DEVELOPMENT AND PERFORMANCE EVALUATION OF A SUGARCANE JUICE EXTRACTOR

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ABSTRACT

Sugarcane juice is rich in vitamins and minerals and its bagasse is a very good source of energy. Currently, the consumption of sugarcane by chewing leads to wastage since the juice may not be completely extracted before the bagasse discarded. Post-harvest losses in sugarcane production are very high due to little or no technology to immediately process sugarcane after harvest. This study has developed a motorized sugarcane juice extractor for medium and small-scale processing to reduce or minimize the post-harvest losses in sugarcane production. Materials used for construction were carefully chosen for material availability, rigidity and its corrosion resistance. The machine is made up of crushing rollers, hopper, screen, juice collecting tray, reduction gear motor and power transmission system. The machine was powered by a 5 hp electric motor. A three-level-three factor experimental design requiring 27 experimental runs using Minitab 16.2.1 software (2010 Minitab Inc.) was employed for this study. Performance tests were carried out at the machine speeds of 145, 200 and 250 rpm, feed rates of 0.5, 0.8 and 1.0 kg/min and three passes of sugarcane and the performance parameters of juice yield and extraction efficiency were determined. Result obtained shows that the optimum juice yield was 76.70 % and extraction efficiency was 77.6 %. The throughput capacity of the machine was determined to be 16.96 kg/h, optimum juice yield and extraction efficiency were obtained at 145 rpm machine operating speed, feed rate of 1.0 kg/min and 3 passes.

Keywords: Extractor, Juice, Mechanical properties, Physical properties, Sugarcane
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INTRODUCTION

Sugarcane (*Saccharium spp*) has a resemblance to the bamboo [1]. It is of the grass family *Saccharium* and tribe *Andropogoneae* [2]. Sugarcane juice has about 15 % of sugar which is in raw unrefined form and other part is made up of water which in turn contains vitamins and minerals. Sugarcane is rich in macro-elements such as calcium, cobalt, copper and other elements [2]. It also contains some health supporting compounds such as iron, vitamins A, B, B1, B2, B3, B5 and B6, high percentage of phytonutrients, protein and soluble fiber [2]. Other studies have shown that sugarcane is rich in polyphenols and the juice helps to fight against viral and bacterial infections, boost immune system and protect against diseases of the liver [3]. There are two known types of sugarcane in Nigeria; industrial or soft sugarcane (*Saccharum officinarum*) and local chewing or hard type (S*accharium barberi*) sugarcane [4]. It is estimated that the production level of sugarcane is about 26.5 million hectares in over 90 countries of the world, with Brazil as the largest producer of sugarcane accounting for 37.83 % of the world sugarcane production area [4].

With the vast fertile land for agricultural purposes in Nigeria, it would be expected that the production of sugarcane to be higher than the estimated 83,000 ha from the approximate yield of 1.4 m tons [4]. This could be as a result of low sugarcane production and processing technologies resulting in high post-harvest losses in sugarcane. The major way of sugarcane consumption in most of Africa countries, including Nigeria, is by chewing to obtain the juice. Though by medical perspective, it helps to exercise the jaw and strengthen the teeth, it leads to wastage since the juice may not be completely extracted and the bagasse discarded indiscriminately. Hence, the need to develop a motorized sugarcane juice extractor that will deliver efficient juice extraction and be available for small and medium scale sugarcane processing. This is with a view to making sugarcane juice extractor available in order to reduce importation of sugar, thereby increasing the country's gross domestic product. Therefore, the objective of this study is to design, fabricate and evaluate the performance of a motorized sugarcane juice extractor for medium and small-scale processing. Hence, creating job opportunities for small-scale entrepreneur in producing readily available and refreshing fresh sugarcane juice.

MATERIALS AND METHODS

Materials

The component parts of the sugarcane juice extractor and the materials used in their fabrication were:

i. Crushing rollers and agitating shafts: produced from 12 mm stainless steel rod
ii. Juice collector and hopper: produced from 2 mm stainless steel sheet.
iii. Frame and engine seat produced from 5 mm angle iron.
iv. Gear mechanism, power transmission unit
v. Machine cover produce from 2 mm galvanized metal sheet.
vi. Fine (0.075 mm) and Coarse (0.55 mm) separating screens made from stainless steel sheet
vii. Bearings (25 mm) were used for holding the shaft at both ends.
viii. A driving sprocket (19 teeth) and driven sprocket (57 teeth).

