



EFFECT OF PULLEY SIZE VARIATION ON THE PERFORMANCE OF AN ARMFIELD-FT28 SCREW PRESS IN VEGETABLE OIL EXTRACTION

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DOI: <https://doi.org/10.70382/tjarbt.v12i1.037>

ABSTRACT

The relationship between operating parameters namely press worm shaft speed, feed rate and choke clearance and dependent variables which included percentage oil yield, cake yield, oil extraction efficiency, material loss and throughput capacity was investigated while mechanically expressing oil from the Mai Bargo variety groundnut seeds (*Arachis hypogaea* L.). A 3 × 3 × 5 factorial concept fitted into completely randomized design

Introduction

Vegetable oil has become a very important component of food and non-food industries (Samatha and Naik, 2020), there is presently an increasing universal demand for good quality vegetable oil because of their nutritional, pharmaceutical and industrial applications thus, studies on vegetable oil to meet its demand in the human society are essential. The present production rate of vegetable oil in Nigeria is inadequate to meet the demand of her citizenry (Sarwar *et al.*, 2019), this has led to the supply of oils of varying qualities to the Nigerian market with some posing various health risks. It is essential to investigate the quality and quantity of oil from some unexploited and underutilized oilseeds to make more oils available for human nutrition, bio-



was used in three replications. The speed was varied over 64.6, 56.6, 40.6 and 32.6 rpm using pulley arrangement, choke clearance was varied at three levels of 2.0, 4.0, and 6.0 mm using feeler type gauges. Calibration markings were made on the press once these desired settings were attained. The product feed rate was at Pre-calibrated values of 500, 1000 and 1500g/minutes. Data collected from performance evaluation of the screw press were analyzed through analysis of variance (ANOVA) using Statistical analysis system (SAS). More comparison mean was further analyzed to know the level of significant using Tukey's test. Throughput capacity of 3.20kg/h was obtained at 40.6rpm worm speed of operation, 2.00mm of choke clearance and 1500g/min feed rate. The results showed that worm speed of operation, choke clearance and feed rate had significant influence on percentage oil yield. Pulley diameter of 312.5 mm gave the best speed for the Optimal percentage oil yield of 32.20% at throughput capacity of 3.20kg/h and at maximum feed rate. The determination co-efficient (R^2) of these models were 0.929 and 0.973 for linear and quadratic respectively, which means that the models had a favorably fitting degree. The result of this study would be useful for rational design and development of groundnut oil screw press.

Keywords: Armfield-FT28 screw press, Screw worm shaft speed, Choke clearance, Feed rate, Percentage Oil yield, Throughput capacity, Groundnut Seeds Extraction.

power, enhance food security and reduce the wide gap between the demand and supply of oil (Ionescu et al., 2021).

Groundnut (*Arachis hypogea*) also known as peanut is specie in the legume. It is an annual herbaceous plant growing 30-50cm tall. The mature fruit develops into a legume pod, the peanut a classical example of grocery pods are 3-7cm long, containing 1-4 seeds ((Mogaji et al., 2022). Groundnut grows between 30-40cm high in the Americas and do not spread, or runs along the ground reaching from 30-60cm high in African with yield of 0.5-40 tons/ha (Riskawati et al., 2021). In most developing countries, 80% of crops yield are around ton/ha (Riskawati., 2021). The production of oil from groundnut entails some post-harvest processing of groundnut which includes: shelling, roasting and pressing (Sarwar et al., 2019). The seed contains adequate proportion of essential nutrient for human development including sodium, potassium, magnesium, calcium, phosphorus, and lower concentrations of iron, zinc, copper; it is also rich in protein, oil, energy. The consumption of the seed reduces the risk of life diseases like cancer and some tobacco-related diseases (Pighinelli & Gambetta, 2012).



Oil extraction is a process which involves expelling oil from oil bearing agricultural seed's a process which can be achieved using several methods like the traditional method, supercritical fluid extraction method and mechanical method (Orhevba *et al.*, 2013).

