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Performance Evaluation of a Screw Press for Extraction of Groundnut (*Arachese hypogea*) Seeds and Cashew (*Anacardium Occidentale*) Kernel

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Abstract: Mechanical extraction of oil from seeds using screw press has been proved to be efficient method of vegetable oil extraction. In this study, the performance evaluation of a screw press was carried out to determine the effects of moisture content of the seed before pressing and the heating temperature of the sample during pressing on the extraction efficiency of the screw press using cashew kernels and groundnut seeds. The study was considered as a 4×3×3 factorial experiment with four levels of heating temperatures (80,90,100 and 110°C), three levels of moisture content (7,8, and 9%wb) and in three replications using a Randomized Complete Block Design (RCBD) with moisture content as a blocking factor. The results of the evaluation shows that extraction efficiency increases with increase in temperature but tends to decrease as the temperature increased beyond 100°C in both samples. Also, the higher the moisture content of cashew kernel, the higher the extraction efficiency. But in the case of groundnut seed, extraction efficiency of the screw press decreases with increase in moisture content. The optimum extraction efficiency of 82.00% (at 9% moisture content) and 81.53 % (at 7% moisture content) was obtained for cashew kernels and groundnut seeds extraction with a corresponding heating temperature of 100°C respectively.

Keywords: Cashew Kernel, Groundnut Seeds, Heating Temperature, Moisture Content, Extraction Efficiency

1. INTRODUCTION

Extraction of oil from oilseeds is an important processing operation. Basically, two methods are used for this purpose. One is solvent extract method in which a solvent, when brought in contact with the preconditioned oilseed, dissolves the oil present in the seed and the separated mixture is later heated to evaporate the solvent and obtain the oil. The other method used involved mechanical oil expression. In this process, the preconditioned oil seed is either pressed with hydraulic press or passed through a screw press where a combination of high temperature and pressure is used to crush and press the oilseed to release the oil.

Oilseeds pressing involve very low initial and operating costs compared to the solvent method of oil extraction and are relatively free of any polluting or fire hazardous substances. This method is mostly widely used for oil expression in the developing countries or for high oil content seeds in combination with a solvent system. Vegetable oils are widely consumed domestically in Nigeria. It is used primarily as a cooking and salad oil. Studies have shown that groundnut oil contains much potassium than sodium and is a good source for calcium, phosphorus and magnesium. It also contains vitamin E, selenium, zinc and arginine (Evans et al., 1974; Hariod, 1990).

Oilseeds production and processing are very important component of modern agriculture, for the fact they are easily available and highly nutritious human and animal food. Oil bearing crops and their products are the second most valuable commodity in the world. Oils obtained from oil seeds such as groundnut, melon seeds e.t.c provide the calories, vitamins and essential fatty acids in the human diet (Bredeson, 1983).

Oil can be extracted from many raw materials, but not all contain edible oil. Some contain poisons and unpleasant flavors (Frank, 1998). Edible oils are derived from animals and plants (Sagha et.al., 2004). Oils from plants are classified as vegetable oils. The largest sources of vegetable oils are annual plants, which include soybeans, corn, cottonseed, groundnut, sunflower, rapeseed, melon and sesame seed (Frank, 1998; O'Brien 1998). Other sources are oil bearing perennial plants such as olive, coconut, shear, cashew and palm (Atiku et. al., 2004).

Oil content of vegetable oil-bearing materials varies between 3 and 70 % of the total weight of the seed, nut, kernel or fruit (Bachman 2004). The rate of vegetable oil consumption is increasing compared with animal fat due to its health implication (Akinoso,2006) .The industry is thus challenged to produce high quality oil products at reduced prices. Importance of oil crops as a vital part of the world's food supply is evidenced in world agricultural trade statistics (FAO, 2005). Oil is obtained from oilseed by either solvent extraction or mechanical expression or the combination of the two processes. For mechanical expression, hydraulic or screw press is employed. The oil is used locally for cooking, lighting and as body cream. It is also used for production of soap, cosmetic and margarine. Further processing improves the quality of the oil (Kheiri, 1985). Good quality edible oil is fresh, pure, free from odours, and any sign of rancidity.