Design consideration and specification

The following considerations and assumptions were made for the design of the sugarcane juice extractor components:

i. Expected capacity of the sugarcane juice extractor is 20 liters of juice per hour.
ii. Selected speed of the roller is 250 rpm
iii. Factor of safety (S) is 0.9
iv. Density of sugarcane is 1041 kg/m^3 [5].
v. Rupture force, F needed to crush sugarcane at horizontal direction is 1478 N, determined from compressive strength test.

Design analysis of the components

Design of crushing rollers: The rupture force and angular velocity of the roller were obtained from Equations 1 and 2 as given by Kehinde *et al*. [6].

$$F = MSwr^2 \quad (1)$$

$$w = \frac{2\pi n}{60} \quad (2)$$

Where:

F = rupture force for crushing sugarcane at horizontal direction = 1478 N
M = maximum force of failure of the machine (N)
S = factor of safety = 0.9
w = angular velocity of the crushing rollers (rad/sec)
r = radius of the crushing rollers (m)
n = speed of the roller = 250 rpm

From Equation 2, $\mathrm{w} = \frac{2 \times 3.142 \times 250 \times 0.9}{60}$ = 23.57 rad/sec

Maximum force of failure of the machine, M is given by $\mathrm{M} = \frac{1}{2}(\mathrm{F} \times \mathrm{S})$ (3)

Therefore, $\mathrm{M} = \frac{1}{2}(1478 \times 0.9)$ = 665.1 N

Rearranging and substituting *M* in Equation 1:

Radius of crushing roller, $r^2 = \frac{\mathrm{F}}{\mathrm{MwS}} = \frac{1478}{665.1 \times 0.9 \times 23.57}$ and $\mathrm{r} = 0.105$ m

Diameter of the crushing roller, D = 2 x r = 0.21 m

Peripheral velocity of the rollers: The velocity of the rollers is obtained from Equation 4 [7].

$$V = \frac{\pi D n}{60} \quad (4)$$

Where:

V = velocity of the crushing roller (m/s)
D = diameter of the crushing roller (m)
n = selected speed of the roller (rpm)

$V = \frac{3.142 \times 0.21 \times 250}{60}$ = 2.7 m/s

Determination of the power required for crushing

The power required by the extractor crushing is determined from in Equation 5 [8].

$$P = F \times V \quad (5)$$

Where:

P = power (watts)
F = rupture force required to crush sugarcane (N), determined = 1478 N
V = velocity of the crushing rollers (m/s), from Equation 4 = 2.7 m/s
P = 1478 × 2.7 = 3990.6 W
Recall that 1 hp is 746 W, therefore, 3990.6 W is equivalent to 5 hp.

Design of crushing shaft: The shaft is an important component in the sugarcane juice extractor and it is acted upon by the weight of the materials being processed and weight of other components part and at the same time transfer torque from one component to the other. The diameter of the shaft was determined from Equation 6 [7].

$$D = \{ \frac{32n}{\pi} ((K_m \times M_{max})^2 + (K_t \times T)^2)^{1/2}\}^{1/3} \quad (6)$$

Where:

D = diameter of the shaft (mm)
K_m = combined shock and fatigue for bending, taken as 1.2
K_t = combined shock and torque for tension, taken as 1.0
M_{max} = maximum bending moment, which is 33.08 Nm
T = torque transmitted by the shaft (Nm)

The torque, $T = F_c \times R$, and n = the factor of safety = 0.9

$$T = F_c \times R = \frac{348 \times 105}{1000} = 36.54 \text{ Nm}$$

$$D = \left[\frac{32\times0.9}{3.142}((1.2 \times 33.08 \times 1000)^2 + (1 \times 36.54 \times 1000)^2)^{\frac{1}{2}}\right]^{\frac{1}{3}}$$

$$D = \left[9.166136((1575772416)^2 + (1353171600)^2)^{\frac{1}{2}}\right]^{\frac{1}{3}}$$

D = 79.080196mm = 80 mmm

Volumetric capacity of the machine: The volumetric capacity of the machine is given in Equation 7 [9]

$$Q_w = \frac{C_J}{\rho} \quad (7)$$

Where:

Q_w = volumetric capacity of the machine (litre/h)
C_J = throughput capacity of the machine (kg/h)
ρ = density of sugarcane (kg/m^3) = 1041 kg/m^3

$$Q_w = \frac{16.96}{1041} = 0.01629 m^3/h$$

Description of the sugarcane juice extractor

The sugarcane juice extractor has three crushing rollers, two screens (fine, 0.075 mm and course, 0.55 mm) to sieve the juice from the bagasse and a collecting tray to collect the screened juice. The first roller is driven by a reduction gear motor which in turn drives the second roller with the help of gears in mesh. The third adjustable roller at the upper part is meant to press down the sugarcane while being crushed by the other two rollers. The components of the sugarcane extractor are; crushing rollers, hopper, screens, juice collecting tray, reduction gear motor and the power transmission system. The exploded, orthographic and sectional views of the sugarcane juice extractor are as presented in Figures 1, 2 and 3, respectively.