Traditional methods, Oil is extracted from oilseeds by separating the flesh and boiling it in water. Salt is added to break the emulsion and the oil is skimmed from the surface. In palm oil processing the fruit is first heated in a 'digester'. Oil can be extracted by pressing softer oilseeds and nuts, such as groundnuts and shea nuts, whereas harder, more fibrous materials such as copra and sunflower seed are processed using ghanis (Savoire *et al.*, 2012). Extracting oil from groundnut seeds involves the use of a traditional press which is unhygienic, inefficient, time consuming and yields a lower quantity of oil (Giwa and Akanbi, 2020). It has been reported by Mbah *et al.*, (2014) that in the oil extraction process, many factors influence the yield of oil. These factors include particle size, seed quality, seed preparation, solute solvent ratio, leaching time and temperature, agitation of the fluid. Kehail *et al.*, (2018) revealed that four basic techniques are used worldwide for the extraction of oil from oleaginous agricultural products. These techniques are chemical extraction, supercritical fluid extraction, steam distillation and mechanical expression (Savoire *et al.*, 2012).

Mechanical pressing is the most common method for oil extraction using different types of presses such as hydraulic press, screw press and rolling press (Nnanna *et al.*, 2021)). Solvent extraction is a method which is able to extract what over 98% of oil (Samatha & Naik, 2020). However, these methods mention above have it some disadvantages such as drudgery in feeding into the machine. Thus, to achieve the maximum benefit of the screw press, the modification of the feeding unit which aids conveyance, reduces labor of constant feed and allows for continuous feedings.

Oil expeller is a device which can produce pressure by rotating feed to expeller screw manually or automatically (Ogunlade and Aremu, 2019). Screw press method for oil extraction is a mechanical method for extracting oil from raw materials. Oil extracted by screw pressing is used either as a food product or as an industrial product. Food products include raw oil in dressings and made up to corn oil, peanut oil, rice bran oil (Ogunlade and Aremu, 2019).

Continuous pressing by means of expellers (also known as screw press) is a widely applied process for the extraction of oil from oil seeds and nuts. It replaces the traditional method for the batch wise extraction of oil by mechanical or hydraulic pressing (Tekale *et al.*, 2019).

Armfield -FT28 oil extraction screw has been developed by (Savoire *et al.*, 2012). to meet an increasing demand for a relatively unsophisticated small-capacity press. It is designed to press seeds, nuts or other fine biomass to extract the oil. In addition, a cake is formed



which can be further purified downstream. Seed or ground meal is gravity-fed to the press from the feed hopper.

Screw press, having barrel constructed from separate cast rings spaced apart by shims. 60mm diameter bore, 155mm drainage length with single-piece worm shaft driven at the discharge end driven by 5hp of electric motor that gives a press worm shaft speed of nominally 120 rpm. Complete with feed hopper, manual feed chute, oil discharge chute and suitable base plate. The extracted oil filters out through the perforation beneath of the feed end casting barrel and collected through the oil outlet while the groundnut cake which is the by-product is forced out as paste and collected through cake outlet.

However, Lower oil yield, high traces oil in cake, more material retained in the pressing chamber and avoided strain in human operators due to manual activities carried out on the press. These short comings attributed to absence of a calibrated product feed device, means for varying choke clearance and regulating of worm speed. For better pressing performance in degree of extraction there is a need for improvement. Varying the worm speed, choke clearance, and product feed to see the level at which the operating parameter has improved the pressing efficiency. This study aimed at investigating the degree of influence on press worm shaft speed, feed rate and choke clearance on mechanically expressed groundnut seeds (*Arachis hypogaea* L.): manipintar (Mai Bargo).

Seed procurement and preparation

The oilseed material used were obtained from Yelwa market, Bauchi, Bauchi state, Nigeria. They were cleaned, manually sorted and the defective ones were discarded and good seeds were packed in airtight polythene bags. The seeds moisture level at harvest was determined using ASAE (1998) method by drying the seeds in an electric oven at 105 °C until there is no change in weight. Equation (1) was used to obtain the moisture content of the seeds:

$$M = I - \frac{F}{F} \times 100 \quad (1)$$

Where; m is the moisture content (% db), I am the weight of seeds before drying (g), and F is the weight after drying (g).

