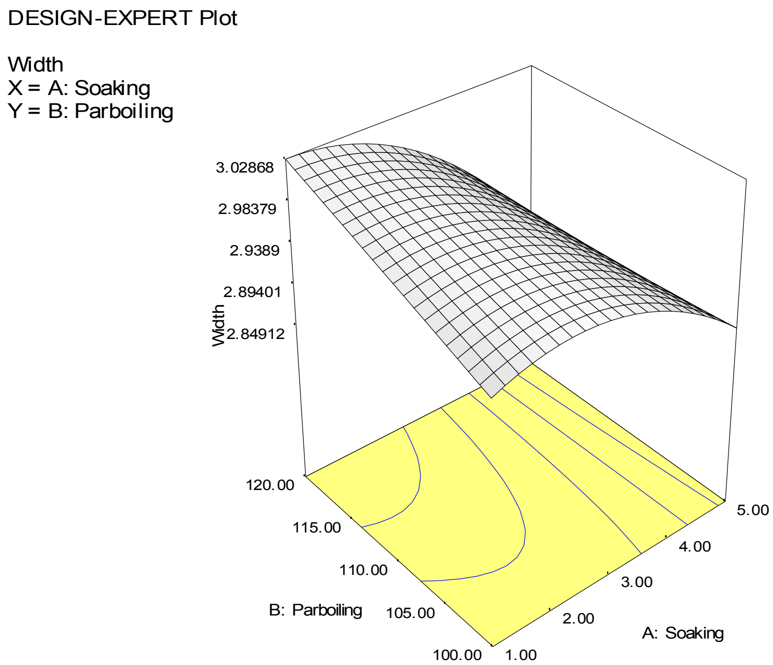

Figure 3: Effect of Soaking and Parboiling on the width of Ofada rice

2F1 best fit the model. The R-squared (0.8935) gave the indication that the model is significant at p>0.05.

Effect of Parboiling and Soaking on Thousand Grain Weight

2Fi was only significant (P<0.05) and best defined the model. PRESS value(1.60), and R- squared value of 0.7996. F- Value of 10.64 implies that the model is significant. The acceptable range for Thousand grain weight (TGW) rice paddy is between (20-30)g ([6]). Values below 20g is an indication for the presence of immature, damaged or unfilled grains ([2]). The model equation is shown in equation 5.

$$TGW = +38.70 - 3.15*S - 0.11*P + 0.02814*S*P \qquad 5$$

P- Parboiling temperature (°C)

S- Soakind duration (days)

The response surface describes the effect of soaking and parboiling on TGW in figure 4.