Performance Evaluation of the Sugarcane Juice Extractor

Industrial sugarcane (*Saccharium officinarium)* variety was used for the evaluation of the performance of the sugarcane juice extractor. Sugarcane stalks were manually fed into the machine transversely between the rollers and then the extracted juice was collected at the juice outlet. For each extraction operation, the average time taken by the crusher to extract juice from sugarcane stalks, the weight of bagasse remaining and the extracted juice were collected and recorded.

Detailed tests were carried out to determine the throughput of the machine at different speeds and feed rates and also the average time it takes the crusher to extract juice from the sugarcane. The bagasse remaining and the juice extracted were collected to determine the extraction efficiency and extraction loss of the machine at different combinations of speeds, feed rates and number of passes.

Experimental design and statistical analysis

A three-level-three factor experimental design requiring 27 experimental runs using Minitab 16.2.1 software (2010 Minitab Inc.) was employed for this study. Speed of machine operation, feed rate of stalk into the machine and number of passes of the stalk (through machine) were the machine independent variables selected and each considered at 3-levels each to optimize their influence and their interaction on the juice yield, extraction efficiency and extraction loss. The coded and uncoded levels of the independent variables are given in Table 1.

Analysis of Variance (ANOVA) and regression was carried out on the data obtained to determine the effect of the machine's operation speed, feed rate and number of passes of sugarcane stalk singly and their interactions on the extraction efficiency, extraction loss and juice yield.

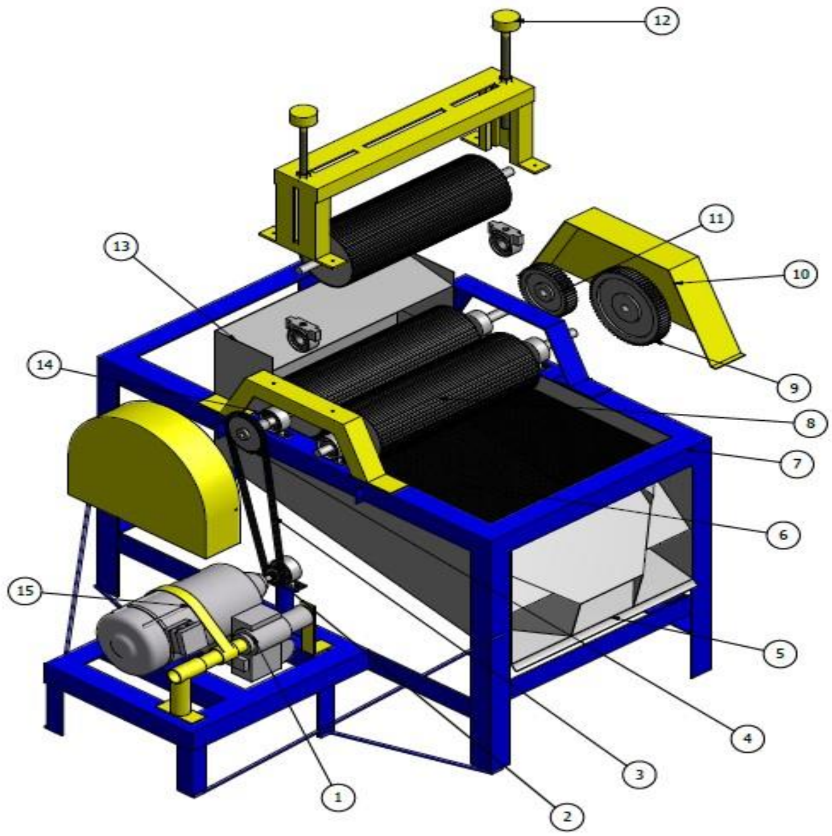

Figure 1: Exploded view of the sugarcane juice extractor

Key: 1 – Reduction gear motor; 2 – Driving sprocket; 3 – Chain; 4 – Driven sprocket; 5 – Juice Outlet; 6 – Stainless screen; 7 – Frame; 8 – Crushing rollers; 9 – Driven gear; 10 – Side Cover; 11 – Driving gear; 12 – Adjusting knob; 13 – Hopper; 14 – Bearing; 15 – Motor support.