Screw press

The Armfield-FT28 screw press (Plate 1) is driven by 5hp of electric motor that gives a press worm shaft speed of nominally 120 rpm, at the discharge end. The power source is a 4kW, four-pole, three-phase electric motor. The screw press, having barrel constructed from separate cast rings spaced apart by shims. 60mm diameter bore, 155mm drainage length



with single-piece worm shaft driven at the discharge end. Complete with bottom feed hopper, manual feed chute, oil discharge chute and suitable base plate.

Calibration of flab

The product feed rate was varied over levels: 500,1000 and 1500g/minutes by use a feed control flap: regulated the quantity of seeds fed into the pressing case from the hopper. Pre-calibration tests were carried out in idle runs to determine how much material would pass through the opening per unit by measuring how long it took for a fixed quantity of material to pass through each flap opening.

Calibration of choke lock cone

The choke clearance was varied at three levels of 2.0, 4.0, and 6.0 mm using feeler type gauges. Calibration markings were made on the press (choke lock cone) once these desired settings where attained.

Press worm shaft speed

the speed of rotation was varied using different pairs (Plate 2) of driving and driven pulleys to obtain the desired worm operation speeds of :64.6,56.6, 48.6,40.6, and 32.6rpm respectively, which was confirm using tachometer.

Selection of Pulley Sizes

In achieving the aim of this work different pulley sizes were selected from the market base on diameter. Pulleys and belts were made based on the following criteria; (i) to the system is designed for maximum speed of 1,450 rpm of 5hp of electric motor.(ii) driver pulley diameter on the motor shaft of 152.4mm.(iii) the speed needed (64.6,56.6,48.6,40.6 and 32.6rpm).

Determination of Pulley Diameter

The dimension of the pulley made from cast iron, takes the shape of a circle shape would be determined according to Babalola *et al.*, (2023) using Equation 1 as stated below:

$$\text{Velocity ratio} = \frac{\text{Diameter of Big or Driver Pulley}}{\text{Diameter of Small or Driven Pulley}}$$
$$V.R = \frac{\omega R}{\omega r} = N_b \times D_b / N_s \times D_s \text{ With } \omega = 2\pi N / 60 \quad (2)$$

Where;

N_b =speed of big or driven pulley (rpm),

N_s =speed of the small or driver pulley(rpm)

D_b = Diameter of the big or driven pulley (mm)

D_s = Diameter of the small or driver pulley (mm)



Plate 1: Armfield-FT28 screw press (Savoire et al., 2012). **Plate 2:** Photograph of the four pulleys used to vary the main shaft speed

Experimental Design

A $3 \times 3 \times 5$ factorial concept, comprising of 3 choke clearance settings, 3 feed rates and five worm rotational speeds constitute 45 treatments fitted into a completely randomized design and carried out in three repetitions to yield 135 total experimented runs was adopted for the study. The three independent variables considered were adjudged from literature to be factors affecting the yield and quality of oil expression from oilseeds using screw press. The effects of these operating parameter on the dependent variable which were oil yield, cake yield, oil extraction efficiency, material loss and throughput capacity were studied.

Independent variables

The independent variables considered include press worm shaft speed, feed rate and choke clearance. The three independent variables considered are very important factors affecting the yield and quality of oil expression from oilseeds using screw press. Personal observations were noted. No secondary data were required, were sourced from literature and are properly cited as such in the work. The speed of operation was varied over five levels; $PWSS_0$, $PWSS_1$, $PWSS_2$, $PWSS_3$ and $PWSS_4$ (64.6, 56.6, 48.6, 40.6 and 32.6rpm) respectively using the pulley arrangement; the speed was measured with a Lutron DT-



2235 model digital surface/contact (Lutron, City). The choke clearance was varied at three levels of CC_1 , CC_2 and CC_3 (2.0, 4.0, and 6.0 mm) respectively using feeler type gauges. Calibration markings were made on the press once these desired settings were attained. The product feed rate was varied over levels: FR_1 , FR_2 and FR_3 (500, 1000 and 1500g/min) respectively, by use a feed control flap: regulated the quantity of seeds fed into the pressing case from the hopper. Pre-calibration tests were carried out in idle runs to determine how much material would pass through the opening per unit by measuring how long it took for a fixed quantity of material to pass through each flap opening.

