Extraction Yield, Efficiency And Loss Of The Traditional Hot Water Floatation (HWF) Method Of Oil Extraction From The Seeds Of Allanblackia Floribunda

Alenyorege E. A., Hussein Y. A., Adongo T. A.

Abstract: The research was conducted to determine the Extraction Yield, Extraction Efficiency and Extraction Loss associated with the traditional Hot Water Floatation method of oil extraction. Matured dry seeds of Allanblackia floribunda (50 Kg) were used. Allanblackia floribunda, a tree species of the Guttiferae family grows naturally in tropical rainforests zones. In Ghana, Allanblackia floribunda is quite unknown hence little production of oil is carried out. However, the oil extracted can have diverse domestic, commercial and industrial uses. The oil production is important not only among small-to-medium scale industrialists, but also to rural populace, as it employs a substantial workforce and serves as a source of income to many communities engaged in the exercise. The method employed is the oldest, cheapest and most practiced in the study location. The extraction process basically comprises of five fundamental steps: thermal conditioning of the seeds; milling; extraction by boiling; oil recovery; and drying. The method yielded 21.1 kg of oil, a residual cake of 26.2 Kg and a process loss of 2.7 Kg at a moisture content of 13.1% representing 42.2% Extraction yield, 58.6% Extraction efficiency and 5.4% Extraction loss. The yield exceeded the minimum oil yield for commercial, domestic and industrial consideration.

Index Terms: Allanblackia floribunda, efficiency, extraction, seeds, floatation, milling, oil

1 INTRODUCTION

Trees such as shea (Vitellaria paradoxa), coconut (Cocos nucifera) and Oil palm (Elaeis guineensis) among others are popular oil seed producing trees in Ghana. The vegetable tallow trees (Allanblackia floribunda) that also produce oil seeds have been relatively unknown and it's medicinal and numerous cosmetic properties minimally tapped. The oil from its seeds just like other traditional oils, is natural, non-genetically modified and can be used to supplement and in some cases substitute for other oils in domestic use and in the commercial production of food and non-food products. It consists almost exclusively of triglycerides of stearic (45-58%) and oleic (40-51%) fatty acids which are components that have always been part of the human diet [1]. Allanblackia floribunda locally known as sonkyi in southern Ghana belongs to the family Guttiferae and genus Allanblackia [2].

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It is an evergreen medium-sized tree up to 30 metres tall with a cylindrical or slightly fluted trunk and a narrow crown supporting horizontal branches. It has a fairly smooth bark and simple opposite leathery leaves evenly distributed along the branches of the tree [3]. A matured tree produces about 100-150 egg shaped fruits of weight between 1.2 and 4.0 kilograms. Fruits may contain 25-40 oil rich brown seeds, with a seed containing 72% oil [4]. Allanblackia floribunda grows naturally in parts of Central, East and West Africa. Countries including Nigeria, Ghana, Democratic Republic of Congo, Uganda and Tanzania have Allanblackia growing naturally in moist lowland and upland rainforest zones. Allanblackia floribunda is found in parts of southern Ghana including Western, Central, Ashanti, Eastern and parts of Brong Ahafo Regions, where cocoa (Theobroma cacao) thrives best [5]. According to Rosenthal et al. [6], oil extraction process has a direct effect on the quality and quantity of proteins and oils obtained and this further plays a good role in the commercialization of the product. The modern way of processing vegetable oil is by chemical extraction, using solvent extracts such as petroleum-derived hexane, which produces higher oil yields and is quicker and less tedious. This technique is used for most of the industrial oils such as soybean and corn oils. However, due to the safety, toxicological, environmental and potential health risks involved in using methods like the hexane extraction, the vegetable oil industry is in need of some suitable and environmentally friendly methods of extraction [7]. Johnson and Lusas [8] reported that the new tendency to shun the use of noxious organic solvents in large installations has renewed interest in alternative extraction processes. Unremitting efforts are being made to develop new and efficient processing alternatives to hexane as the extracting solvent for production of quality edible oils, with concurrent recovery of important nutrients [9]. According to Sineiro et al. [10], like other bio-renewable solvents, the use of water as the most economical extracting agent is gaining interest, especially with the aim of eliminating toxic solvents. Aqueous oil extraction has re-surfaced as a promising practice for extraction of oil from certain oil bearing seeds. As reported by Rosenthal et al. [6], aqueous extraction process was developed as a substitute to the solvent oil extraction process in the 1950s. It was predicted to be environmentally safe and cheap with simultaneous recovery of oil and protein from oil-bearing seeds, nuts and mesocarps [11]. The hot water flotation method of oil extraction from oilseeds is a traditional process used in rural areas of many developing countries of Africa. According to Rosenthal et al. [6], the hot water floatation method comprises of five fundamental steps: (I) thermal conditioning of the seeds; (II) milling; (III) extraction by boiling; (IV) oil recovery; and (V) drying. The study therefore seeks to evaluate the performance of the traditional hot water floatation method of oil extraction in terms of its extraction yield, efficiency and loss as it is used by rural folks in extracting oil from the seeds of Allanblackia floribunda.