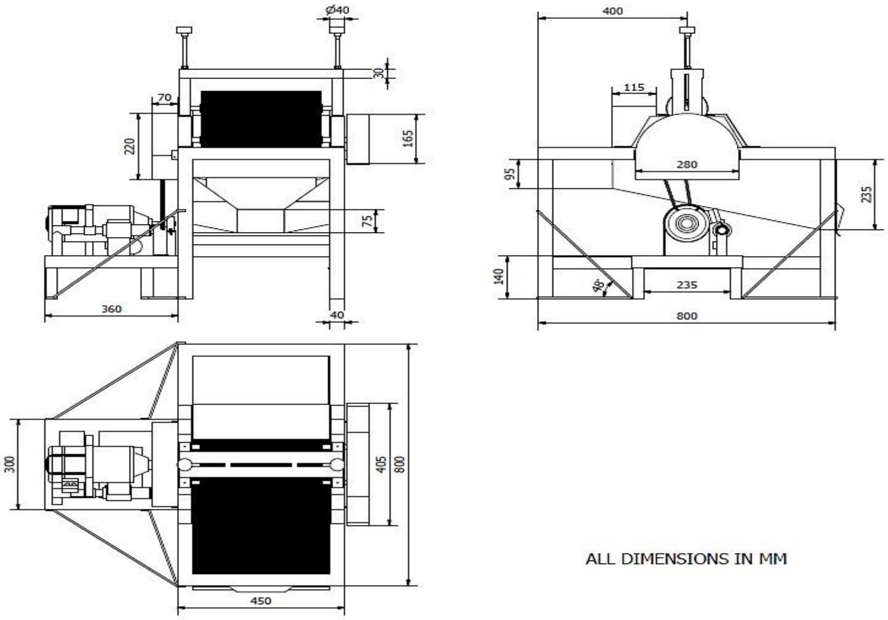

Figure 2: Orthographic views of the sugarcane juice extractor

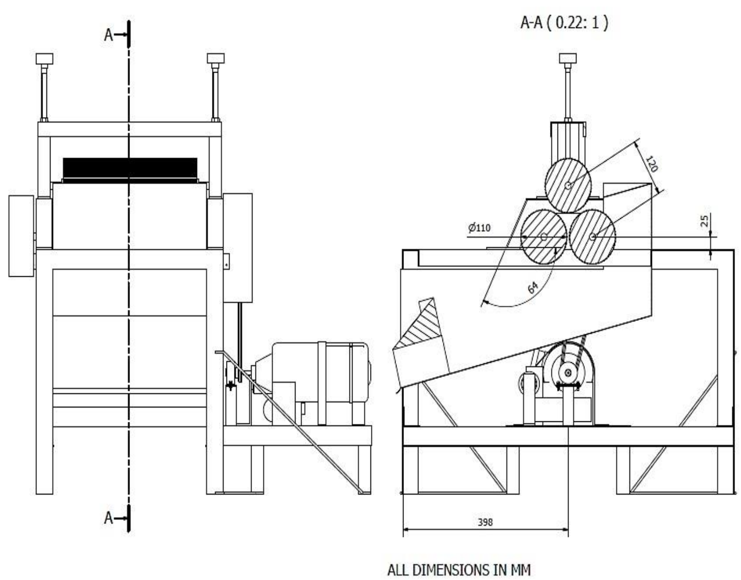

Figure 3: Sectional view of the sugarcane juice extractor

Table 1: Test variables and their levels of variation

S/N	Variables	Symbols	Levels		
			1	**0**	**-1**
1	Speed, rev/min	Sp	250	200	145
2	Feed rate, kg/min	Fr	0.5	0.8	1.0
3	Number of passes	NP	1	2	3

Evaluation of the responses

Juice Yield: Juice yield is the amount of juice that could be extracted from a sugarcane stalk. It is expressed mathematically in Equation 8 [10].

$$J_Y = \left(\frac{W_{JE}}{W_{JE}+W_{RW}}\right) \times 100\% \quad (8)$$

Where: J_Y = juice yield (%), W_{JE} = weight of juice extracted (g) and W_{RW} = residual waste (g)

Extraction Efficiency: Extraction efficiency is the ratio of the weight of juice extracted to the weight of feed stalk processed and the moisture content of the cane stalk in percentage. This is expressed mathematically in Equation 9 as given by Olaoye [11].

$$J_E = \left(\frac{W_{JE}}{C+W_{FS}}\right) \times 100\% \quad (9)$$

Where: J_E = extraction efficiency (%), C = juice content present in a sugarcane stalk and W_{FS} = weight of feed sample (g)

