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Oil point pressure of cashew *(Anacardium occidentale)* kernels

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A b s t r a c t. The effects of moisture content (4, 6, and 8%), heating temperature (70, 85, 100, and 115°C) and heating time (15, 25, 35 and 45 min) on the oil point pressure of coarsely ground and finely ground cashew kernel aggregates were investigated using a laboratory press. For aggregates it was observed that oil point pressure decreased significantly with increase in moisture content, heating temperature and heating time. The lowest oil point pressure values obtained were 0.1572 MPa (for fine cashew kernel aggregates at a moisture content of 4% heated at 115°C for 45 min) and 0.1664 MPa (for coarse cashew kernel aggregates at a moisture content of 6 % heated at 100°C for 45 min). For both particle sizes at moisture content >8 % and heating temperature >100°C, the dead weight of the hydraulic press was sufficient to bring oil out of the oil bearing cells.

K e y w o r d s: cashew kernels, oil point, particle size, temperature, time, moisture content

INTRODUCTION

Cashew nut (*Anacardium occidentale*) is one of the most valuable edible nuts in the world due to its kernel which is widely consumed in Europe, United States of America and Asia (ITDG, 2005; Andrighetti *et al.,* 1994). Some of the major exporters are India and Brazil, sharing 60 and 31% of the world market, respectively. During the last two decades, cashew nut production in Nigeria increased from 25,000 metric tonnes in 1980 to about 200,000 metric tonnes in 2001 (Azam-Alli and Judge, 2001), making Nigeria one of the leading producers in Africa. Commercial processing of cashew nut into kernels is traditionally popular in India and Asia, but Nigeria like some other cashew producing countries who hitherto were exporting raw cashew nuts are now building capacity for local processing in order to increase obtainable revenue from cashew when it is exported as processed kernels. Though cashew nut is an oil seed, not much has been officially documented on oil expression from the kernel. USDA (2002) reported that cashew kernel consists of 46.92% edible oil, 8.33% saturated fatty acid, 25.46% unsaturated fatty acid and 20.02% amino acids. Previous research works on oil expression were focused on groundnut, soybean, cotton seed, conophor seed, palm kernel, rape seed, sesame seed, sunflower, crambe seed and castor oils (Adeeko and Ajibola, 1990; Ajibola *et al.,* 1993, 2000, 2002; Farsaie and Singh, 1984; Fasina and Ajibola, 1989; Koo, 1987; Oyinlola and Adekoya, 2004; Singh *et al.,* 2004; Sukumaran and Singh, 1989).

Oil can be obtained from an oil seed through mechanical methods or solvent extraction (Oyinlola and Adekoya, 2004). Mechanical expression of oil involves the application of pressure (using hydraulic or screw presses) to force oil out of the oil bearing material. In solvent extraction, solvent such as naphthalene is usually applied to remove oil from the material. Mechanical expression is, however, preferable due to the fact it is economical compared with the solvent process. Certain pretreatment operations known to influence oil yield in mechanical oil expression include heat treatment, moisture conditioning and size reduction (Adeeko and Ajibola, 1990; Ajibola *et al.,* 1993; 2000; Dedio and Dornell, 1977; Hamzat and Clarke, 1993; Oyinlola and Adekoya, 2004). Heat treatment of oil seed has been observed to rupture the oil bearing cells of the seed, coagulate the protein in the meal, adjust the moisture level of the meal to optimum level for oil expression, lower the viscosity and increase the fluidity of the oil to be expelled and destroy mould and bacteria thereby facilitating oil expression from the material (Adeeko and Ajibola, 1990). The optimum heating temperature for most oil seeds has been observed to be in the range of 90-110°C at an average retention time of 20 min (FAO, 1989). Norris (1964) reported that size reduction, heat treatment and application of pressure are required for efficient oil expression from oil seeds with large particle sizes.