Dependent variables

These includes oil yield, cake yield, oil extraction efficiency, material loss and throughput capacity. They were determined in accordance to standard evaluation methods. The seeds were subjected to similar conditions of moisture and temperature applications for each experimental run (Akangbe & Herak, 2018)

Experimental Procedure

The evaluation of the machine was carried out in the Crop Processing and Storage Laboratory of the Department of Agricultural and Bioresource Engineering, of Abubakar Tafawa Balewa University, Bauchi. Mai Bargo variety of groundnut seeds purchased from the market at storage moisture content, manually cleaned to remove foreign materials. Weighing balance, measuring cylinder, prepared groundnut seeds, cake receiving container and oil receiving container were used for the evaluation. The choke-ring clearance of the duration also screw press was calibrated using feeder gauge to obtain the actual measurements of 2.0, 4.0, and 6.0mm respectively, using the choke regulator. The machine was being subjected to three different levels of product feed rate of 500, 1000 and 1500g/minutes measured of groundnut seeds. The screw press was powered by a 5hp electric motor and the speed of rotation was varied using different pairs of driving and driven pulleys to obtain the desired worm operation speeds of 64.6, 56.6, 48.6, 40.6, and 32.6rpm respectively. The continuous helical screw shaft conveyed, crushed and pressed the material in order to extract the oil. The oil phase was separated from the solid phase (press cake) by the screen. The oil extracted and the press cake was collected and weighed separately.

Percent oil yield of the groundnut seeds (*Arachis hypogaea* L.): manipintar (Mai Bargo)

Percentage yield of oil was similarly determined as the fraction of oil expressed in relation to the mass of the oil-bearing material (Akangbe & Herak, 2018), as shown in Equation (3) below:



$$POY = \frac{M_{OC}}{M_{SS}} \times 100 \quad (3)$$

Where;

POY = Percentage oil yield (%),

M_{OC} = Mass of oil (g),

M_{SS} = Mass of oilseed sample (g).

Throughput capacity (C_T) this is the mass flow rate and the quantity of kernels processed per time by the screw press, throughput capacity was calculated using Equation (4) as stated by (Smith *et al.*, 2022).

$$C_T = M_P/T \quad (4)$$

Where;

C_T =Throughput capacity (kg/h)

M_P =Mass of the groundnut seed that passes through the barrel (g)

T= Time (s).

Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA) to test for significant effects at 95 % confidence limit using the procedure recommended by Steel and Torrie (1980). When significant difference is observed, treatment means were separated using Tukey's test.

Effects of Press Worm Shaft Speed, Feed Rate and Choke Clearance and their interactions on Percentage Oil Yield.

Tables were used to present the responses of percentage oil yield as influenced by the variation of the press worm shaft speed, feeding rate and choke clearance. Each independent single interactive factor as well as multiple interaction factors was discussed in response to their effects on the percentage oils yield, table for the means values was ranked and analysis of variance was carried out to validate the results obtained.

Table 1: ANOVA on Effects of Press Worm Shaft Speed, Feed rate, and Choke Clearance, on the Percentage Oil Yield

Source	df	Mean Square	F-Value
Corrected Model	44	99.976	808.575**
Intercept	1	85091.093	688534.539**
Press worn shaft speed(rpm)	4	1048.337	8483.001**



Source	df	Mean Square	F-Value
Feed rate (g/min)	2	829	6.705*
Choke clearance (mm)	2	29.440	238.220**
Press worn shaft speed(rpm) * Feed rate (g/min)	8	5.641	45.541*
Press worn shaft speed(rpm) * Choke clearance (mm)	8	2.004	16.42*
Feed rate (g/min) × Choke clearance (mm)	4	0.715	5.787*
Press worn shaft speed(rpm) * Feed rate (g/min) * Choke clearance (mm)	16	0.984	7.962*
Error	90	124	
Total	135		
corrected	134		