Extraction Loss: Extraction loss, E_L (%) is the loss encountered during the extraction of juice from the sugarcane stalk. It was mathematically expressed as in Equation 10 [10].

$$E_L = \left[\frac{W_{FS}-(W_{JE}+W_{RW}}{W_{FS}}\right] \times 100\% \quad (10)$$

Extractor's capacity: Throughput (capacity) is the amount of materials that passes through the machine at a time. This is expressed with Equation 11 [7].

$$C_J = \frac{W_{JE}}{T} \quad (11)$$

Where:

C_J = throughput capacity of the machine (kg/h)

W_{JE}= Weight of the juice extracted (kg)

T = time used for extraction (h)

$$C_J = \frac{0.66}{0.0389} = 16.96 \text{ kg/h}$$

RESULTS AND DISCUSSION

The complete design matrices of the experiments carried out and the results obtained from the experiments for the juice yield, extraction efficiency and extraction loss responses are presented in Table 2.

Effect of machine speed, feed rate and number of passes on the juice yield.

The experimental values obtained for juice yield response at the design points are given in Table 2, the ANOVA result is given in Table 3 and the interaction effects of the three factors on juice yield evaluated by Response Method (RSM) using three-dimensional plots are given in Figures 4a-c

Table 2: Experimental design matrix and results of the responses

Run	Independent factors			Dependent responses		
	Speed (Rev/min)	**Feed rate (Kg/min)**	**No. of passes**	**Juice yield (%)**	**Extraction Efficiency (%)**	**Extraction loss (%)**
1	250	0.5	2	41.02	37.65	22.00
2	145	0.5	1	70.80	70.60	10.00
3	145	1.0	3	76.70	77.64	14.00
4	200	0.8	2	53.00	60.58	6.25
5	145	0.8	1	60.00	65.69	6.25
6	200	0.5	3	58.69	63.50	8.00
7	200	1.0	3	57.50	62.94	7.00
8	200	0.8	1	52.63	58.39	5.00
9	145	1.0	1	68.42	70.58	5.00
10	250	1.0	3	47.36	52.94	4.00
11	200	0.8	3	59.18	63.50	8.13
12	145	0.5	3	76.20	75.31	14.00
13	200	1.0	1	51.04	57.65	4.00
14	200	0.5	2	56.52	61.19	4.00
15	250	1.0	2	41.48	45.88	6.00
16	145	1.0	2	74.40	74.30	8.00

17	200	0.5	1	50.00	56.48	4.00
18	145	0.8	2	69.01	71.53	11.25
19	145	0.5	2	72.70	75.31	12.00
20	250	1.0	1	36.95	36.47	11.00
21	250	0.5	1	37.66	34.12	23.00
22	250	0.5	3	45.00	42.36	21.00
23	250	0.8	1	39.39	37.95	16.25
24	250	0.8	2	42.85	43.79	12.50
25	145	0.8	3	72.60	75.91	8.75
26	250	0.8	3	46.93	49.63	8.75
27	200	1.0	2	56.45	61.76	6.80

The ANOVA result in Table 3 shows that the factors and their interactions directly or indirectly had significant effect ($p \leq 0.05$) on the juice yield. The operating speed (Sp) with the highest value of "F" is the most effective parameter affecting juice yield, followed by the number of passes (Np) and the interaction effect between speed and feed rate (SpFr), while the feed rate (Fr) and the interaction effects of the variables are not significant factors as indicated by the value of "Prob > F" which is higher than 0.05. The response surface graph (Figure 4a) shows that the juice yield increases with decrease in operating speed and increase in the feed rate.

Table 3: Analysis of variance (ANOVA) for juice yield (%)

Source	DF	Seq.SS	Adj. MS	F	P
Sp	2	3835.15	1917.57	518.82	0.000
Fr	2	14.38	7.19	1.95	0.205
Np	2	298.38	149.69	40.50	0.000
SpFr	4	61.56	15.69	4.25	0.039
SpNp	4	4.67	1.19	0.32	0.855
FrNp	4	4.10	1.03	0.28	0.884
SpFrNp	2	2.91	0.09	0.236	0.618
Error	6	29.57	3.70		
Total	26	4250.12			

R^2 = 0.993, Adj. R^2 = 0.977, SD = 1.923, SE Fit = 1.613

Sp = Speed, Fr = Feed rate, Np = No. of passes, Significant at $P \leq 0.05$

Similarly, Figure 4b shows that as the speed reduces and the number of sugarcanes passes increases, the juice yield increases, while Figure 4c shows that as both the feed rate and the number of passes increase, the juice yield increases. This is because the top crushing roller was adjusted at the second and third passes to further extract more juice from the wet bagasse. Several authors have reported considerable increase in juice extracted from sugarcane beyond one pass [6]. Similar observation was reported by Al-Gaadi *et al.* [12] for squash seed extraction machine combining speed, feed rate and wet based vegetable.

