Mechanical Oil Expression from African Oil Bean Seed as Affected by Moisture Content and Seed Dimension

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Abstract: Present production level of vegetable oil cannot meet the demand of the citizenry; new low cost oil seeds are needed to produce inexpensive and readily available oil suitable for food, pharmaceutical and industrial applications especially from under-utilized oil seed crop like African oil bean. Investigations were carried out on effect of moisture content and seed dimension on mechanical oil expression from African oil bean seed using an oil expeller. Fresh seeds were procured, de-hulled and found to have initial moisture content of 12%db; the seeds were conditioned by dehydration and rehydration prior to oil expression to obtain moisture levels 8, 10, 12, 14 and 16%db. Major diameter of the seeds were measured using digital vernier caliper and further classified into size dimensions (<40, 41-45, 46-50, 51-55, >55mm). Oil yield and expression efficiency were obtained in accordance with standard evaluation methods. Highest oil yield and expression efficiency (51.7 and 85.4%) was obtained at moisture content 8%db and seed dimensions less than 40mm while lowest oil yield and expression efficiency was obtained at 14%db and seed dimension >55mm. Increase in moisture content causes reduction in oil yield and expression efficiency while increase in the seed dimension causes decrease in the oil yield. African oil bean seed contains high oil yield; extraction of the oil will aid its commercialization and boost its economic status.

[Ademola K. AREMU and Clement A. OGUNLADE. **Mechanical Oil Expression from African Oil Bean Seed as Affected by Moisture Content and Seed Dimension.** *J Am Sci* 2017;13(9):67-73]. ISSN 1545-1003 (print); ISSN 2375-7264 (online). http://www.jofamericanscience.org. 7. doi:10.7537/marsjas130917.07.

Keywords: moisture content, seed dimension, oil yield, expression efficiency, African oil bean seed

1. Introduction

Due to existing huge market for vegetable oil, the market unfortunately has been flooded with adulterated and different types of vegetable oil, including health hazard products which cause heart problems, obesity, hypertension and cancer among others. To most people, there is no difference between vegetable oil products since they all almost look alike and can perform the same function, they believe all are good for consumption (Obi, 2013). Moreover, there is an increasing consciousness in eating and drinking habits of some; they are careful of excess sugar in beverages because of diabetes and also mindful of cholesterol, fattening foods, additives and preservatives in food. Oil seed plants are good preventive sources against such ailments and many more including arthritis, rheumatism, sexually transmitted diseases, hypertension, boils and several other life-threatening diseases (Eilert *et al*., 1981). There is a steady rise for the demand of vegetable oil in most developing countries for nutritional, pharmaceutical and industrial importance, this oil can be obtained from various agricultural products especially oil seed crops. Vegetable oil has been extracted from cotton, sesame, groundnut, melon, palm kernel, castor oil, soybean, corn, pumpkin, moringa, sunflower, rapeseed, roselle etc however, African oil bean (*Pentaclethra macrophylla* Benth) seeds, a leguminous tree of the family leguminosae and sub-family mimosoideae cultivated in Nigeria since 1937 (Ladipo, 1984; Ladipo and Boland, 1995) has been found to contain oil which can be extracted to serve as an additional vegetable oil since no oil from a single source can be suitable for all purposes (Ramadan and Morsel, 2003). Presently, the quest for traditional vegetable oils has increased immensely because of the ever-growing World population and their use for industrial purposes thus leading to illegal importation of oil. There gaps in the vegetable oil market as the present production level in Nigeria cannot meet the demand of Nigerians (Obi, 2013) hence; new low cost oil seeds are needed to produce inexpensive and readily available oil suitable for food, pharmaceutical and industrial applications. Separation of oil from oilseeds is an important processing operation; the process employed has direct effect on the quality and quantity of oil obtained from the oilseeds. Basically, two methods are used for this purpose; solvent extraction 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, this method is highly efficient (over 98% oil recovery) but requires a large infrastructure with high initial cost, there is also fire and pollution hazard as it requires large quantities of highly flammable solvents and very high technical-know-how The other method used involves mechanical oil expression in which the preconditioned oilseed is passed through a screw press where a combination of high temperature and shear is used to crush the oilseed to release the oil. The oil expression efficiency of mechanical method depends on the oilseed and some pre-treatment conditions; it involves very low initial and operating costs compared to the solvent method of oil extraction and is relatively free of any polluting or fire hazardous substances. Previous studies on African oil bean seed have been focused on medicinal and nutritional aspects of the plant with very few information available on the solvent extraction of oil from the seeds however, literature is very scarce on mechanical oil expression from African oil bean seeds and optimization of the mechanical oil expression. The optimization of mechanical oil expression from African oil bean seeds is of utmost importance for the development and commercialization of this potential underutilized oil seed crop. The objective of this study is to determine the effect of independent variables (moisture content and seed dimension) on the oil yield and expression efficiency from African oil bean seeds.

