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Original Research Article

Optimum dilution ratio and water temperature for extracting oil from thevetia nuts

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Investigations were conducted into the determination of optimum dilution ratio and water temperature for extracting oil from thevetia kernel (*Thevetia peruviana*) using a laboratory screw press capable of transmitting maximum pressure of 4.23×10^{-2}MPa. Samples of 100g weight of the ground thevetia nuts were mixed with 5, 10, 15, 20 and 25ml of water (dilution ratios) at the water temperature levels of 20, 40, 60, 80 and 100°C and pressing times of 5, 10, 15, 20, 25 and 30 minutes. Optimum value of dilution ratio and water temperature for extracting oil from thevetia kernel was found to be 10ml to 100g weight of thevetia meal and 100°C respectively. Maximum oil yield of 35.73g (35.73%) was also obtained for the same weight of thevetia meal. The thevetia oil is dark yellow colour in nature at room temperature. Data from the experiment was analyzed statistically using Analysis of Variance and Duncan Multiple Range test to establish the relationship between oil yield and the mentioned pre pressing conditions. It was found that dilution ratio, water temperature and pressing time were significant at 0.05 level. This means that they have significant effect on oil yield.

Key words: Dilution ratio, water temperature, expression, solvent extraction, thevetia nuts, screw press, oil yield.

INTRODUCTION

Thevetia nuts found on *Thevetia peruvian*a plant, commonly called Allamanda plant or flower belong to the order APOLCYNALES and Family APOCYNACEAE. The plant is dicotyledonous, obsolescent flowering, erect perennial shrub, reaching a height of 3.0 to 3.9m, containing latex in cells surrounding greenish brown stems. It has yellow funnel or bell shaped flowers. The flowers are bi-sexual and hypogenous with the 6 to 8 flower in fluorescence on one such stalk. The plant produces whitish sticky latex when the leaves, flowers or fruits are plucked. Fruits may be described as drope, follicle or berries usually borne in pair and house the oilseed in brownish hard nut and the seeds are oblong in shape. It is a very popular plant found in the tropics and in the sub tropical region of the world (Agbaje, 1999).

The plant mostly grown as ornamental plant was reported to contain 62% oil by weight and 37.4% protein. (Jairro, 1981). The crystalline form of thevetia oil is effective in the treatment of cardiac infection (Obadofin, 1991). The oil can be used for non-edible purposes like in soap industries, drying oil industries, plant and vanished plasticizers, floor and shoe polishes, carbon papers etc.

Traditionally, oil is extracted or expressed from oilseed for edible and non-edible purposes while the residual cake is usually fed to livestock and poultry. Food manufacturers nowadays use many forms of fats and vegetable oils as ingredient in a wide variety of food products or further process the fats and oils into manufactured products. Groundnuts, Cottonseeds, soybean, sesame seeds, linseeds, melon seeds, conophor nuts, palm kernel etc are known oilseeds in Nigeria. The demand for table and industrial oil usage increase with an increase in the population of the world and the discovery of the new uses of oil.

Most of the oils are obtained in a two-step process, by first pressing the oilseeds (oil expression) and then solvent or wet extraction. Although, expression is a cheaper