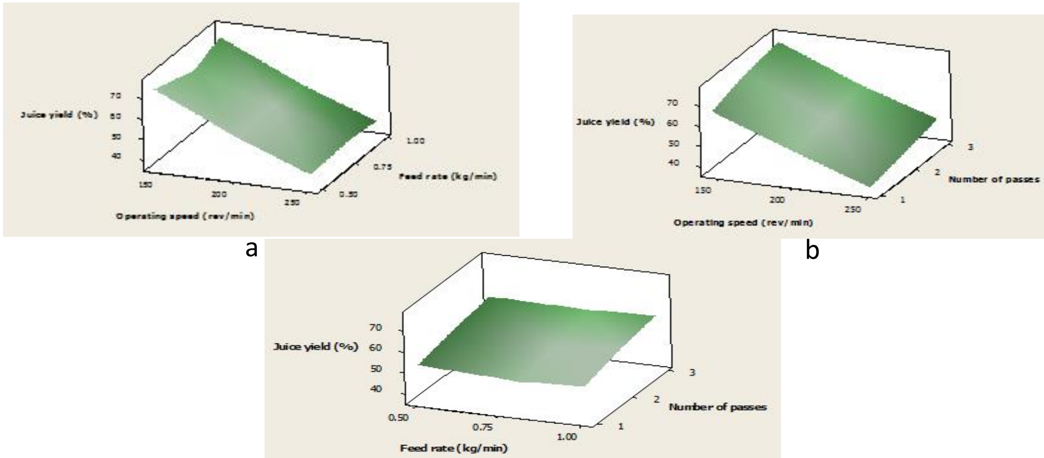

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Figure 4: Interaction effect of (a) operating speed and feed rate (b) operating speed and number of passes and (c) feed rate and number of passes on the juice yield

Using the coefficients determined, the predicted model for the juice yield is given in Equation 12. The regression model for the juice yield was found to be highly significant with a coefficient of determination (R^2) of 0.993. From Table 3 and Equation 12, it could be concluded that the linear and interactive effects of Fr and Np were the primary determining factors of juice yield followed by the linear effect of Sp. However, juice yield was negatively influenced by the Sp and the Fr and positively influenced by the Np and the interaction effects of the independent variables.

$$J_Y = 112.147 - 0.312948\,Sp - 12.8041\,Fr + 2.03519\,Np + 0.0505634\,SpFr + 0.00495572\,SpNp + 3.11426\,FrNp - 0.00878041\,SpFrNp \quad (12)$$

Where: J_Y = juice yield, Sp = Speed (rev/min), Fr= Feed rate (kg/min). Np = Number of passes

Effect of machine speed, feed rate and number of passes on the Extraction efficiency

The experimental values obtained for the extraction efficiency as a response at the design points are given in Table 2, the result of the ANOVA is given in Table 4 and the interaction effects of the three factors on extraction efficiency evaluated by RSM using three-dimensional plots are given in Figures 5a-c.

The result of the ANOVA as presented in Table 4 shows that the linear terms, the interaction effect between speed and feed rate and the combined interaction effects between speed, feed rate and number of passes were significant at 5 % level of significance, this implied cross interaction of speed and feed rate could be jointly investigated [8]. It was shown in the response surface graphs (Figures 5a and b) that the extraction efficiency increases as the operation's speed reduces while the feed rate increase as the speed reduces and the number of sugarcanes passes increases, respectively. While Figure 5c indicated that the extraction efficiency increases with increase in both the feed rate and the number of passes.

Table 4: Analysis of variance (ANOVA) for extraction efficiency (%)

Source	DF	Seq.SS	Adj. MS	F	P
Sp	2	4280.10	2144.55	791.46	0.000
Fr	2	31.19	15.59	5.75	0.028
Np	2	312.01	161.01	59.42	0.000
SpFr	4	70.90	17.72	6.54	0.012
SpNp	4	31.50	8.37	3.09	0.082
FrNp	4	8.24	2.06	0.76	0.579
SpFrNp	2	10.05	4.77	1.32	0.025
Error	6	21.68	2.71		
Total	26	4776.60			