2. MATERIALS AND METHODS

2.1. Source of Seeds and Locatıon of Experıment

The matured dry seeds (50 Kg) were obtaind from processors in Sikaa, a farming community in the Nkoranza North District of the Brong-Ahafo Region of Ghana. It lies within the semi-equatorial region with generally high temperates and a bimodal rainfall pattern.The experiment however took place in the Kasalgu Sheabutter Village, now Sekaf Ghana limited a shea butter processing company in Tamale in the Northern Region of Ghana.

2.2. Determination of Moisture Content

A Marconi TF 933 C moisture meter was used to determine the moisture content of milled seeds. A milled sample of weight 80 g was taken as recommended. The moisture meter was set up and the sample prepared and placed on the meter accordingly. The meter was activated and the dial reading taken and converted to the corresponding moisture content using the Annexure Conversion Table.

2.3. Experımental Descrıptıon

The hot water floatation (HWF) method of edible oil extraction is traditionally used in the rural areas of many developing countries in Africa. The advantage of the HWF method over other small-scale oilseed processing techniques, such as those using expellers or ghanis, is its simplicity. The equipments required (including pestle and mortar, boiling and kneading pans, seed roaster,calabash) are readily available and less expensive. However, some authors predict low oil yields and that the process can be time consuming and arduous. The method may be applied to most oilseeds with varying degrees of oil yield. The seeds were crushed with a pestle in a mortar, roasted at a temperature of 65°C for 4 hours and pounded in a mortar to a much finner particles for easy milling or grinding.The fine crushing of the seeds is the first phase in cell distraction. It facilitates the diffusion of the soluble compounds and the release of the oil.The ground seeds was kneaded while adding warm and cold water intermittently to form a paste. Water plays a crucial role in hydrolyzing the paste, which dislodges oil from hydrophilic surfaces in the slurry. The paste was then released into boiling water (100°C) and boiled with periodic stirring. A grey coloured mass (slurry) starts forming as oily fat began separating from the oil-water mixture. Liberated oil floated to the surface. The oil was carefully skimmed from the surface of the mixture using a calabash and heated to remove remaining moisture (drying).The oil was then cooled and prepared for packaging or storage.

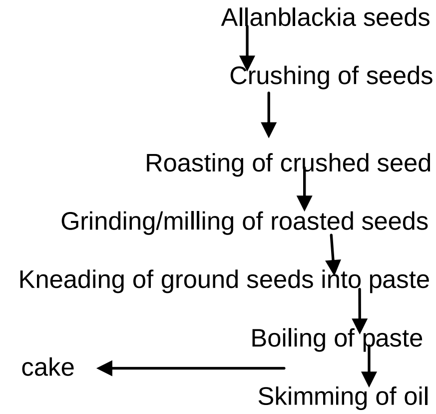

Fig1. *Simplified flow chart of the HWF method of oil extraction*

2.4. Measurement of Parameters

Extraction yield refers to the amount of oil that can be derived from an oil seed. İt is usually represented as a percentage. Oil yield was determined as the ratio of the weight of oil recovered to the weight of the crushed seed sample before extraction. It was represented mathematically by Adeeko and Ajibola [12] and Olaniyan and Oje [13] in (1) as:

$$Ey = Wor/Wcss\ x100\% \qquad (1)$$

Extraction effeciency, an important parameter in oilseed processing is the percentage of oil extracted in relation to the amount of oil present in the seed. Oil extraction efficiency was computed as the ratio of the weight of oil recovered to the product of the seed oil content and weight of crushed seed sample before extraction. It was mathematically stated by Adeeko and Ajibola [12] and Olaniyan and Oje [14] as shown in (2):

$$Ee = Wor/(Soc\ x\ Wcss)\ x\ 100\% \qquad (2)$$

Extraction loss was calculated as the difference between the weight of the crushed seed sample before extraction and the sum the total weights of oil recovered and residual cake after extraction divided by the weight of the crushed seed sample before extraction. It was denoted mathematically in (3) by Olaniyan and Oje [13] as:

$$El = (Wcss - (Wor + Wrc))/Wcss\ x\ 100\% \qquad (3)$$

Where, Ey= Extraction yield (%); Ee= Extraction efficiency (%); El =Extraction loss (%); Wor = weight of oil recovered after extraction (g); Wrc = weight of residual cake after extraction (g); Wcss= weight of crushed seed sample before extraction (g); and Soc = seed oil content (72% or 0.72).