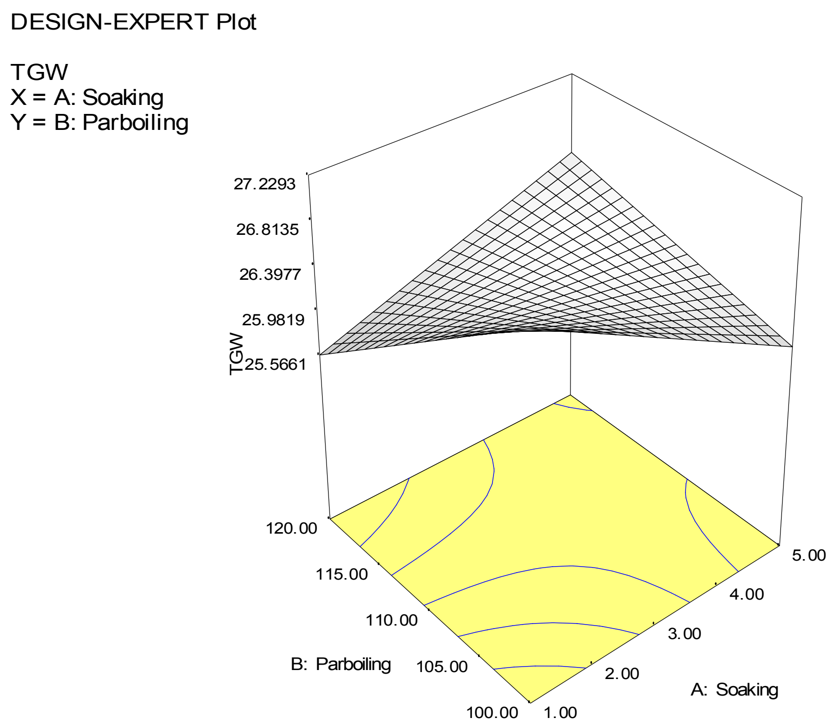

Figure 1: Effect of soaking and parboiling on TGW of Ofada rice

The TGW values were on high side above the minimum level. The TGW is a useful index to "milling outturn" in measuring the relative amount of dockage or foreign material in a given lot of rice ([16]).

Percentage Sphericity

This described the shape of the Ofada rice. High percentage of sphericity indicated that the shape of the rice will make it easier for the rice to role on surface and the is a useful property in engineering design of rice processing equipment ([16]). The linear model was best fit for the prediction. The R- squared is 0.961. The response surface plot is given in figure 5.

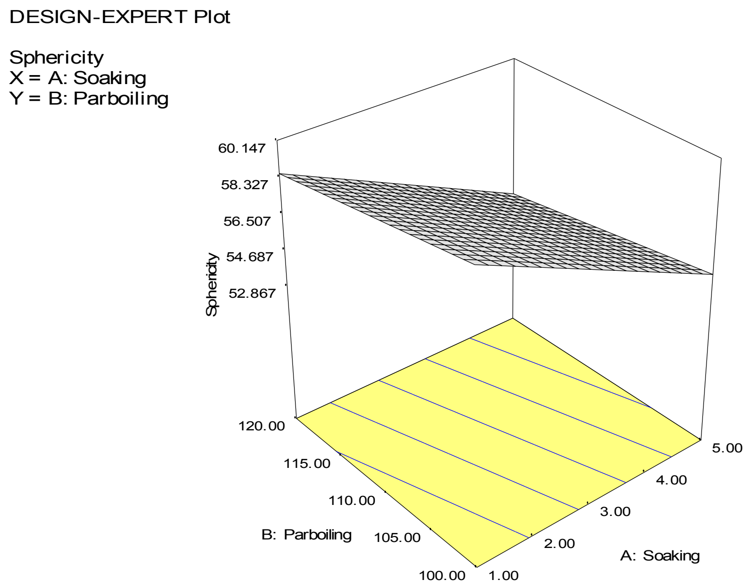

Figure 5: Effect of Soaking and Parboiling on Sphericity of ofada rice

% Sphericity =+69.5872-1.41894*S-0.080213*P....................................... 6

P- Parboiling temperature (°C)

S- Soakind duration (days)

Effect of soaking and parboiling on Head Rice Yield

Table 1 showed the percentage of head rice yield varied with treatment. The maximum HRY was 74.67%, this was achieved at 120°C parboiling temperature and 5 days of soaking and the minimum HRY was 50.27% at 100°C and 1 day of soaking. According to [10] and [11] head rice yield relatively increases with the degree of parboiling. Improvement in parboiling temperature increased gelatinization process thereby hardened the kernel and also simplified the hulling process. Linear effect of period of soaking and parboiling temperatures was significant at $p<0.05$. The quadratic model maximizing coefficient of determination of R-Squared 0.8630 was the best fit. The model has Non significant lack of fit which is satisfactory for the model to fit. This revealed that the model can be used to determine the functional relationship among soaking periods (days), parboiling temperature, and hear rice yield of Ofada rice. Figure 6 and equation 7 revealed the response surface plot and model equation of HRY with soaking period and parboiling temperature respectively.