R^2 = 0.995, Adj. R^2 = 0.985, SD = 1.646, SE Fit = 1.381

Sp = Speed, Fr = Feed rate, Np = No. of passes, Significant at $P \leq 0.05$

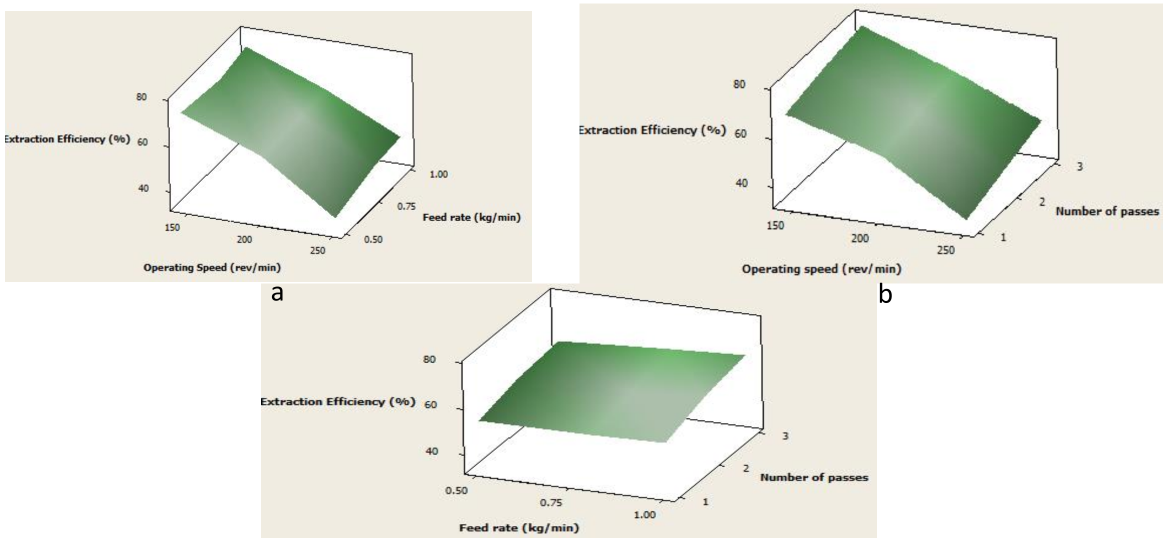

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Figure 5: Interaction effect of (a) operating speed and feed rate (b) operating speed and number of passes and (c) feed rate and number of passes on the extraction efficiency

The performance evaluation also shows that the optimum extraction efficiency of the motorized juice extractor depends on the extraction speed and number of sugarcanes passes. Similar finding was reported by Al-Gaadi *et al.* [12] for summer squash seed extraction machine combining speed, feed rate and wet based vegetable [13, 14] for other juice extractors. The regression model for the extraction efficiency in Equation 13 was found to be significant with a coefficient of determination (R^2) of 0.995. Equation 13 showed that the linear terms of Sp and Fr and interactive effect of SpFr were the primary determining factors of extraction efficiency. However, extraction efficiency was negatively influenced by the Sp, Fr, SpNp and FrNp (increase in these variables and their interactions will reduce the extraction efficiency) while increase in Np and the interaction effect of SpFr would lead to increase in extraction efficiency.

$$J_E = 123.821 - 0.36753Sp - 9.19104Fr + 4.58609Np + 0.0417653S - 0.0135873SpNp - 6.24437FrNp + 0.0467407SpFrNp \quad (13)$$

Where: J_E = extraction efficiency (%), Sp = Speed (rev/min), Fr = Feed rate (kg), Np = Number of passes

Effect of machine speed, feed rate and number of passes on the extraction loss

The experimental values obtained for the extraction loss response at the design points were given in Table 2, the result of the ANOVA of the experiment was given in Table 5 and the response surface graphs of the interaction effects of the operating speed, feed rate and number of passes on the extraction loss were given in Figures 6a - c.

The ANOVA result in Table 5 shows that the operating speed (Sp) with the highest value of 34.95 of "F" is the most effective parameter affecting extraction loss, followed by the feed rate (Fr) with the value of 18.10 and the interaction between speed and feed rate (SpFr) with 11.22.