The acceptability of the products at world edible oil market depends on its ability to satisfy basic standard tests for fats and oil (Takakura, 2002).

Edible oil can be extracted from cashew nuts but no evidence of it being carried out commercially has been found. The cashew apple is very sour and astringent until fully ripe, when it becomes edible. In contrast to the nut, the apple was neglected until recently, although it is available in far greater tonnage. A number of processes have now been developed for converting the cashew apple into various products such as juice, jam, syrup, chutney and beverage (Winterhalter 1991).

The fat of nut is completely natural and unprocessed which is best for the body. It is especially rich in Linoleic acid (Omega-3) and is least damaging to heart and arteries. In fact, it constitutes about 47% of the total weight of the nut. Nuts often produce oil half their weight. This could be good news for people who feel weak or debilitated. Cashew has what is called the 'good fat. Cashew has the right combination of fat and the ratio of saturated to monounsaturated and polyunsaturated is 1:2:1 which is ideal for human consumption. The relative abundance of monounsaturated fatty acids in cashew nut is conducive to the promotion of good health and that the relative abundance of fat in cashew nut in no way poses a nutritional risk (Achal 2005).

Studies have shown that groundnut oil contains much potassium than sodium and is a good source for calcium, phosphorus and magnesium. It also contains vitamin E, selenium, zinc and arginine (Evans et al., 1974; Hariod, 1990). Findings have demonstrated that diets high in groundnut oil are as effective as olive oil in preventing heart disease and are heart healthy than very low fat diets (Pattee and Young, 1989; Hariod, 1990).

2. MATERIALS AND METHODS

2.1. Description of the Screw Press

The isometric view of the screw press is shown on Figure 1. The screw press consists of the frame, piston, press cage cylinder, collector (tray) and the heater band as its major components for efficient operation. The rigid frame which holds the ram shaft is made of 3 inches angle iron and support the pressure created by the screw. It is well constructed and firmly mounted to the work surface before the pressing operation begins. The frame also comprises of two beams and four columns. The piston is a solid screw, and provides the necessary pressure required for the expression of the oil from the seeds. The press cage is a pipe made of mild steel of 10mm thickness, inner diameter 150mm and outside diameter 160mm with the overall height of 210mm, it has an opening through which the oilseed would be admitted in to the cage and also consists of perforations at its lower part for oil drainage. The oil is drained into the oil collector placed below the cage through the perforations. The heater band is attached to the cage to generate the necessary heat required for the oil expression. The oil collector tray is a mild steel plate of 20mm thickness and 200mm diameter. A galvanized plate of 1mm thickness was wedged round the plate for easy collection of the oil. A circular groove of 10mm deep is made on the flat plate and the groove has the same diameter as the external diameter of the cage with little clearance of 0.05mm in order to allow the easy fixing and removal of the press cage cylinder, The heater band generates the heat required for the oil extraction and the electronic temperature controller regulate the current that flows in to the system and thereby regulate the temperature of the press cage.