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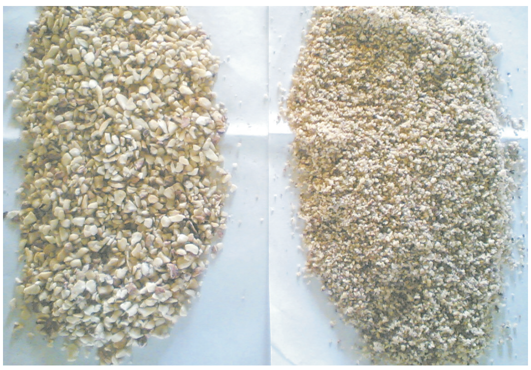
Dedio and Dornel (1977) found that increasing the moisture content of flake seed from 8 to 16% decreases oil yield. At higher moisture level mucilage is developed in the outer cell and the addition of more water causes swelling of the mucilage and this produces a cushioning effect which prevents the rupturing of the oil cells. Oil point pressure indicates the threshold pressure at which oil emerges from a seed kernel during mechanical oil expression (Ajibola *et al.,* 2002; Faborode and Favier, 1996). The effective pressure to be applied to an oil seed for the oil-bearing cells to start discharging their contents is determined by first identifying its oil point pressure. This helps to optimise the pretreatment and pressing operation for efficient oil expression from that seed. For most seed kernels, oil point pressure is determined by varying the heating temperature, heating time, moisture content and applied pressure (Ajibola *et al*., 1993; Owolarafe *et al.,* 2003; Sukumaran and Singh, 1989). The optimal condition at which the oil point pressure of an oil seed is identified improves the oil expression efficiency and provides useful information for design and performance evaluation of oil expellers (Mrema and McNulty, 1985). This study was therefore undertaken to investigate the effects of some processing conditions such as moisture content, heating temperature, heating time and particle size on the oil point pressure of cashew kernel.

MATERIALS AND METHODS

Seventy kilograms of cashew kernels were obtained from Olam Nigeria Ltd, Oyo town, Nigeria. A laboratory press, Gallenkamp 300, plus oven and Metler electronic weighing, available in the materials testing laboratory, Department of Agricultural Engineering Obafemi Awolowo University, Ile Ife, were also used in the study.

Samples were classified into two different particle sizes – coarse and fine aggregates, as documented by Adeeko and Ajibola (1990). Coarse aggregates passed through 5.6 mm sieve aperture while fine particles passed through 2.36 mm sieve aperture (Fig. 1).



Coarse Fine

Fig. 1. The cashew kernel aggregates used for the experiment.

Foreign and extraneous materials were removed manually from the kernels. The kernel sizes were reduced into fine and coarse aggregates based on the findings of Adeeko and Ajibola (1990). The moisture content was determined by heating 30 g of cashew kernels for six hours at 130°C in Gallenkamp 300 plus Series (Young *et al.,* 1982).

$$MC_{wb} = \frac{m_b - m_a}{m_b - m_c} 100\%, \qquad (1)$$

where: MC_{wb} – moisture content (wet basis), m_b – weight of container plus sample before oven drying, m_a – weight of container plus sample after oven drying, m_c – weight of container.

This moisture content was adjusted to 4, 6, and 8%. Moisture adjustment was carried out by adding water to the sample to raise the moisture from the initial value (3.2%) to the required level of 4, 6, and 8%. The amount of water that was added was determined by the formula:

$$MC_{db} = \frac{MC_{wb}}{100 - MC_{wb}} 100\%, \qquad (2)$$

$$m_w = MC_{db}\ m_d\,, \qquad (3)$$

where: MC_{db} – moisture content (dry basis), MC_{wb} – moisture content (wet basis), m_d – mass of dry matter, m_w – mass of water to be added.

The samples were sealed in labelled polyethylene bags and kept in a freezer at -10°C until the time of use (Adebona *et al*., 1986; Mpagalile *et al.,* 2006,2007; Singh *et al.,* 2004). At the time of use, the samples were removed from the freezer 24 h before experimentation to allow gradual thawing and moisture equilibration of the samples. After this, 30 g of each sample was heated in the oven at heating temperatures of 70, 85, 100, and 115°C for 15, 25, 35 and 45 min using a 2 × 4 × 4 factorial experimental design. The factors and the levels selected were based on review of literature on other oil seeds. The moisture loss due to evaporation under different combinations of heating temperature and time was calculated. The samples were then put inside a cylindrical container which had several 2 mm holes drilled at the base to allow oil passage during pressing. The holes were stuffed with tiny strips of tissue paper so as to spot oil when the oil point was attained.