HRY (%)= $-268.01+21.29*S+4.81*P-0.88*S^2-0.02*P^2 - 0.14*SP$ -------------- 7

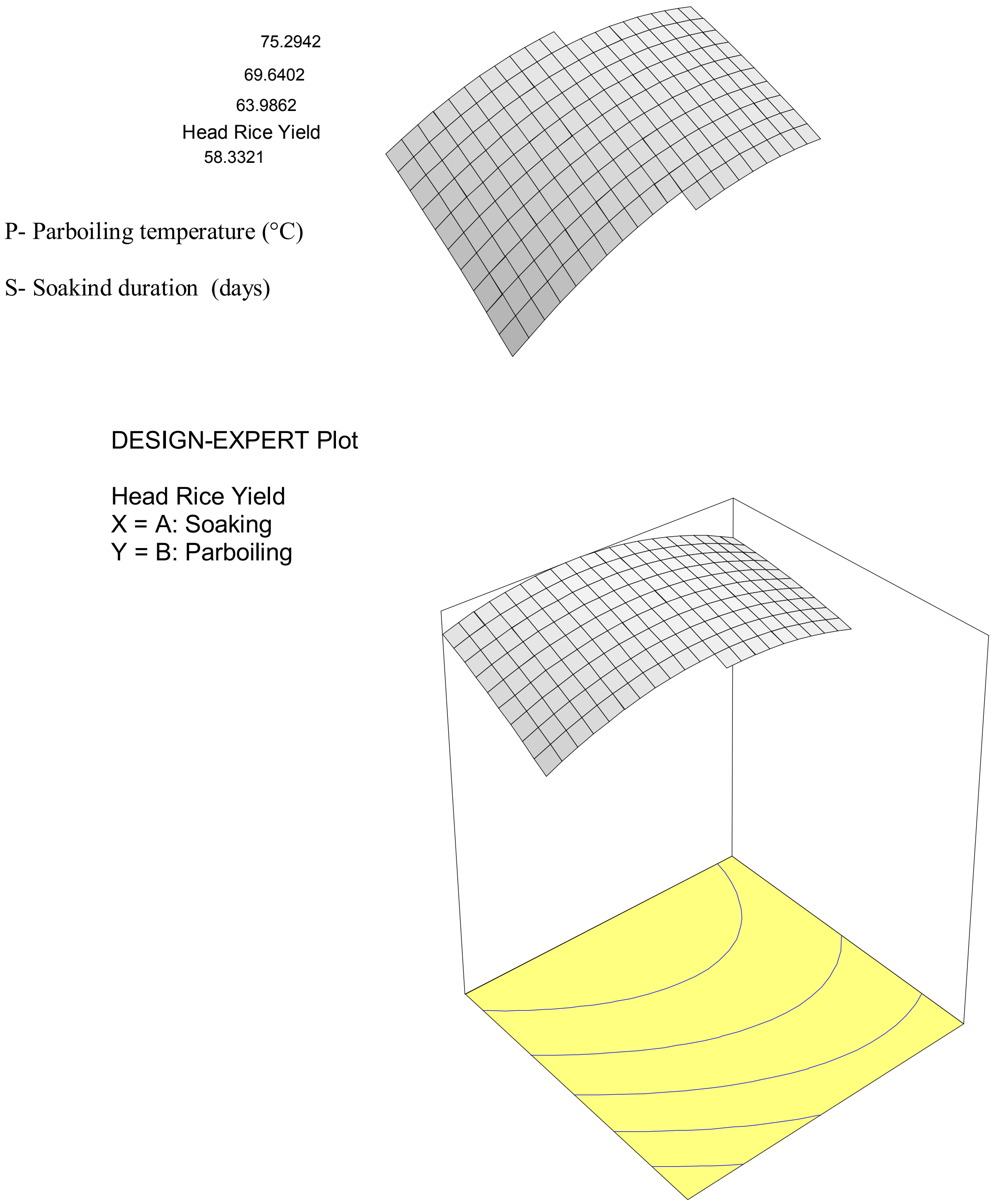

Figure 6: Effect of Soaking period and Parboiling temperature on HRY of Ofada rice

Effect of Soaking and Parboiling on the Brokenness of Ofada rice

The percentage of brokenness ranged from 2.03 to 21.27% (Table 1). The response surface plot was shown in figure 7. The observed effect of soaking on rice is similar to the findings of [5] and the effect of parboiling is also related to the findings of [11]. The relatively high percentage of broken fractions could be attributable to low moisture content which usually occur during milling operation.According to ([10]), it may also be due to incomplete parboiling which result into white belly kernel, which causes increase in breakage during the milling.The minimum value of brokenness was obtained at highest parboiling temperature and period of soaking (120°C) and 5 day respectively but the effect of parboiling was more significant in compares with soaking. The quadratic effects of the variables, soaking period and parboiling temperatures best describe the relationship (Eq. 3). All the model terms were significant, and the model satisfied lack of fit test at $p<0.05$. The coefficient of determination R- Squared for the fit was 0.9893, R- square values more than 0.75 are relatively adequate for prediction purpose[7].