2. Material and Methods

Mechanical method of oil expression from oil bearing agricultural products was adopted for this research with the aid of an oil expeller (Plate 1).

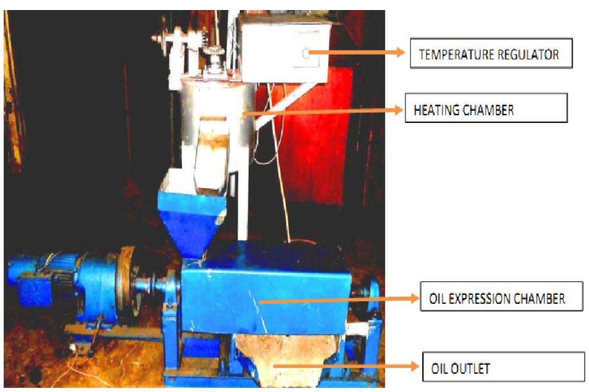

Plate 1: Oil Expeller

The oil yield and expression efficiency was determined in accordance with Phillipines Agricultural Engineering Standard PAES 230 and 231 for oil expellers. The weight of oil obtained, input materials were taken using an Electronic Compact Scale (SF 400A, 5000g x 1g), the following relationships were used accordingly to obtain the oil yeid and expression efficiency:

$$Oy = \frac{Wo}{Wi}\ x\ 100\% \quad \ldots 1$$

$$E_e = \frac{W_o}{X.w_i}\ x\ 100\% \quad \ldots 2$$

Where: *Oy* is the oil yield (%), *Wo* is the weight of oil collected (g), *Wi* is the weight of seeds fed into the hopper (g), *Ee* is the extraction efficiency (%), *X* is the oil content of African oil bean seeds [0.604]

Sample Collection and Preparation: fresh seeds of African Oil Bean were procured from Ojoo market, Akinyele Local Government, Ibadan, Oyo State, Nigeria. The seeds were visually inspected to discard the defective ones, they were decorticated by removing the hulls and the beans were kept in air-tight polythene bags. Fresh un-dehulled and dehulled African oil bean seed samples are presented in Plate 2a and b.

a

b

Plate 2: a- Undehulled, b- dehulled African Oil Bean Seeds

Effect of Moisture Content and Seed Dimension on Oil Yield and Expression Efficiency: the oil yield and efficiency of expression depend on crop parameters like moisture content and seed dimension. The initial moisture content of the seeds was determined using ASAE (1998) method for determining moisture content of oil seed crops by oven drying the seeds at 105^{0}C to constant weight. The initial moisture content of the seeds was obtained to be 12 % dry basis, the seeds were preconditioned to varying levels of moisture by dehydrating them to moisture levels 8 and 10 %db and rehydrating them to moisture levels 14 and 16 % dry basis. Mass of water added to obtain a predetermined moisture content level during rehydration was obtained using Equation 3 (Bisht, 1986):

$$Q = \frac{A(b-a)}{(100-b)} \quad \dots 3$$

Where: Q is the mass of water added (g), A is the initial mass of samples, a is the initial moisture content of samples and b is the final (desired) moisture content of samples.

