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STUDIES ON THE EFFECT OF PRESSURE ON YIELD OF MECHANICALLY EXPRESSED NEEM SEED KERNEL OIL

[1]Orhevba, B.A; [2]Chukwu, O.; [3]Osunde, Z.D. & [4]Ogwuagwu, V.
[1,2,3] Department of Agricultural and Bioresources Engineering, Federal University of Technology, PMB 65, Minna, Niger State, Nigeria
[4]Department of Mechanical Engineering, Federal University of Technology, PMB 65, Minna, Niger State, Nigeria

Abstract

Investigation was carried out to determine the effect of pressure on the yield of neem seed kernel oil expressed using an oil expeller. Matured neem seed kernels were obtained and the initial moisture content determined (8.1%). The initial oil yield in the samples was also determined (37.71%) using solvent extraction method. The seed kernels were then subjected to oil extraction using a multiseed oil expeller with capacity of 15-20kg/h and powered by a 7.5Kw, 3 phase electric motor with in-built reduction gear. The expression was carried out at different pressures which were calculated and arrived at based on preliminary tests carried out prior to the main experiments. The pressures at which the machine was operated are as follows: 602.91, 723.07, 925.84 and 1334.88 KN/m^2. Three replicates of the experiments were done. The recorded oil yield obtained at the different machine pressures was compared with the initial oil content of the seed kernels. The following oil yield values were obtained at the different machine pressures: 16.81% (602.91KN/m2), 20.52% (723.07KN/m2), 24.99% (925.84KN/m2) and 22.38% (1334.88KN/m2). New Duncan's Multiple Range Test (DMRT) was used to determine the differences in the mean treatment effect of machine pressures on oil yield. From the results, it was observed that higher pressure seems to yield more oil up to a maximum of $925.84KN/m^2$. Further increase in applied pressure beyond this point led to a reduction in yield. The highest oil yield of 24.99% was recorded at $925.84KN/m^2$ while the minimum oil yield of 16.18% was observed at $602.91KN/m^2$. Thus, more yield was obtained at higher pressure levels up to an extent, beyond this pressure level didn't yield more oil.

Keywords: Pressure, Oil expeller, Neem seed kernel, Oil Yield, Oil content.

1.0 Introduction

Neem (*Azadirachta indica*) tree is native to tropical South East Asia and is a member of the Mahogany family, *Meliaceae* (ICIPE, 1995; Okonkwo, 2004). The most famous part of the tree is the oil obtained from the seed kerne (Adewoye and Ogunleye, 2012). According to Ikasari and Indraswati (2008), Ahmed and Grainge (1985); neem seed is a part of the neem tree which has high concentration of oil of between 35-45%. The quality of the oil differs according to the method of processing. Neem oil is a vegetable oil expressed from the fruits and seeds of neem plant, an evergreen tree which has found its use widely in different regions of the globe for medicinal and agricultural purposes (Kovo, 2006; Ranajit *et al*., 2002; Awad and Shinamaila, 2003; Muñoz-Valenzuela *et al*., 2007; Kumar *et al.,* 2010). Peter (2000) reported the uses of neem seed oil to include the following: soap production, raw material for pesticides and cosmetics, plant protection, stock and textile protection, lubrication oil for engines, lamp oil, candle production and refining to edible oil. Kovo (2006) reported its use as an insect repellant and pesticide.

Oil extraction is the process of expelling oil from oil bearing agricultural seeds and there are different methods employed in the extraction of oil; these include the traditional method, supercritical fluid extraction method, mechanical method and the solvent extraction process (contact equilibrium process) or a combination of mechanical and solvent extraction processes. Mechanical expression of oil involves the application of pressure (using hydraulic or screw presses) to force oil out of the oil bearing material. Mechanical extraction process is a more suitable method for both small and large (commercial) capacity operations, this may be due to the fact it is economical compared with the other extraction methods. According to (Adeeko and Ajibola, 1990; Ajibola *et al.,* 1993; 2000; Dedio and Dornell, 1977; Hamzat and Clarke, 1993; Oyinlola and Adekoya, 2004) some pretreatment operations known to influence oil yield in mechanical oil expression include heat treatment, moisture conditioning and size reduction. Norris (1964) also reported that application of pressure is part of the requirements for efficient oil expression from oil seeds. The intention of this study is therefore to investigate whether pressure affects the yield of oil expressed using an oil expeller.