A diagram and picture of the laboratory oil press used for pressing operation are shown in Fig. 2. The lever which served as a pressure transfer medium had a dead weight of 90 kg and an effective length of 3000 mm. The weight of the loading drum was 30 kg. The pressure transferred from the lever arm to the sample in the test cylinder through the point load and compression piston was varied by moving the cylinder and its content along the lever arm. The test cylinder was a 50 mm long galvanized steel pipe with an internal diameter of 40 mm. The cylinder had one of its ends closed with a 12 mm thick metal base with 2 mm holes drilled at a pitch of 15 mm. The compression piston was a solid steel cylinder, 70 mm long and 39 mm in diameter. A 20 metric

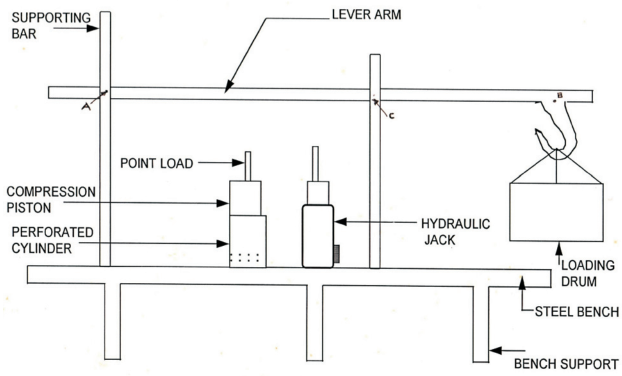


Fig. 2. Schematic diagram of the laboratory press (Ajibola *et al*., 2000, 2002).

tonnes hydraulic jack was used to raise and lower the lever bar for applying pressure to the sample. Oil point was identified by using the method adopted by Ajibola *et al.* (2000, 2002), and Sukumaran and Singh (1989) on sesame seed, soybean, and locust bean, respectively. The cylinder containing the sample was placed under the compression piston. Known weight was added to the loading drum while the lever arm was suspended by the hydraulic jack. The jack was released gently to allow the suspended lever arm to lower down gradually to rest on the pressing ram and compression piston.

The pressure generated was transferred through the cylinder onto the kernels. The jack was then used to lift the lever arm in order to remove the cylinder and piston. After each pressing operation, the tissue paper strips in the holes of the cylinder were removed and examined for oil marks (which was an indicator whether the pressure at that point due to the load was sufficient to bring oil out of the kernel or not). The distance from this point to the support was measured and converted to pressure using the principle of moment of forces.

RESULTS AND DISCUSSION

Effect of processing conditions on oil point pressure of coarse aggregates of cashew kernels

The average oil point pressure of coarse aggregates under different processing conditions of heating temperature, heating time and moisture content are shown in Table 1. The results showed that the oil point pressure reduced with increase in heating temperature and heating time at all moisture levels. It can be seen that oil point pressure reduced with increase in temperature;this is due to the fact that moisture is lost due to temperature rise during heat treatment, which facilitates rupturing of oil bearing cells, creating a void which serves as migratory space for the contents of the oil bearing cells as heating continues (Adeeko and Ajibola, 1990). This also lowers viscosity of oil and coagulates protein, thus enabling oil to ooze out of the cell into the inter-kernel void (Ajibola *et al.,* 1993). Similar results were obtained by Ajibola *et al.* (2002), Owolarafe *et al.* (2003) and Sukumaran and Singh (1989), for the oil point pressure of soybean, locust bean, and rapeseed respectively. Furthermore, it was observed that oil point pressure decreased with increase in moisture content from 4 to 6 % at temperatures of 70, 85, and 100°C, this because there was adequate moisture to transfer oil from the oil bearing cells and it suggests that 4% moisture is too low for oil to flow out readily. Oil point pressure was, however, observed to slightly increase with increase in moisture content from 4 to 6% at a temperature of 115^{o}C because the pressure required to bring out oil of the oil bearing cells was higher. This also agrees with findings of previous researchers (Adeeko and Ajibola, 1990; Ajibola *et al.,* 1993; Fasina and Ajibola, 1989; and Owolarafe *et al.,* 2003) on oil expression from groundnut, sesame seed, conophor nut, and locust bean, respectively. Oil point pressure increases as moisture content increases for heating temperatures 70 and 115°C, implying that at this two temperature heat treatment resulted in relatively low oil point pressure. When the air pick-up efficiency is high, water evaporates faster from the surface of the product than from the inside; the surface becomes hard and dry, it stops further diffusion of the water in the product thus requiring more force to press oil from the kernel (Senadeera and Kalugalage, 2004; Shanmugam and Natarajan, 2007). Temperature increase causes evaporation of all free water as the evaporation front progresses towards the centre of the product, making moisture transfer more difficult. The soluble compounds brought up to the surface of the product by the movement of the water clog the pores of the product thereby requiring high pressure to extract oil at 8% moisture contents.