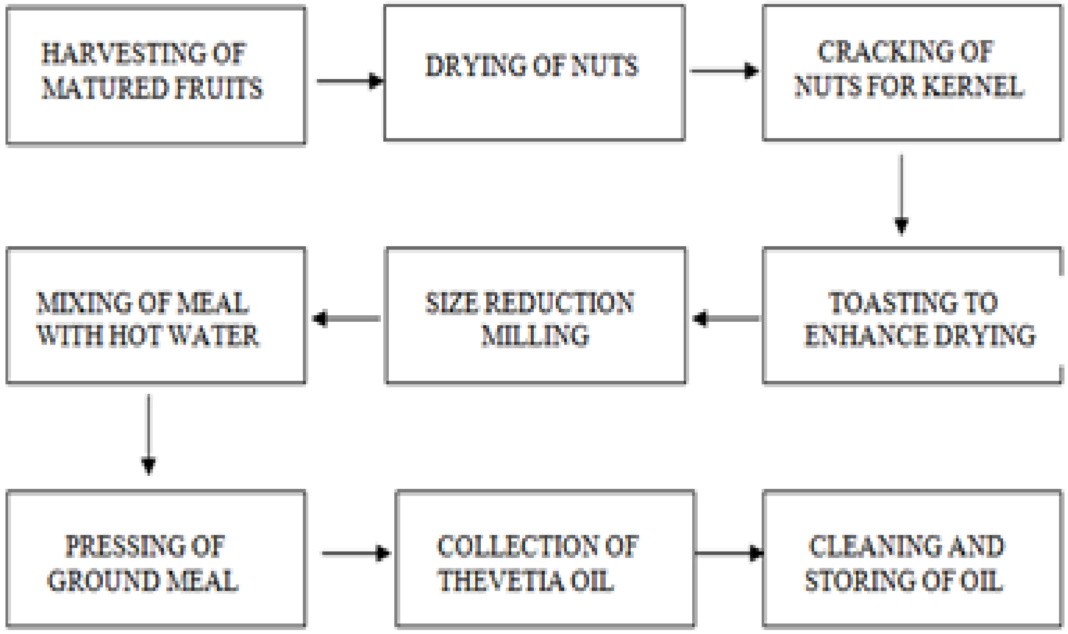

Figure 1: Stages in Local Processing of Thevetia Oil
Source (Author)

process, it leaves behind oil. The best yield is obtained if pressing is followed by solvent or wet expression. The methods used in the preparation of the milled product of the extraction of thevetia oil followed the procedure presented as Figure 1. Mechanical oil expression is accomplished by either hydraulic or screw presses. Although, the screw press is more efficient, the hydraulic press is more common with small and medium processor due to relatively lower initial and operating costs (Adeeko and Ajibola, 1990). Efficient removal of oil from oil-bearing seeds using screw press requires subjecting the oil seeds to pre-pressing conditions. There is therefore, a need to determine and study what the optimum pre-pressing conditions are for high oil yield.

Pre-pressing conditions such as particle size reduction, heating temperature, moisture content of seeds, dilution Ratio, water temperature, pressing time are known to affect the yield and quality of oil expression and wet extraction (Khan and Hanna, 1983; Norris, 1964; Adeeko and Ajibola, 1990; Fashina and Ajibola, 1989; Ward, 1976; Agbaje, 1999). Heat treatment lowers the viscosity of the oil to be expelled, coagulate the protein in the meal to the optimum level for the expression according to Adeeko and Ajibola, (1990). This inturn allows the oil to flow readily. Sivakumaran et al., (1985) concluded that temperature and period of pre-heating and moisture content were interactive factors that influence the yield of oil expressed from peanuts at constant pressure of expression. A moisture content of 6% (wet basis) was found by Singh et al., (1984) to be the optimum for expression of oil from peanut and sunflower seeds. Olaoye (1994), observed that the effective milling of shear nut also affects the proper determination of optimum dilution ratio for oil extraction and further explained that below the optimum dilution ratio oil bearing material will not be fully exposed to the effect of heat treatment and above the optimum dilution ratio the excess water leads to loses in the waste water. He concluded that an appropriate dilution ratio of 1:3 of water to crude oil is required for his own modified procedure for local shear oil processing with a settling period of 60 minutes.

No study is known to have identified the effect of pre-processing conditions such as dilution ratio, water temperature and pressing time on oil yield from thevetia kernels. Agbaje (1999) reported the optimum dilution ratio and water temperature for maximum oil yield from Groundnut solvent oil extraction were 14ml to 100g weight of the groundnut meal and 80°C respectively. He also found that oil yield increased progressively with the increase in the pressing time from 5 to 30 minutes. The objective of this research work was to determine the effective dilution ratio, water temperature and pressing time for extracting oil from thevetia kernels.