Moreover, major diameter of the seeds were measured using a digital vernier caliper, the major diameter of the seeds was found to range between 38.32-66.28mm thus, the seeds were classified into five size fractions (<40, 41-55, 46-50, 51-55 and >55mm) to obtain the effect of size dimension on oil yield and expression efficiency. The purpose of size reduction is to expose a greater area of oil-bearing cells to the moisture and heat during cooking (Ibrahim and Onwualu, 2005). The number of experiments for the determination of effect of moisture content and seed dimension on oil yield and expression efficiency was determined using the Equation 4 (Harper and Wanninger, 1969, Akinoso *et al.,* 2006a and 2006b).

$$N = (L_1)(L_2)(L_3) \dots \dots \dots \dots \dots \dots (L_m) \quad \dots 4$$

Where: N is the number of experiment (25), L is the levels of independent variables (5 each) and m is the number of independent variables (2).

3. Results

The effect of moisture content and seed dimension on the mechanical oil expression African oil bean seeds was investigated. It was observed that moisture content and seed dimension affect the oil yield and expression efficiency of African oil bean seeds. Highest oil yield (51.7%) and expression efficiency (85.4%) was obtained at a moisture content of 8% dry basis and major seed diameter <40mm while lowest oil yield (34%) was obtained at a moisture content of 14% dry basis and seed size >55mm as presented in Figures 1 and 2 respectively.

Mathematical models were developed to define the realtionship between the moisture content of African oil bean seeds and the oil yield at a known seed dimension <40, 41-45, 46-50, 51-55 and greater than (> 55mm) as presented respectively in Equations 5-9.

$$Y = -4.38\,x + 54.44\ (R^2 = 0.8342) \quad .. 5$$
$$Y = -3.8\,x + 52.04\ (R^2 = 0.7564) \quad .. 6$$
$$Y = -3.46\,x + 50.74\ (R^2 = 0.8158) \quad .. 7$$
$$Y = -3.24\,x + 50.28\ (R^2 = 0.7946) \quad .. 8$$
$$Y = -3.04\,x + 49.24\ (R^2 = 0.7518) \quad ..9$$

Where: Y is the oil yield (%) and x is the moisture content (%db)

4. Discussions

Pre-treatment conditioning is a preliminary processing activity that involves size reduction, moisture content adjustment, heat treatment and pressure application (Ibrahim and Onwualu, 2005). These activities depend on the nature of the oil-bearing material, methods and devices adopted in the oil extraction. The moisture content of seeds is an important factor that affects the yield and quality of the oil extracted thus, moisture adjustment of the seed is necessary before pressing. From the study, it was observed that moisture content had significant effect on oil yield from African oil bean seeds; an increase in moisture content led to reduction in oil yield and expression efficiency. as moisture level increases, the oil yield and expression efficiency decreases; a similar trend was reported by Singh *et al.* (1984) for peanuts and sunflower seeds which produced highest oil yield at moisture content of 6% (wet basis) respectively, cashew kernels gave highest oil yield of at moisture content less than 8% (Ogunsina *et al.,* 2008), maximum and minimum oil yield from palm kernel was obtained at 4.5 and 9.3 %wb respectively (Akinoso *et al.,* 2006), Ajibola *et al.* (1993) reported highest oil yield for sesame seeds at 6.1 %moisture content, Adejumo *et al.* (2013) recorded the oil yield of 38.48% at 10% moisture content for moringa seeds, Orhevba (2013) also reported highest oil yield (24.86%) for neem seeds at 8.1%wb. Lawson *et al.* (2010), Bamgboye and Adejumo (2011) (roselle), Abidakun *et al.* (2012) (dika nut), Santos *et al.* (2013), Yusuf *et al.* (2014), Adejumo *et al.* (2015) also reported that reduction of moisture level of some potential oil seed plants gave higher oil yields and oils obtained under high moisture content are cloudy (Ibrahim and Onwualu, 2005).