T a b l e 1. Oil point pressure of coarsely ground cashew kernels under different processing conditions

Heating temperature (°C)	Heating time (min)	Moisture content (%)		
		4	6	8
		Mean values oil point pressure (MPa)		
70	15	0.2270^{a}	0.2137^{a}	0.2170^{cd}
	25	0.2166^{b}	0.1957^{cd}	0.2092^{ef}
	35	0.2166^{b}	0.2033^{bc}	0.2180^{bcd}
	45	0.2166^{b}	0.2103^{ab}	0.2224^{abc}
85	15	0.2135^{b}	0.2013^{c}	0.2243^{a}
	25	0.2073^{c}	0.2013^{c}	0.2231^{ab}
	35	0.2023^{d}	0.1909^{de}	0.2240^{ab}
	45	0.1994^{d}	0.1807^{fgh}	0.2155^{d}
100	15	0.1948^{e}	0.1855^{ef}	0.2155^{d}
	25	0.1846^{f}	0.1791^{fgh}	0.2135^{de}
	35	0.1814^{f}	0.1705^{ij}	0.2083^{ef}
	45	0.1760^{g}	0.1664^{j}	0.2042^{f}
115	15	0.1750^{g}	0.1796^{fgh}	0.1948^{d}
	25	0.1698^{h}	0.1830^{fg}	0.1879^{h}
	35	0.1700^{h}	0.1740^{ih}	0.183^{h}
	45	0.1671^{h}	0.1773^{igh}	0.183^{h}

a,b, c, d, e, f, g, h: means on the same column with the same superscript are not significantly different (P>0.05).

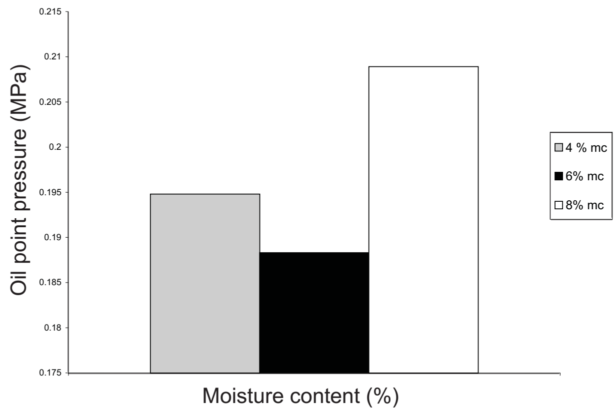


Fig. 3. Effect of moisture content on the oil point pressure of coarsely ground aggregates of cashew kernel.

In Fig. 3 it is shown that oil point pressure increased significantly ($p<0.05$) for all moisture levels considered. It first reduced from 4 to 6%, then increased as moisture content increased to 8%. The effect of moisture level on oil expression efficiency may be due to mucilage on the outer walls of the particles which swells with more water producing a cushioning effect which prevents rupturing of oil cells thereby hindering free oil flow leading to a higher oil point pressure. When moisture adjustment is low, the space or void created in the oil bearing cells becomes very small to hold substantial amount of oil, therefore oil expression will require higher pressure (Tunde-Akintunde *et al*., 2001). The highest oil point pressure of 0.2773 MPa was recorded at 4% moisture content with heating temperature of 70°C for 15 min, although the effect was not significantly different from the 8% moisture content with heating temperature of 85°C for 15, 35 and 25 min. The lowest oil point pressure of 0.1773 MPa was recorded at 6% with heating temperature of 115°C for 45 min. The relationship between oil point pressure, heating time and moisture contents at 85°C for coarsely ground aggregates is shown in Fig. 4.