% Brokenness= +910.70-6.88*S-15.55*P+0.04*S^2+0.07*P^2+0.06*S*P -----------8

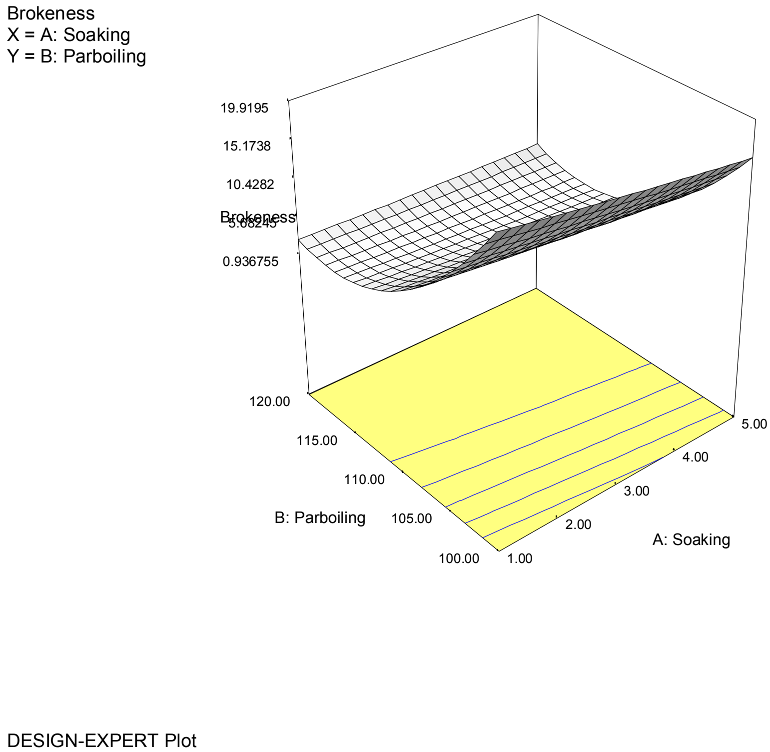

Figure 2: Effect of soaking and parboiling on broken rice grains

Effect of soaking and parboiling on chalkiness of Ofada rice

The effect of treatments on the chalkiness of Ofada rice ranged from 0 to 19.20 percent. The zero level of chalkiness was established at 120°C of parboiling temperature and 5 day period of soaking (Table 1). The response surface plot was shown in Figure 8. High period of soaking and parboiling temperatures prevent chalkiness. Chalkiness indirectly contributes to rice breakage through easier cracking [(6).] Generally, percentage chalkiness higher than 1 % is considered not acceptable ([4]). Although, chalkiness cannot be seen after cooking, it is an important physical property that determines price competitiveness of rice sample at the market. Properly parboiled rice at high temperature can totally remove chalkiness. Quadratic model was significant at ($P< 0.05$). The second order model of multiple regressions satisfactorily explained the relationship (Eq.3). The model satisfies lack of fit test which was insignificant. Coefficient of determination of R-Squared was high (0.8307) and with the lowest standard deviation (3.46). The predicted model equation is given below (eqn 9);