The major diameter of African oil bean seeds were found to range between 38.32-66.28mm, this findings are in tandem with Asoegwu *et al.* (2006) who reported major diamter of 30-76.85mm. Seed dimension/particle size also affects the yield of oil from the seeds, it was observed that the oil yield decreases as the seed dimension increases, highest oil yield was obtained at seed dimensions less than 40mm while the least oil yield was obtained at seed dimensions greater than 55mm. Effect of particle size on oil yield differs from one oil seed to another, the purpose of size reduction is to expose a greater area of oil-bearing cells to rupture. Higher oil yields were obtained from coarsely ground groundnuts compared to the finely round samples (Ward, 1976; Adeeko and Ajibola 1994), finely ground melon seeds on the other hand, gave higher oil yield than the coarsely ground samples (Ajibola *et al.,* 1993), Olajide (2000) obtained optimum oil yield for coarsely ground groundnut kernels while optimum oil yield was obtained for finely ground sheanut kernels, Sayyar *et al.* (2009) reported optimum oil yield for coarse particle size of jatropha seeds.

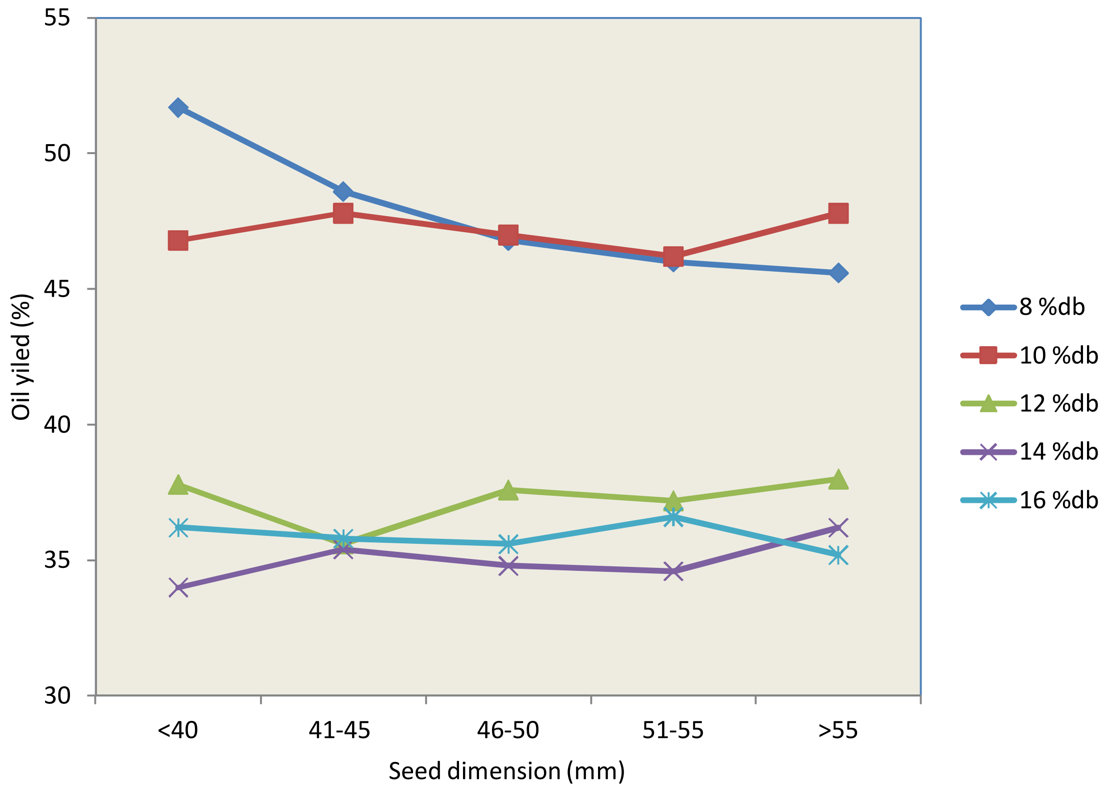

Figure 1: Effect of Moisture Content and Seed Dimension on Oil Yield

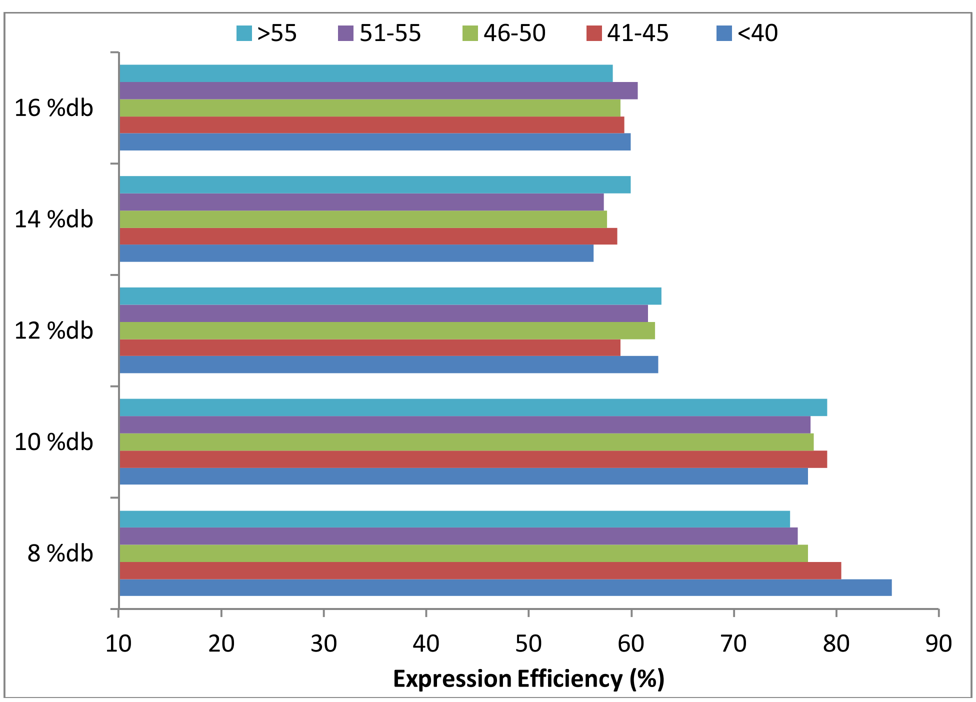

Figure 2: Effect of Moisture Content and Seed Dimension on Expression Efficiency

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The oil yield from African oil bean seeds were found to range from 34-51.7% depending on various conditions like moisture content, seeds dimension, haeting time and temperature, Sodiq (2012) reported 60.4% oil yield for the same seeds using solvent extraction method and microwave heating and Enujiugha and Ayodele (2003) reported that African oil bean seed contains more than 52% oil in its cotyledon and proper processing of the