Effect of processing conditions on oil point pressure of finely grounded cashew kernels

The average oil point pressure values of fine aggregates under different processing conditions of heating temperature, heating time and moisture content are shown in Table 2. It shows that the higher the heating temperature, heating time and initial moisture content, the higher the moisture loss due to heating. It was also found that oil point pressure decreased as heat treatment increased. Using dead weight of the hydraulic press, oil was expressed at 0.155 MPa without subjecting the samples to any processing conditions. Tunde-Akintunde *et al*. (2001) reported that when a large surface area is exposed to heat there will be moisture adjustment, protein coagulation, lowering of viscosity of the oil, which causes rupturing of the oil bearing cells leading to very low oil point pressure. Oil point pressures at 4 and 6% moisture contents were relatively higher than at 8%. At heating temperatures of 100 and 115°C and at 4% moisture content, the oil point pressure fell rapidly at 35 min, which may be due to the complete removal of water from the oil bearing cells. Oil point was observed to reduce with increase in heating tem-

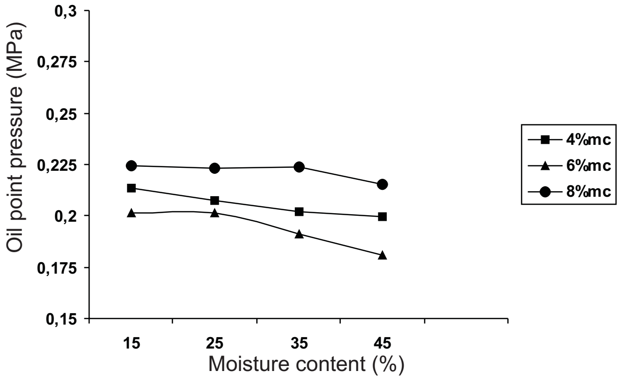


Fig. 4. Relationship between oil point pressure, heating time and moisture contents at 85°C for coarsely ground aggregates.

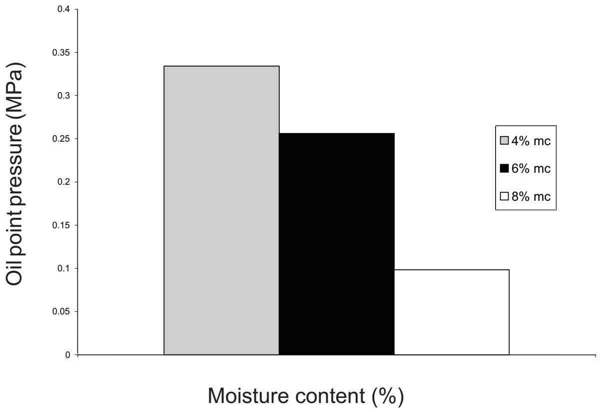


Fig. 5. Effect of moisture content on the oil point pressure of finely ground aggregates of cashew kernel.

perature and heating time at all moisture level considered in the study. However, oil point was observed to increase with increase in moisture content form 4 to 6%, contrary to what was observed for coarsely ground kernels.

For finely ground sample, as heat treatments increased, oil point pressure progressively decreased. The rate of drying got higher with increase in surface area exposed to heat treatment; the oil point pressure of finely ground aggregates was therefore lower. However, at heating temperature of 100°C, the oil point pressure tends towards zero (Fig. 5). At 8% moisture content, it was observed that oil expression was possible without subjecting the samples to any heat treatment. This is as a result of weakening of the cell wall by too much moisture which therefore required little or no effort to bring out oil from the oil bearing cells.