3. Results and Dıscussıon

The experiment yielded 21.1 kg of oil, 26.2 kg of residual cake and a process loss of 2.7 kg representing 42.2% Extraction yield, 58.6% Extraction efficiency and 5.4% Extraction loss at a moisture content of 13.1%. Extraction yield and efficiency were satisfactory (above 40 and 50% respectively) with a slightly high process or extraction loss despite the high seed oil content of 72%. The oil yield obtained from the seeds by this method, was comparatively high since most commercial oil bearing seeds have oil yields of about 30 - 40% and above [15]. The yield was also over 10 % higher than the figure (30 %) reported by Matchet [16] as the recommended minimum commercial, industrial and domestic yield. The weight of the residual cake was partly due to incomplete cell lysis within the seeds which possibly trapped and retained some amount of oil.

TABLE 1:
Yield of screw pressed Allanblackia floribunda seed oil obtained at different temperatures and varied moisture contents of milled seeds [17].

Temperature °C	Moisture Content (%) 3.1	5	7	9	11	13	15	17	19	21	23
	Oil Yield (%)										
60	28.7	30.2	30.6	31.7	32.2	32.8	33.4	34.6	36.9	35.1	34.3
70	29.3	30.9	29.6	31.4	31.9	32.5	36.7	37.4	37.0	36.3	35.8
80	30.5	33.1	34.8	35.9	39.2	39.2	39.6	42.3	43.5	42.7	41.8
90	31.8	33.9	35.3	44.8	46.1	42.7	42.5	42.9	43.8	43.1	42.7
100	32.5	40.9	41.2	43.4	45.2	48.6	46.5	47.1	46.6	45.4	43.9
110	30.9	31.7	32.5	35.7	36.9	37.1	38.2	38.9	44.6	42.3	41.8

The yields of the pressed oil obtained at temperatures ranging from 60 to 110°C and moisture contents of milled seeds from 3.1 to 23% shown in Table 1 indicates varied yields at specific temperatures and moisture contents. The best condition for utmost yield of pressed seed oil (48.60%) was achieved at 100°C and 13% moisture content of milled seed and the lowest (28.70) at 60˚C and 3.1% moisture. It is therefore evident that there is an optimal moisture content and temperature for oil seeds like A. floribunda to obtain a maximum or minimum yield of oil [18]. With reference to this previous research that employed a different method of extraction (screw pressing), the HWF method despite been considered less efficient, at 13.1% seed moisture content resulted in comparative extraction yield and efficiency despite a process loss of over 5% by weight. Alonge et al. [19], reported that heating temperature, moisture content of seeds, heating time and other pretreatment procedures and extraction conditions had effect on oil yield, extraction efficiency and quality parameters of oil in their analysis of the effects of some processing factors on groundnut and soybean oil extraction. Some of the above mentioned measures could possibly have resulted in the slightly high extraction loss with the less than 50% oil yield. Temperature influence the yield of oil and better extraction is achieved by heating, which reduces the oil viscosity, releases oil from the intact cells and removes moisture. It was afterwards concluded that oil recovery increases with decreasing moisture content. Moisture lubricates the seed meal during extraction and increases the flow of oil through the pores of the cake, thus reducing the amount of oil retained in the cake and increasing the oil yield. The effect of moisture content, heating temperature and heating time on the yield of oil expressed from castor bean was investigated by Olaniyan [20] and the outcome showed that by and large, the oil yield at any pressure is dependent on the moisture content of the sample after heating. The results of this experiment could have been influenced since moisture was only monitored prior to roasting. Solid-to-liquid ratio is another important parameter that allows the products to be dispersed in the aqueous media. A high amount of water will produce a less stable emulsion and will ultimately simplify the separation process [6]. This ratio could have been interfered with by the sporadic addition of water during the paste forming stage.

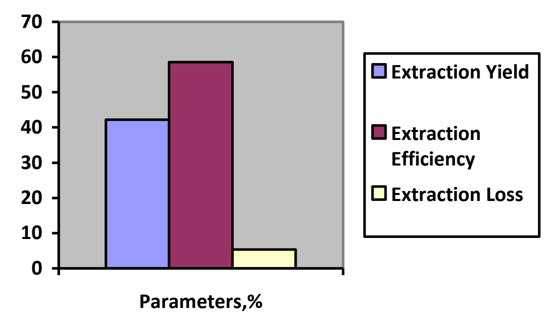

Fig2. *Performance of the HWF method of oil extraction*

4. CONCLUSION

Despite the HWF method being considered as low yielding, tediuos and time consuming by some researchers, it proves to be comparatively high yielding, efficient, environmentally friendly, less expensive and employs no toxic chemicals. Another important aspect observed was the technological limits of the traditional hot water floatation method that did not enable a full separation of liquid and solid phases and frequent monitoring of some extraction conditions. Relatively limited knowledge of the commercial value of A. floribunda oil, unexploited extraction methods of A. Floribunda oil and the reasonable abundance of the trees in Ghana coupled with the high oil content of A. floribunda seeds provides a sound basis for tapping into this resource for domestic, commercial and industrial purposes.

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