2.0 Materials and Methods

Neem seeds used for the experiments were obtained from Katsina, Katsina State, Nigeria. The seeds were sun dried for some days to allow for easy removal of the kernels. The dried endocarps were then cracked to obtain the seed kernels; after decortication, the hulls of the seeds and other dirt were removed by winnowing. The moisture content of the seed was determined using ASAE 1998 standard for oil seed. Initial moisture content of the seeds was 8.1%. A multiseed oil expeller was used in carrying out oil expression.

2.1 Determination of Machine Pressure

Preliminary testing was done to determine (calculate) the pressure generated within the system: Diameter of barrel was a constant; worm was loosened completely, the worm shaft had four different points with different diameters (measured, noted and marked), these points on the worm corresponds to other points on the shank (outer part of the worm shaft which could be seen even when the worm shaft is inside the barrel) which were already marked, these points on the shank could be seen as the shaft was adjusted. The more the worm shaft was adjusted inwards through the adjustment mechanism; the higher the diameter covered by the worm and the lesser the clearance between the worm and the barrel and thus the more the pressure generated within the system. The measured diameters at the different points on the worm shaft are 0.07, 0.072, 0.074 and 0.076m. These values were substituted into the formula reported by Hannah and Stephens (1984) to obtain the Torque (equation 1).

$$P_W = \frac{2\pi NT}{60}$$ (Hannah and Stephens, 1984) 1

Where:
P_W = Power, W
N= Revolutions per minute
T= Torque, Nm
The torque and the diameters calculated were then substituted into equation 2 to get the different pressures exerted by the machine.
Torque = Force × Distance

$$P_r = \frac{F}{A}$$ 2

Where:
P_r = Pressure, N/m^2
F = Force, N
A= Area, m^2

2.2 Oil Expression

The oil was expressed using a National Cereals Research Institute, Badeggi (NCRI) developed oil seed expeller (Plate 1). The expeller capacity ranged from 15-20 kg/h and was powered by a 7.5kW, 3 phase electric motor with in-built reduction gear. It was run at 75 rpm.

The experimental procedure was by running the screw press for about 3 minutes before loading the pre-treated samples as described by Akinoso (2006). The Experiments were carried out at the following pressures 602.91, 723.07, 925.84 and 1,334.88 KN/m^2. Oil Expressed and cakes from the samples were collected separately. Cleaning of the expeller barrel was done after each expression. Three replicates of the experiments were done.

Plate 1: NCRI Developed Oil Expeller

2.3 Determination of Oil Yield

The expressed oil at the different pressures was collected and left to stand for 96 hours as recommended by Olajide (2000) and the volume measured. The weights of the cakes were determined by use of an electronic weighing balance. The recorded oil yield was compared with the initial oil content of the seed.
Soxhlet oil extraction method as reported by Akinoso *et al.;* (2006) was applied initially to determine the initial oil content of the seed. The mean value of three samples was expressed as percentage content as follows:

$$\%\ Oil\ Content = \frac{Weight\ of\ oil\ in\ Solution}{Weight\ of\ seed\ samples} \times 100$$ 3

The weights of the oils expressed were obtained by use of a weighing balance. Percentage oil yield and Expression efficiency were calculated as follows:

$$\% \, Oil \, Yield = \frac{Weight \, of \, oil}{Weight \, of \, expressed \, seed} \times 100 \quad 4$$

$$\% \, Expression \, Efficiency = \frac{Oil \, Yield}{Total \, Oil \, Content} \times 100 \quad 5$$

3.0 Results and Discussion

New Duncan's Multiple Range Test (DMRT) was conducted to determine the differences in the mean treatment effect of applied pressure on oil yield as shown in Table 1.

Table 1: New Duncan Multiple Range Test for Oil Yield at various pressures

Pressure	Oil yield
602.91	16.18a
723.07	20.52b
925.84	24.99d
1334.88	22.38c

Means with the same alphabet are not significantly different from each other

The result of the comparison among the four levels of applied pressure revealed that each level of pressure recorded significantly different oil yield. Higher pressure seems to yield higher oil to maximum of 925.84KN/m^2. Further increase in applied pressure beyond this point led to a reduction in yield. The highest oil yield of 24.99% was recorded at 925.84KN/m^2 while the minimum oil yield of 16.18% was observed at 602.91KN/m^2.