Table 5: Analysis of variance (ANOVA) for extraction loss (%)

Source	DF	Seq.SS	Adj. MS	F	P
Sp	2	310.603	157.801	34.95	0.000
Fr	2	161.459	81.730	18.10	0.001
Np	2	5.978	2.989	0.66	0.542
SpFr	4	200.719	50.68	11.22	0.002
SpNp	4	103.755	25.939	5.74	0.018
FrNp	4	6.373	1.593	0.35	0.835
SpFrNp	2	12.045	4303.0	1.542	0.049
Error	6	33.123	4.515		
Total	26	834.011			

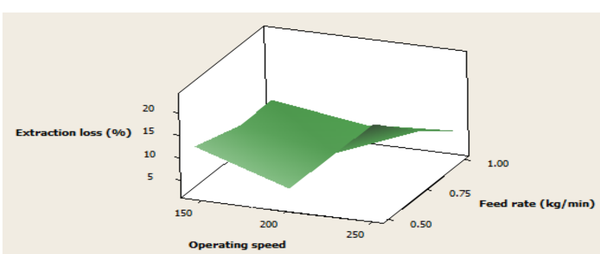
R^2 = 0.956, Adj. R^2 = 0.859, SD = 2.125, SE Fit = 1.613

Sp = Speed, Fr = Feed rate, Np = No. of passes, Significant at P ≤ 0.05

The number of passes (Np) and interaction effect between the feed rate and number of passes (FrNp) were not significant factors as indicated by the value of "Prob > F" which is higher than 0.0500. The response surface graph of the interaction effect between operating speed and feed rate in Figure 6a shows that a reduction in the operating speed and feed rate results in a reduction in the extraction loss, while an increase in the speed and feed rate increases the extraction loss from the machine. Maximum extraction loss of 13.33 % was obtained at operating speed of 250 rev/min and feed rate of 0.5 kg/min. Figure 6b shows that extraction loss increases with decrease in operating speed and increase in number of passes. While Figure 6c shows that low extraction loss was obtained when there was a combination of low feed rate and few numbers of sugarcane passes, while a high extraction loss occurs when there was an increase in the feed rate and number of sugarcanes passes. The result was in line with the report of Davies [15] on the evaluation of continuous screw press for extraction of soya bean and Al-Gaadi [12] on the evaluation of summer squash seed extracting machine. The number of sugarcane passes influences the rate at which loss in extraction occurs due to the number of passes, that is, extraction loss at one pass is smaller than the extraction loss at two and three passes. The predicted model for the extraction loss as given in Equation 14 was found to be significant with a coefficient of determination (R^2) of 0.956. Equation 14 shows that the linear terms of Fr and Np and interaction effect of FrNp were the primary determining factors for extraction loss. However, increase in Fr and Np reduces extraction loss while an increase in FrNp would lead to increase in extraction loss, therefore in this situation, increase in number of passes and feed rate is encourage to minimize extraction loss.

$$E_L = -15.3911 + 0.162239\,Sp - 3.67079\,Fr - 3.14861\,Np - 0.0345156\,SpFr + 0.0209538\,SpNp + 17.7602\,FrNp - 0.0928355\,SpFrNp \qquad (14)$$

Where: E_L = extraction loss (%), Sp = Speed (rev/min), Fr = Feed rate (kg/min) Np = Number of passes



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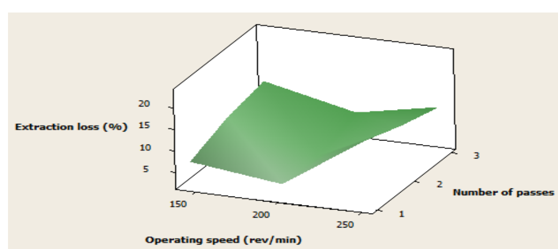

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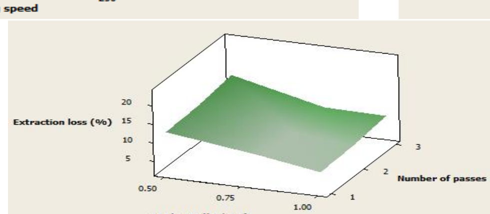

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Figure 6: Interaction effect of (a) operating speed and feed rate (b) operating speed and number of passes and (c) feed rate and number of passes on the extraction loss

CONCLUSION

A sugarcane juice extractor of 16.96 kg/h capacity, 76.70 % and 77.60 % juice yield and extraction efficiency, respectively, have been developed for medium and small-scale processing. Its operating speed, feed rate and number of passes of sugarcane stalk influenced the juice yield, extraction efficiency and the extraction loss of the developed machine. The optimum juice yield, extraction efficiency and the minimum extraction loss of the sugarcane juice extractor were obtained at operating speed of 145 rpm, feed rate of 1.0 kg/min and 3-times of sugar cane passes. The predicted models were found to adequately represent the experimental data points for the juice yield, extraction efficiency and extraction loss with an R^2 values of 0.993, 0.995 and 0.956, respectively.

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