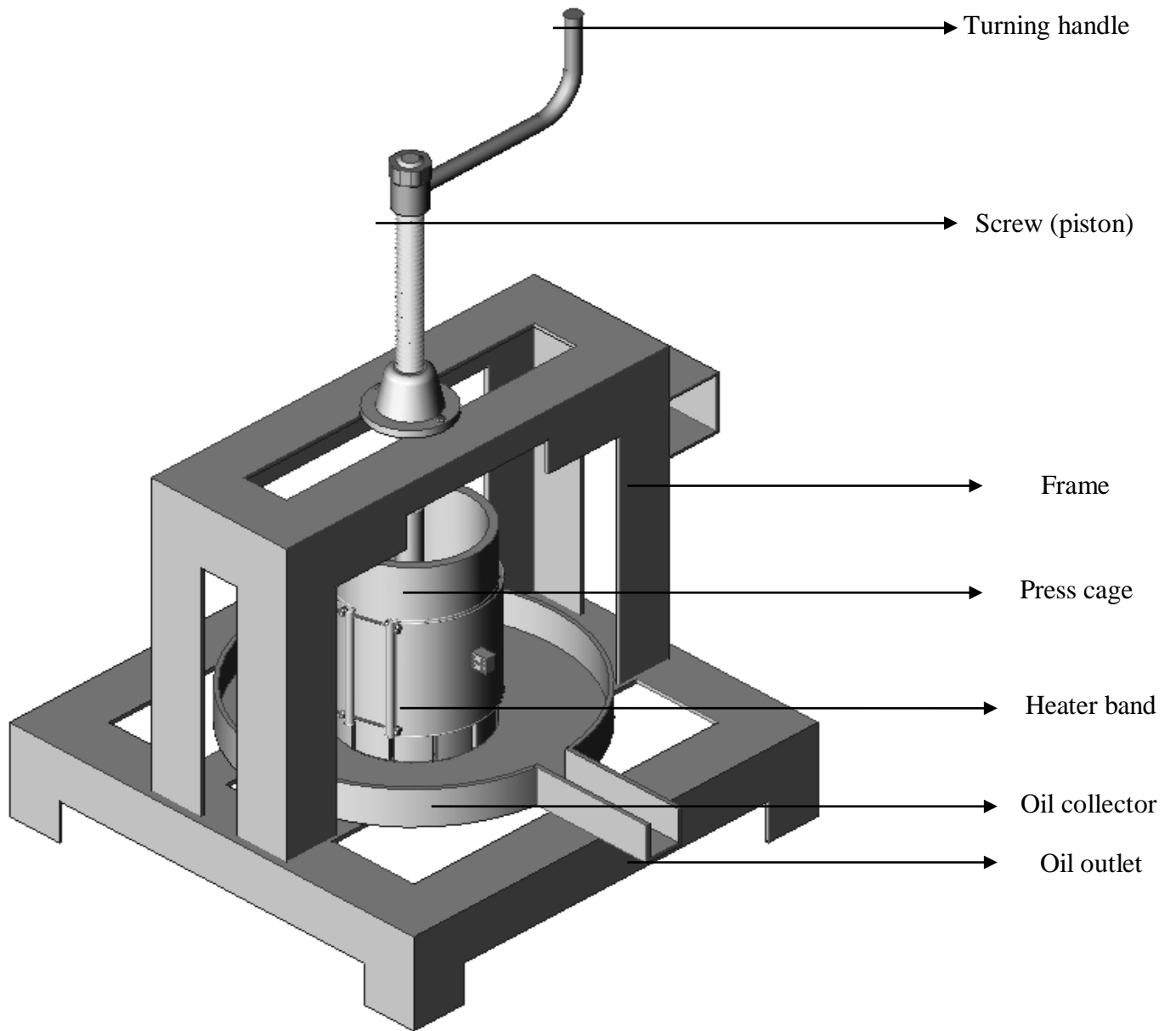


Figure 1: Isometric view of the Screw Press

2.2. Sample Preparation

The groundnut seeds used for the evaluation of the screw press were purchased from Uchi market Auchi Edo State, Nigeria while the cashew kernels were purchased from cashew processing plant located at Ogbodoroko village in Ilorin, Kwara State, Nigeria. The initial moisture content of the two samples were determined to be 8 and 8.5% wb for groundnut seed and cashew kernels respectively before the samples were sundried to a moisture content below 6.5% which is appropriate for oil extraction. The samples were then grinded to a uniform granular size using attraction mill before conditioning and pressing operation.

2.3. Extraction Procedure

During the performance evaluation of the machine (Figure 2), the grounded samples were weighed using weighing balance and later transfer in to the pressing cloth before pressing in order to prevent the grounded samples from coming out of the perforations made on the press cage cylinder. During the pressing operation, the electronic controller device was regulated to various heating temperatures under considerations in order to maintain the temperature of the sample inside the cage. Pressing was done for 10 minute before the cake was extruded and weighed and then the weight of oil was taken and recorded for each of batches.