Soetaredjo *et al*., (2008) reported that seed particles will deform and compactly fill up empty voids at low pressure level, when the pressure is increased, the voids will diminish and the seed particles begin to resist the applied pressure through contact points between particles. Further increase in pressure will force the oil to start flowing out of the particles; they concluded that the neem oil point appeared to be at 2000 psi, and that 5000 psi is the optimum pressure since further pressure beyond this (6000 psi) gave insignificant increase on the oil yield. Adeeko and Ajibola (1990) reported that this was so because empty voids between particles from which the oil could flow out were becoming smaller at higher pressures.

Fig. 1 shows the graphical illustration of the effect of applied pressure on oil yield. As earlier revealed in the Duncan Multiple Range Test (Table 1), the figure shows a progressive increase in oil yield as pressure increased steadily from 602.91 to 925. 84 KN/m^2 but began to drop with further increase in pressure up to1334.88KN/m^2, this trend agrees with the findings of Mwithiga and Moriasi (2007). They reported that oil yield of soy beans increased with increase in extraction pressure; that the oil yield increased slowly initially with increase in pressure before it reached a region (50-70kgf/m^2) during which there was a rapid increase in the yield; they however reported that this yield began to reduce with further increase in pressure beyond 70kgf/m^2. The pressure at which the oil yield increased may probably be the pressure at which the structure of the seed mass crumbled (Mwithiga and Moriasi, 2007).

Olaniyan and Oje (2007) reported that oil yield of shea butter from shea kernel increased progressively from with increase in applied pressure from 1.5 to 8.8 MPa. Ebewele *et al*., (2010) also reported a consistent increase in oil yield of rubber seed oil when the pressure was increased from 5MPa to 8MPa.

The trend observed in this work also agrees with the work of the following researchers: Adeeko and Ajibola (1990), who reported that Oil yield from groundnut increased with increase in pressure up to 20 MPa beyond which the yield leveled off; Ajibola *et al*., (1990a) reported a significant increase in oil yield from melon seeds when applied pressure was increased from 5 to 18 MPa but oil yield either leveled off or decreased slightly when the pressure was increased to 25 MPa; Fasina and Ajibola (1989) reported an increase in oil yield from conophor nuts as pressure increased from 10 MPa to 25 MPa.

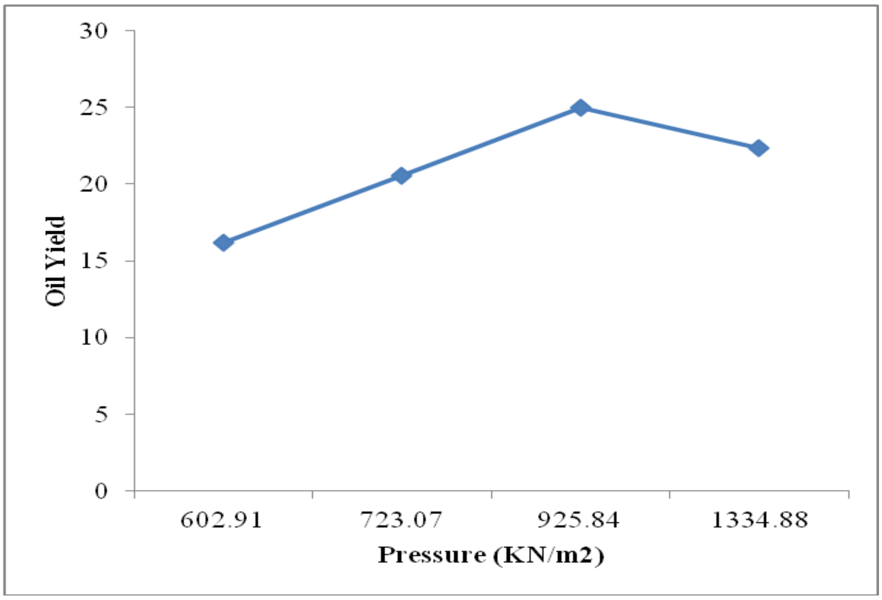

Fig.1: Effect of Machine Pressure on Oil Yield

4.0 Conclusion

From the results obtained, it can be concluded that this work agrees with the results of similar researchers who reported that during the process of oil expression from oilseeds, increasing the pressure applied during screw pressing tended to decrease the size of the capillaries through which oil flows and further increase in pressure may eventually lead to the sealing of the capillaries and some inter kernel voids. Thus, increase in pressure leads to increase in oil yield up to a point, beyond this point, there is no further increase in yield.

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