Effect of particle sizes on the oil point pressure

The effect of particle size on oil point pressure is shown in Tables 1 and 2, when the values in both cases are compared. For the two particle sizes, the highest oil point occurred at heating temperature of 70°C, heating time of 15 min and 4% moisture content. The lowest oil point pressure of 0.1572 MPa was recorded for fine particles at heating temperature of 115°C, heating time of 45 min and moisture content of 4%. For coarse particles, the lowest oil point pressure of 0.1664 MPa recorded was at heating temperature of 100°C, heating time of 45 min and 6% moisture content. Therefore, the overall lowest pressure for expressing oil from finely ground cashew kernel is obtainable at 4% moisture content, heating temperature of 115°C and heating time of

T a b l e 2. Oil point pressures of finely ground cashew kernels under different processing conditions

Heating temperature (°C)	Heating time (min)	Moisture content (%)		
		4	6	8
		Mean values oil point pressure (MPa)		
70	15	0.2940^{a}	0.2728^{c}	0.2125^{a}
	25	0.2899^{a}	0.2899^{ab}	0.2042^{bc}
	35	0.2899^{a}	0.2890^{ab}	0.2062^{b}
	45	0.2784^{b}	0.2841^{ab}	0.1970^{d}
85	15	0.2784^{b}	0.2784^{c}	0.2004^{cd}
	25	0.2644^{c}	0.2730^{c}	0.1948^{d}
	35	0.2517^{d}	0.2734^{c}	0.1846^{e}
	45	0.2460^{e}	0.271^{c}	0.1719^{f}
100	15	0.235^{f}	0.2445^{d}	0.000^{g}
	25	0.2156^{g}	0.2323^{ef}	0.000^{g}
	35	0.2083^{h}	0.2324^{ef}	0.000^{g}
	45	0.1985^{i}	0.2261^{f}	0.000^{g}
115	15	0.193^{j}	0.2403^{ed}	0.000^{g}
	25	0.1785^{k}	0.2324^{ef}	0.000^{g}
	35	0.1672^{L}	0.2324^{f}	0.000^{g}
	45	0.1572^{m}	0.2336^{ef}	0.000^{g}

a,b, c, d, e, f, g, h: means on the same column with the same superscript are not significantly different (P>0.05).

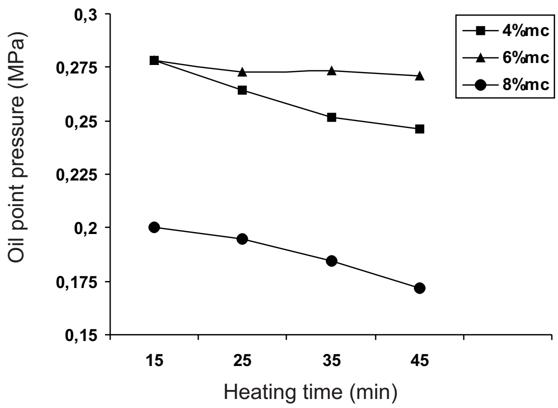


Fig. 6. Relationship between oil point pressure, heating time and moisture contents at 85°C for finely ground aggregates.

45 min, if the cost of machinery involved in breaking down kernels to fine particles will not add significantly to the cost of production. Otherwise a coarse particle of 6% moisture content can be subjected to heating temperature of 100°C and heating time of 45 min. A typical relationship between oil point pressure, heating time and moisture contents at 85°C for finely ground aggregates is shown in Fig. 6.

CONCLUSIONS

1. It was found that oil point pressure decreased with increase in heating temperature and heating time. This shows that the heat treatment caused breakdown of oil cells and increased oil flow from the oil bearing cells.

2. For coarsely ground particles, oil point pressure first reduced from 4 to 6%, then increased as moisture content increased to 8%, while for finely ground particles oil point pressure reduced with increase in moisture content.

3. Oil point pressure for the coarsely ground cashew kernel particles was found to be lower than that of the finely ground particles.

4. Generally, oil expression from an oil seed involves heat treatment, particle size reduction, moisture conditioning and pressure application. These require a lot of energy and material input.

5. Consequently, optimal conditions that guarantee high oil yield of good quality are usually sought for oil expression.

6. The pressure applied to an oil seed can be partitioned into oil point pressure and the effective pressure.

7. The effective pressure for oil expression determines to an extent oil yield from that seed.

8. For a given applied pressure, the lower the oil point pressure the higher the effective pressure for oil expression. This therefore maximizes oil yield.

9. The results of this study suggest that in oil expression from cashew kernel, high oil yield could be obtained by processing coarsely ground particles at low moisture levels.

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