** highly significant * significant

Effects of Choke Clearance, Feed Rate and Press Worm Shaft Speed on Percentage Oil Yield

Analysis of variance (ANOVA) of the effect of percentage oil yield on choke clearance, feed rate and press worm shaft speed under pressing extraction performance evaluation show highly significant differences at 0.05 probability level (Table 1). Turkey's mean comparison had illustrated that mean percentage oil yield having similar letters were not significantly different as shown in Table 2. The interaction of choke clearance 2mm and feed rate 500.00g/min, press worm shaft speed with 48.6 and 40.6rpm there were significant differences on percentage oil yield with average value of 32.03 and 32.10% and press worm shaft speed with 64.6, 56.6, and 32.6rpm did not show significant differences with average values of 20.33, 20.33, 22.97% respectively. Choke clearance 2mm and feed rate of 1000.00g/min, press worm shaft speed with 64.6, 56.6, 32.6rpm did not show significant differences on percentage oil yield with mean 20.13, 20.50, 31.90 and 23.03rpm%, press worm shaft speed with 48.6 and 40.6rpm were significantly different with mean values of 31.90 and 32.90%. Similarly, at choke clearance 2mm and feed rate with 1500.00g/min, press worm shaft speed with 64.6, 56.6, 48.6, 32.6 rpm, were not significantly different with mean of 20.90, 21.10, 32.03 and 20.17%. While press worm shaft speed with 40.6rpm was significantly different with means of 32.20%. The combination between press worm shaft speed of 40.6rpm, 4mm choke clearance and feed rate of 500.00g/min was significantly different with mean of 32.10%. Also, at choke clearance of 4mm feed rate of 500.00g/min with 64.6, 56.6, 48.6 and 32.6rpm of, press worm shaft speed were not significantly different with mean of 20.00, 20.10, 20.10 and 23.00%. Also with feed rate of 1000.00g/min and press worm shaft speed of 40.6rpm was significantly different with mean of 31.30%. While press worm shaft speed with 64.6, 56.6, 48.6 and



32.6rpm were not significantly different with mean of 20.50,20.50,21.00 and 22.21%. Similarly, feed rate of 1500.00g/min with 64.6,56.6,48.6 and 32.6rpm of press worm shaft speed were not significantly different with mean of 22.27,23.13,31.03 and 20.20rpm, press worm shaft speed with 40.6rpm was significantly different with mean of 31.20%. Lastly, choke clearance 6mm and feed rate 500.00g/min, press worm shaft speed with 40.6rpm there was a significant differences with mean of 30.69rpm and press worm shaft speed with 64.6,56.6,48.6 and 32.6rpm were not significantly different with mean values of 18.93,19.30,20.19 and 19.87% accordingly, while press worm shaft speed with 64.6,56.6,48.6 and 32.6rpm and feed rate of 1000.00g/min were not significantly different with mean values of 19.00,20.07,21.06 and 19.90rpm while press worm shaft speed with, 40.6rpm was significantly different with mean of 30.80% on percentage oil yield. Similarly, at feed rate with 1500.00g/min, press worm shaft speed with 64.6,56.6,48.6 and 32.6rpm were not significantly different with mean values of 19.20,19.20,19.21, and 22.87rpm, while press worm shaft speed with, 40.6rpm was significantly different with mean of 30.90% on percentage oil yield.

Three factor interactions of choke clearance, feed rate and press worm shaft speed were presented in Table 2. For the choke clearance of 2mm, the least percentage oil yield of 20.33% was at the press worm shaft speed of 64.6rpm and feeding rate of 500g/min while at the same clearance, the highest percentage oil yield was 32.20% at the press worm shaft speed of 40.6rpm and feeding rate 1500g/min. 4mm choke clearance produces as low as 20.00% of percentage oil yield at the press worm shaft speed of 64.6rpm and feeding rate at 500g/min, the interaction of 40.6rpm and 1500g/min yielded maximum percentage oil yield of 31.20% at the same choke clearance of 4mm.