MATERIALS AND METHODS

The laboratory press

The laboratory press used in the experiment is capable of

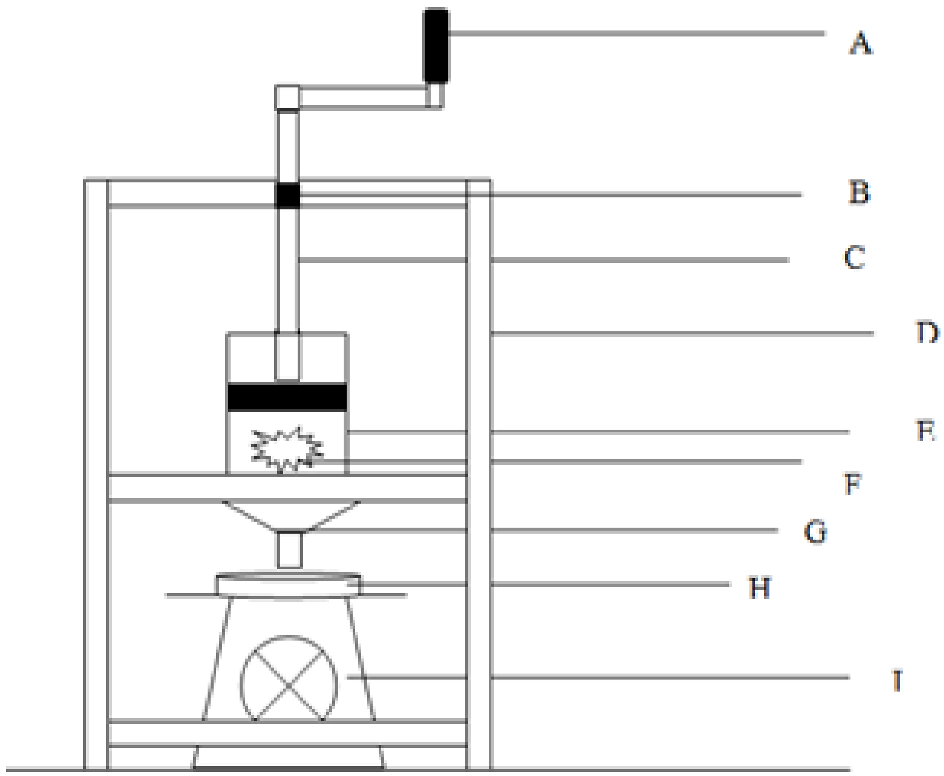

Figure 2: Schematic Diagram of the Laboratory Press used in the Experiment. A, turning bar; B, nut; C, threaded Plunger; D, Frame; E, Pressing Chamber; F, Cake Sample; G, Funnel; H, Collecting dish; I, Weighing balance.

transmitting maximum pressure of 4.23×10^{-2} MPa. It has a press unit assembly. The press in Figure 2 consists of a turning bar, the threaded pressing ram, nut, plunger, pressing chamber and the frame. The frame is made of a 35mm by 35mm angle iron. The length is 300mm, width 300mm and height 500mm. the frame provides a rigid support for the pressing chamber and the ram thereby maintaining tightness to aid in transmitting the pressure uniformly over a giving load in the pressing chamber. The pressing chamber is a hollow square pipe inside which the mixed paste is put for pressing. The chamber has a perforated base plate of 4mm diameter drilled holes to allow for removal of expressed oil. It is made of mild steel with dimension 100 × 100 × 150mm. The turning bar is made of a shaft 200mm in diameter and 180mm long. It is used in rotating the pressing ram. The nut is welded to the frame permanently to allow only the movement of the pressing ram. To the end of the pressing ram is a welded plunger – a metal disc of 4mm thickness and 82mm by 82mm in dimension. The plunger helps in transmitting the pressure from the pressing ram evenly on the sample in the chamber. For this reason, it is made to fit tightly into the pressing chamber with maximum clearance. A triple beam balance (6250g) capacity and a thermometer were used to measure weights and water temperature respectively. Stopwatch was also used in measuring the Pressing Time.

Experimental Design and Test Procedure

A factorial experiment in a split plot design was used as in Miller and Freund (1987). The factors included in the design were water temperature, dilution ratio and pressing time. The ranges of factors considered for this study were selected based on the review of literatures and preliminary laboratory studies. Five levels of water temperature, five levels of dilution ratio and six levels of pressing time were used in the test. For each combination of the level of factors, the experiments were replicated twice making a total number of test ran in the experiment to be three hundred.

The thevetia nuts used in the study was obtained from a Catholic Church compound in Kabba Kogi state, Nigeria. The nuts were cracked manually to release the kernel bearing the oil. Kernels were dried to moisture content of range of 6 to 8% (w.b), cleaned and milled to obtain only fine ground sample. The experiment was conducted in the processing and storage laboratory of the Department of Agricultural Engineering in University of Ilorin, Nigeria.