Figure 2: Pictorial view of the screw press during pressing operation

2.4. Measurements and Calculations

2.4.1. Sample Conditioning

The samples after milling was conditioned to different moisture content of 7, 8 and 9% wb by adding a calculated amount of water to a known kilogram of the samples using the equation reported by Yusuf, (2012).

$$\text{Amount of water (g)} = \left\{ \left(\frac{100 - I_m}{100 - R_m} \right) - 1 \right\} \times M g \quad (1)$$

I_m = initial moisture content of the sample (%)

$R_m =$ required moisture content (%)

$M_g =$ mass of sample (g)

2.4.2. Determination of Extraction Efficiency

The extraction efficiency of the machine is expressed as optimum extraction capacity of the machine and it is determined mathematically as:

$$EE (\%) = \frac{W_{OE}}{XW_{TS}} \times 100\% \quad (2)$$

Where;

$OE =$ Oil yield (%)

$EE =$ Extraction Efficiency (%)

$W_{OE} =$ Weight of oil extracted (Kg)

$W_{CK} =$ Weight of cake (Kg)

$W_{TS} =$ Total Weight of Sample (Kg)

$X =$ Oil content (44 and 47% for groundnut and cashew kernel respectively)

3. RESULTS AND DISCUSSION

The data obtained for the average values of extraction efficiency for cashew kernel and groundnut seed extraction at different heating temperatures and moisture content using the screw press is as shown on Table 1.

Moisture Content (%)	Heating Temperature ($^{\circ}$ C)	Extraction Efficiency (%)	
		Cashew kernel	Groundnut seeds
7	80	60.66 \pm 0.56	70.80 \pm 0.49
	90	70.00 \pm 0.03	80.00 \pm 0.04
	100	71.98 \pm 0.11	81.53 \pm 0.16
	110	71.01 \pm 0.04	79.94 \pm 0.12
8	80	65.35 \pm 0.21	64.08 \pm 0.09
	90	74.92 \pm 0.12	73.81 \pm 0.01
	100	77.01 \pm 0.15	75.87 \pm 0.02
	110	76.13 \pm 0.27	74.99 \pm 0.01
9	80	72.95 \pm 0.08	59.86 \pm 0.02
	90	81.02 \pm 0.06	65.95 \pm 0.01
	100	82.00 \pm 0.04	70.79 \pm 0.01
	110	81.05 \pm 0.03	68.96 \pm 0.01

3.1. Effects of Heating Temperature on the Extraction Efficiency of the Screw Press at different Moisture Content

Figure 3, 4 and 5 represent the effects of heating temperature on the extraction efficiency of the screw press at 7, 8 and 9% wb moisture contents respectively.

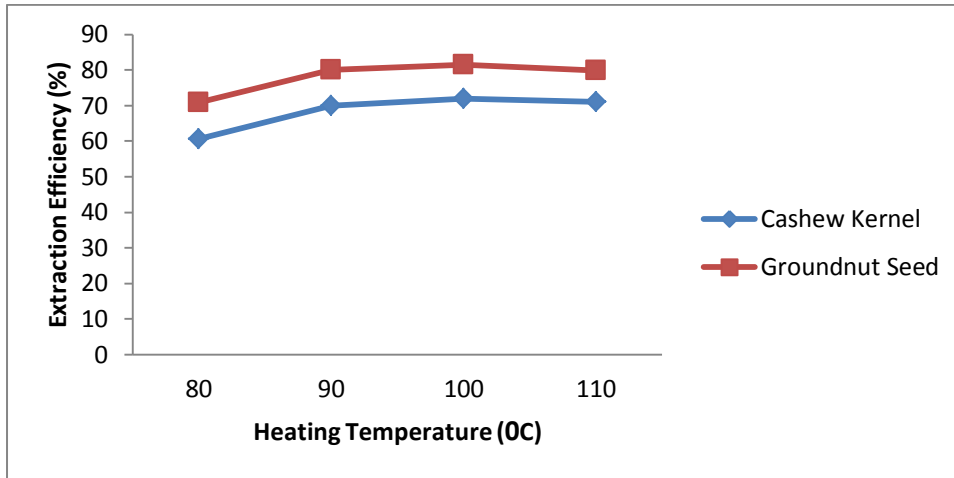


Figure 3: Effects of Heating Temperature on the Extraction Efficiency of the Screw Press at 7% Moisture Content