At the choke clearance of 6mm, the least percentage oil yield recorded was 18.93% for the press worm shaft speed of 64.6rpm and feeding rate of 500g/min which at the same choke clearance, the highest percentage oil yield was 30.90% at the press worm shaft speed of 48.6rpm feeding rate of 1500g/min. It was observed that the choke clearance of 2mm, feeding rate of 1500g/min and press worm shaft speed of 40.6rpm gives highest percentage oil yield of 32.20%.

There is a clear correlation between choke clearance and percentage oil yield for all clearance and feeding rate levels. As the press worm shaft speed decreases from 64.6 to 32.6rpm, the percentage oil yield consistently improves across all conditions. This clearly indicates that the higher the press worm shaft speed the less effective the percentage oil yield, this is due to increased impact force and shearing action received by the seeds from the pressing camber. The effect of choke clearance on percentage oil yield is also consistent across different screw press speed and feeding rate. There is a negative relationship between choke clearance and percentage oil yield. Narrowed clearance



produces higher percentage oil yield and it is due to increased contact and shearing between the barrel wall and conical choke when the clearance adjusted to narrowed path to be passed by the fed seeds.

The impact of the feeding rate on percentage oil yield is more complex and interacts with the other two factors (choke clearance and press worm shaft speed), there is a positive trend between feeding rate and percentage oil yield noted at lower press worm shaft speeds and narrowed clearance. However, it is point worm noting that excessive high feeding rate could lead to over loading and reduced efficiency, especially at narrow choke clearance (Jain & Jain, 2018) reported.

Table 2: Effects of Choke Clearance, Feed Rate and Press Worm Shaft Speed on Percentage Oil Yield

CC	CC ₁			CC ₂			CC ₃		
FR	FR ₁	FR ₂	FR ₃	FR ₁	FR ₂	FR ₃	FR ₁	FR ₂	FR ₃
PWSS									
PWSS₀	20.33 ^b	20.13 ^d	20.90 ^{cd}	20.00 ^c	20.50 ^c	22.27 ^{cd}	18.93 ^d	19.00 ^b	19.20 ^c
PWSS₁	20.33 ^b	20.50 ^d	21.10 ^c	20.10 ^c	20.40 ^c	23.13 ^c	19.30 ^{bc}	20.07 ^b	19.83 ^c
PWSS₂	32.03 ^a	31.90 ^a	32.03 ^b	32.10 ^a	20.50 ^c	31.03 ^b	30.53 ^a	30.83 ^a	30.87 ^a
PWSS₃	32.00 ^a	32.10 ^a	32.20 ^a	32.10 ^a	31.30 ^a	31.20 ^a	30.67 ^a	30.83 ^a	30.73 ^a
PWSS₄	22.97 ^c	23.03 ^c	20.17 ^d	23.00 ^d	22.93 ^b	20.20 ^d	19.90 ^b	19.90 ^c	22.87 ^b

^{abcd}Means of the same column with different superscript are statistically ($P < 0.05$) different using Tukey's PWSS = Press Worm Shaft Speed (rpm), FR = Feed Rate (g/min), CC = Choke Clearance (mm).

Analysis of variance (ANOVA) on Effects of Press Worm Shaft Speed, Feed Rate, Choke Clearance and their interactions on Throughput Capacity

The Analysis of variance (ANOVA) has been carried out to ascertain if there were significant effects of press worm shaft speed, feed rate, choke clearance and their interaction on throughput capacity as shown in Table 3. The results of the (ANOVA) revealed that there is a highly significant difference of the press worm shaft speed ($P = 571.467$, $P = 0.000$ ($P\text{-value}$) < 0.05 on the throughput capacity. It indicates there is difference in the press worm shaft speed which had a significant effect on the throughput capacity caused due to the reduction in speed implicitly mean that throughput capacity was not the same among press worm shaft speed. The feed rate showed significant effects on the throughput capacity ($P = 86.530$, ($P\text{-value}$) < 0.05) This means that higher the feed rates the higher throughput capacity. This can be deduced that at least on the feed rate level there is a significant difference. The choke clearance showed high significant effects on the throughput capacity ($P = 9.319$, ($P\text{-value}$) < 0.05) This indicates