Chalkiness(%)= +509.56-17.54*S-8.36*P+1.25*S^2+0.04*P^2+0.08*S*P --------- 9

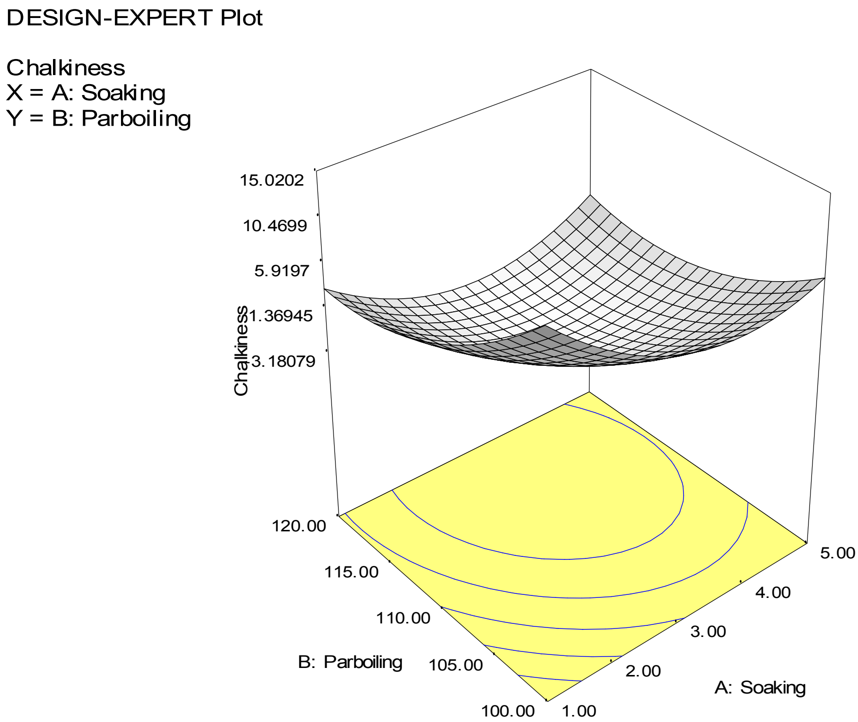

Figure 3: Effect of soaking and parboiling on chalkiness of Ofada rice

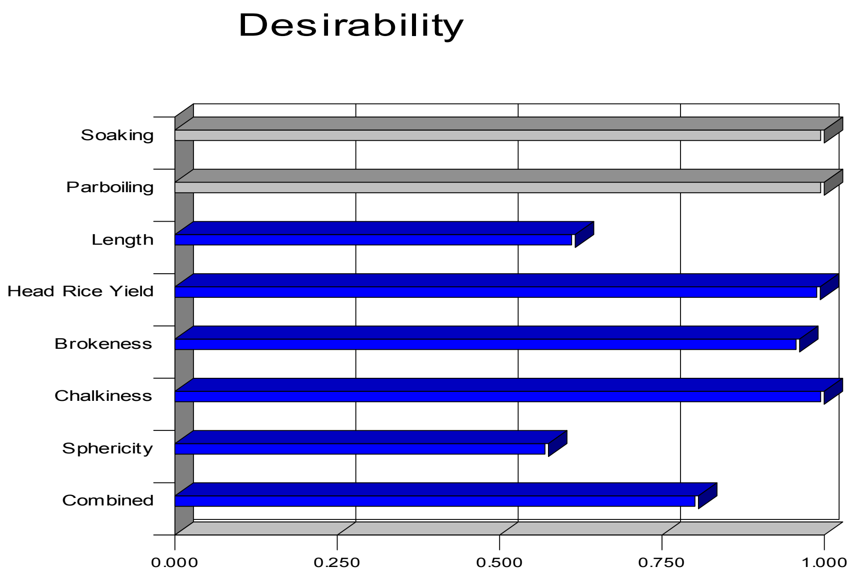

Figure 4: Desirability of the effects

Conclusions

Soaking period and parboiling temperatures influenced the size characteristics, sphericity, TGW, Head rice yield, chalkiness, and brokenness at 95% confidence. The quadratic model best described thesize characteristics (length, breadth,width), chalkiness, brokenness, and Head Rice Yield while sphericity and thousang grain weight were best described by linear models. The best solution predicted was combination of soaking for 2 days: 6hours and parboiling temperature 119ºC to obtained 6.13mm (length),2.20mm (breadth), 3.02mm (width), 56.58%(sphericity), 2.70%(brokenness),75.02% (HRY), 258.16%(TGW) at desirability 0.833. The prediction will be useful at upgrading the present quality of local rice and sustainable physical quality. Hence, allows healthy competition of indigenous rice with imported rice.

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