Samples of 100g weight of the paste were mixed with 5, 10, 15, 20 and 25ml of water (dilution ratio) at the water temperature levels of 20, 40, 60, 80 and 100°C and pressing

Table 1. Average Value of Experimental Results

Average Value of ResultsWater Quantity (ml)	% Oil Yield at Different Water Temperature, °C				
	20	40	60	80	100
5	28.03	25.95	26.16	31.00	31.10
10	25.06	35.02	29.50	30.56	35.73
15	38.99	36.54	36.66	32.90	23.44
20	42.10	40.80	30.48	35.00	30.71
25	25.70	23.70	41.00	25.60	26.16

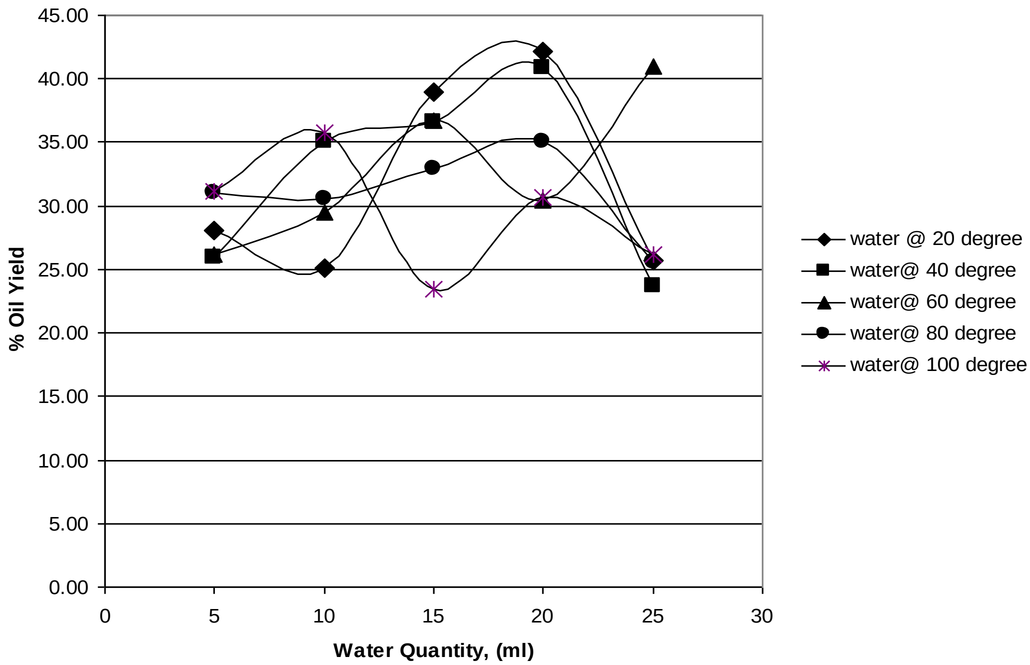

Figure 3: Graph of Oil Yield against Different Hot Water Quantities (Dilution Ratio)

time of 5, 10, 15, 20, 25 and 30 minutes. The different water temperatures were obtained by either keeping the water in the refrigerator or heating it to required temperature. Different 100g of ground samples of kernel were mixed with different quantities of water at different temperatures, wrapped in cheese cloth and then pressed in the screw press. A piece of wire mess was placed at the base of the pressing chamber to act as a filter. The water quantity added, quantities of oil expelled within a given pressing time were noted and recorded. The processes were repeated for all levels of dilution ratio, water temperature and pressing time. The percentage oil removed was based on the weight of unpressed sample using the equation below:

The Percentage Oil Yield, Y=

$$E = \frac{W_1 - W_2}{W_1} \times \frac{100}{1} \text{.........(i)}$$

Where

W_1 = weight of unexpressed Sample

W_2 = weight of expressed Sample

Note:

W_1 =weight of sample + weight of Water Added

Extraction efficiency (E) is defined as

$$E = \frac{W_1 - W_2}{0.62W_1} \times \frac{100}{1} \text{.........(ii)}$$

RESULTS AND DISCUSSION

The average oil yield values from the two replicates is presented as Table 1 and plotted against dilution ratio (water quantity added) at different water temperatures to observe the trends and possible relation between these variables. Figure 3 shows the relation in graphical form. The result of the statistical Analysis of Variance ANOVA Table for Water Temperature versus Oil yield, dilution ratio versus oil yield and Pressing Time versus Oil yield were presented in Tables 2 to 4.