that choke clearance had significant effects on the throughput capacity. The mean throughput capacity varied with choke clearance. The interactions between press worn shaft speed and also feed rate and press worn shaft speed * choke clearance all had significant effects throughput capacity. It shows a level of significance ($F=100.306$, $P=0.0061$ (P-value) <0.005) and ($F=18.301$, $P=0.0021$ (P-value) <0.005). This indicates that all the treatment in the interactions had significant effects on the average throughput capacity. It can be understood that interaction effect revealed that the relationship between press worn shaft speed and also feed rate and press worn shaft speed *choke clearance with throughput capacity relied on the press worm shaft speed, Feed rate, choke clearance. Interaction between feed rate and choke clearance showed non-significant difference ($F=1.911$, $P=0.13423$ (P-value) <0.005). The treatment on the three-factor Interaction of Press worn shaft speed * Feed rate *Choke clearance showed non-significant difference ($F=1.648$, $P=0.14041$ (P-value) <0.005). effects on throughput capacity. More comparison mean was further analyzed to know the level of significant.

Table 3: (ANOVA) on Effects of Press Worm Shaft Speed, Feed Rate, Choke Clearance and their interactions on Throughput Capacity

Source	df	Mean Square	P-Value
Corrected Model	44	106.8	75.730*
Intercept	1	130.219	145601.495**
Press worn shaft speed(rpm)	4	0.511	571.467**
Feed rate (g/min)	2	.077	86.530*
Choke clearance (mm)	2	.008	9.319*
Press worn shaft speed(rpm) × Feed rate (g/min)	8	.090	100.306*
Press worn shaft speed(rpm) × Choke clearance (mm)	8	0.002	18.301*
Feed rate (g/min) × Choke clearance (mm)	4	0.002	1.911*
Press worn shaft speed(rpm) × Feed rate (g/min) × Choke clearance (mm)	16	0.002	1.648ns
Error	90	0.001	
Total	135		
corrected	134		

** highly significant * significant ns- significant

Effects of Choke Clearance, Feed Rate and Press Worm Shaft Speed on Throughput Capacity

Analysis of variance (ANOVA) of the effect of throughput capacity on choke clearance, feed rate and press worm shaft speed under pressing extraction performance evaluation



show significant differences at 0.05 probability level (Table 3). Turkey's mean comparison had illustrated that mean Throughput Capacity having similar letters were not significantly different as shown in Table 4. Variation of throughput capacity mean values as influenced by interactions of feeding rate, choke clearance and speed were presented in Table 4. At the clearance of 2 mm, the least throughput capacity recorded 2.67 kg/h was at the speed of 32.6rpm and feeding rate of 1500g/min while at the same clearance, the highest throughput capacity was 3.20 kg/h at the press worm shaft speed of 64.6rpm and feeding rate of 1500g/min. 4 mm clearance produces 3.20 kg/h of throughput capacity at the speed of 64.6 rpm and feeding rate of 1500 kg/h, the interaction of 64.6 rpm and 1500 kg/h yielded maximum throughput capacity of 3.20kg/h at the same clearance of 4 mm. At the choke clearance of 6 mm, the least throughput capacity recorded 2.67 kg/h was at the speed 32.6 rpm and feeding rate of 1500 g/min while at the same clearance, the highest throughput capacity was 3.20 kg/h at the speed of 64.6 rpm and feeding rate of 1500 g/min.

The data trends had shown the linear relationship between increase in choke clearance as well as increase in feeding rate produces relatively decrease of throughput capacities. However, the decrease of press worm shaft speeds had evidently decreases the throughput capacity, at 64.6rpm, the throughput capacity was 3.20 kg/h but 32.6 rpm, the capacity had decrease to 2.67 kg/h.