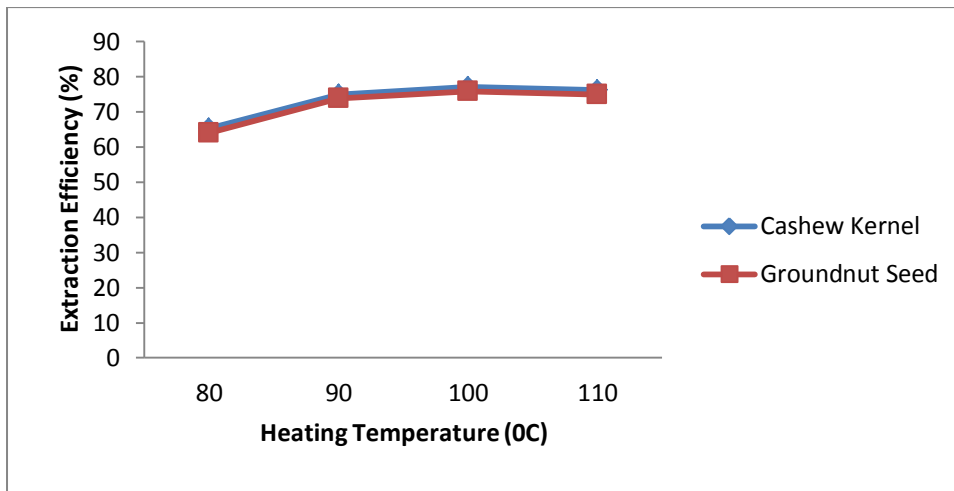


Figure 4: Effects of Heating Temperature on the Extraction Efficiency of the Screw Press at 8% Moisture Content

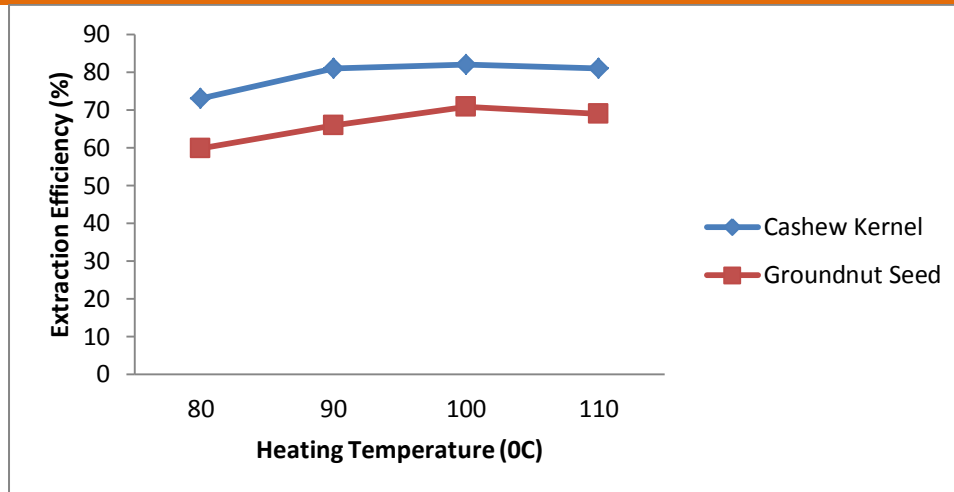


Figure 5: Effects of Heating Temperature on the Extraction Efficiency of the Screw Press at 9% Moisture Content

4. CONCLUSION

The performance evaluation of the screw press was investigated for extraction of cashew kernels and groundnut seeds. Effects of heating temperature and moisture content of samples on extraction efficiency was determined. The study result established that heating temperature and moisture content has significant effects on the extraction efficiency of the screw press irrespective of the samples. The extraction efficiency increases with increase in heating temperature but tend to decrease as the temperature rise above 100°C for both samples. Also, the extraction efficiency increases with increase in moisture content of cashew kernels but the reverse is the case for groundnut seeds. The heating temperature of 100°C produces the optimum extraction efficiency of 80.00% and 81.53% for cashew kernel and groundnut seeds respectively at an average extraction time of 10 minute in all cases.

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