Table 2.Analysis of Variance of the effect of water temperature on oil yield

Source	d f	SS	MS	F value	Pr > F
Temp	4	3181.10	795.28	6.06	0.0001*
Error	145	19022.20	131.20		
Corr.Total	149	22203.30			

*Significant at P ≤ 0.05

Table 3. Analysis of variance of the effect of dilution ratio on oil yield

Source	d f	SS	MS	F value	Pr > F
Temp	4	8647.94	2161.90	23.13	0.0001*
Error	145	19022.20	131.20		
Corr.Total	149	22203.30			

* Significant at P ≤ 0.05

Table 4. Analysis of variance of the effect of pressing time on oil yield

Source	d f	SS	MS	F value	Pr > F
Temp	5	3630.40	726.10	5.63	0.0001*
Error	144	18572.90	128.90		
Corr.Total	149	22203.30			

* Significant at P ≤ 0.05

Table 5. Analysis of variance of the effect of water temp vs dil. ratio interaction on oil yield

Source	d f	SS	MS	F value	Pr > F
Temp	16	5756.90	359.80	9.74	0.0001*
Error	125		131.20		
Corr.Total	149	22203.30			

* Significant at P ≤ 0.05

Statistical analysis

The data obtained from the different combination of factors were analyzed statistically using the method of Analysis of Variance (ANOVA), main effect and interactions in Duncan's Multiple Range Test.

Dilution ratio and oil yield

Oil yield was found to increase significantly at high water temperature of 60 to 100°C for water quantities from 5ml to 10ml above which excess water result in losses in the wastewater and the meal becomes watery, the wrapping cloth finds it difficult to stop the paste from coming out with the oil in the pressing chamber. This explains why at low temperature and high dilution ratio, the percentage oil yield which is the function of weight of material coming out of the pressing chamber is unreasonably high. However, the effective dilution ratio for extracting oil from thevetia kernel was found to be 10ml to 100g weight of thevetia meal. This effect was more significant at the temperature of boiling water (100°C).

Water temperature and oil yield

Temperature affects the coagulation of protein and viscosity of oil in any extraction process. A look at the plotted graph in Figure 3 reveals that temperature of water added affect oil yield, in that high oil yield is obtained at high water temperature. The highest good quality oil of 35.73g (35.73%) was obtained when 10ml of hot water at 100°C was added to a 100g weight of ground sample. It is interesting to note that within a short pressing time large percentage of oil was extracted due to the reduction in the viscosity of the oil at high temperature. This is clear from Figure 3 that for all levels of water temperature, oil yield increased as water temperature increased from 40 to 100°C.

Pressing time affect the quantity of oil collected over a period of time. In oil presses, application of pressure only last for few minutes under which high amount of oil is expelled. So, Pressing time effect depends on the type of press used. It is seen from Tables 5 to 10 that factors and their interaction in the Duncan's Multiple Range test were significant at 0.05 level of significance. This means that

Table 8. Duncans multiple range test
Effect of Temperature on Oil Yield*

Temperature, °C	% Oil Yield
20	36.602[b]
40	142.927[a]
60	38.623[ab]
80	29.627[c]
100	32.797[bc]

* Mean with the same letters are not significantly different at P ≤ 0.05 using Duncans Multiple Range Test.

Table 9. Duncans multiple range test
Effect of Dilution Ratio on Oil Yield*

Dilution Ratio, (ml)	% Oil Yield
5	23.790[c]
10	35.787[b]
15	44.963[a]
20	43.053[a]
25	32.982[b]

* Mean with the same letters are not significantly different at P ≤ 0.05 using Duncans Multiple Range Test.

Table 10. Duncans multiple range test
Effect of Pressing Time on Oil Yield*

Pressing Time, minutes	d f
5	27.580[c]
10	32.246[bc]
15	36.152[ab]
20	38.502[ba]
25	40.130[a]
30	42.080[a]

* Mean with the same letters are not significantly different at P ≤ 0.05 using Duncans Multiple Range Test.

dilution ratio and water temperature have significant effect on oil yield.

Conclusion

The results presented in this paper demonstrated that there is an optimum dilution ratio (hot water quantity) and water temparature for solvent or wet extraction process, for thevetia kernels it is 10ml to 100g weight of thevetia ground thevetia nuts and 100°C respectively. Oil yield increases progressively with pressing time up to certain time when it will be constant. Also, the more water in the paste the more difficult the expression rate due to clogging of the hole through which the expelled oil flows out.

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