seeds has the possibility of increasing the oil content from around 52 to more than 60.1 percent (Enujiugha and Akanbi, 2005) however, the oil yield obtained are in the same range with some other oil seeds and nuts reported in literature including (Ibrahim and Onwualu, 2005) castor oil 35-55%, linseed 35-44%, Niger seeds 38-50%, neem kernels 45%, rape/mustard seed 40-45%, sesame 35-50%, fresh coconut 35-50%, dried coconut copra 64%, palm kernel nuts 46-57%, sheanut 35-44%, Akinoso *et al.* (2006a) reported average oil yield 47% for palm kernel, Akinoso *et al.* (2006b) for sesame seeds with 34.78%, Ejikeme (2013) reported 42.42% oil yield for wild bush mango seed, Premi and Sharma (2013) reported 33.3% oil yield for moringa seeds, Bamgboye and Adejumo (2015). However, some lower oil yields were reported for some seeds and nuts like cotton seeds 15-25%, sunflower seeds 25-40%, Adepoju and Okunola (2013) for sorrel seeds with 17.85% oil yield.

5. Conclusion

Investigations were carried out on the effect of moisture content and seed dimension on mechanical oil expression from African oil bean. The oil yield obtained from the seeds is an evidence that African oil bean seed can be classified as an oil bearing seed capabale of supplying the necessary vegetable oil for either food, industrial or pharmaceutical applications depending on its quality characterisation, this will also enhance the economic status of the seed and possibly aid its commercialization.

Acknowledgements:

Author will like to appreciate the Department of Agricultural and Environmental Engineering, Faculty of Technology, University of Ibadan, Nigeria and Dr FAKAYODE, Olugbenga Abiola of the Department of Agricultural Engineering, University of Uyo, Akwa Ibom, Nigeria for the provision of the oil expeller used for this study.

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9/22/2017