At each cylinder speed (64.6, 56.6 ,48.6 ,40.6 and 32.6 rpm), throughput capacity generally decreases with increasing feeding rate (500, 1000 and 1500 g/min), this lineup with the earlier view that providing more seeds increase throughput capacity, however, the rate of increase in throughput capacity with speed appears to diminish at slower speed (especially at 32.6rpm). This could attribute to the fact that the pressing chamber space is limited. Higher throughput gives lower oil recovery per kg of seeds, due to shorter residence/retention time in the press. Throughput can also be affected by changing the rotational speed of the screw and feed rate of the machine, and this concurred with the report published by (Abubakar et al., 2017)

Table 4: Effects of Choke Clearance, Feed Rate and Press Worm Shaft Speed on Through capacity

CC	CC ₁			CC ₂			CC ₃		
FR	FR ₁	FR ₂	FR ₃	FR ₁	FR ₂	FR ₃	FR ₁	FR ₂	FR ₃
PWSS									
PWSS₀	3.09 ^a	3.10 ^a	3.20 ^a	3.20 ^a	3.20 ^a	3.20 ^a	3.20 ^a	3.20 ^a	3.20 ^a
PWSS₁	3.06 ^a	3.09 ^a	3.19 ^a	3.19 ^a	3.19 ^a	3.18 ^{ab}	3.19 ^a	3.19 ^a	3.19 ^a
PWSS₂	3.04 ^a	3.07 ^a	3.18 ^a	3.16 ^a	3.16 ^{ab}	3.17 ^{bc}	3.16 ^b	3.12 ^b	3.18 ^b



PWSS ₃	3.02 ^a	3.06 ^a	3.20 ^a	3.10 ^b	3.12 ^b	3.12 ^c	3.08 ^c	3.10 ^c	3.16 ^b
PWSS ₄	2.80 ^b	3.02 ^a	3.08 ^b	3.09 ^b	3.09 ^b	3.09 ^c	3.06 ^c	3.09 ^c	2.67 ^c

^{abcd}Means of the same column with different superscript are statistically ($P < 0.05$) different using Tukey's

PWSS = Press Worm Shaft Speed (rpm), FR = Feed Rate (g/min), CC = Choke Clearance (mm).

Linear and Quadratic Regression on Effects of Press Worm Shaft Speed, Choke Clearance and Feed Rate on Percentage Oil Yield

Analysis of multiple regressions was conducted to determine whether press worm shaft speed, choke clearance and feed rate significantly predicted the percentage oil yield. Table 5 shows the multiple regression models for both liner and quadratic P-values < 0.0001 , which indicated that the models were significant for both linear and quadratic regression. The determination co-efficient (R^2) of these models were 0.929 and 0.973 for liner and quadratic respectively, which means that the models had a favorably fitting degree. From the models, it is clearly shown that the levels of percentages of the variance on percentage oil yield are on the press worm shaft speed, choke clearance and feed rate. As a result, the models could be used to determine the effects caused by various test factor on the percentage oil yield.

Table 5: Linear and Quadratic Regression on Effects of Press Worm Shaft Speed, Choke Clearance and Feed Rate on Percentage Oil Yield

	Model	Equation	Sig. F	R^2	Adj R^2
Percentage Oil Yield	Linear	POY=212.95 -0.057PWSS -1.833FR +0.400CC	< 0.001	0.929	0.926
	Quadratic	POY=0.013Btype ² 2.86Btype -.833FR+0.400CC +346.25	- < 0.001	0.973	0.926

POY = Percentage Oil Yield, PWSS = Press Worm Shaft Speed, FR = Feed Rate, CC= choke clearance

Conclusion

From the research conducted, the following conclusions were drawn:

- Pulley diameter of 312.5 mm gave the best press worm shaft speed for the Optimal percentage oil yield oil of 32.20% at throughput capacity of 3.20kg/h and at maximum feed rate.



- ii. Model development for percentage oil yield prediction revealed that quadratic regression analysis indicates high significant effect.

Acknowledgement

The authors sincerely acknowledge the support and contribution that made this research work possible. We are grateful to the department of Agricultural and Bioresource engineering of Abubakar Tafawa Balewa University for providing the resource and environment for this work. Our special thanks to the technical staff and management of the laboratory at Abubakar Tafawa Balewa University for granting us access to their facilities and for their invaluable assistance during the testing and evaluation phases of our fabricated briquetting machine. Our appreciation extends also to our colleagues within the research group for their insightful discussions and constructive feedback throughout the design, fabrication and writing process.

Conflict of Interest

Authors have declared that no competing interests exist.

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