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Production of Candle from Oil Extract of a Legume - Soybean

M.E. Ojewumi, O.O. Olanipekun, O.R. Obanla, E.O. Ojewumi, R.S. Bassey

Abstract: ***This research confirmed that candles produced from oil extract of soybeans are eco-friendly and healthier alternatives to commercial candles made from paraffin wax. The soybeans were sorted, washed, crushed, dehulled and grinded prior to extraction to increase the surface area. Soybean oil is about 30% of the total soybean composition. Soxhlet extraction method was used with hexane as solvent. The extracted oil was then solidified with stearic acid to form wax inside a mold. Physical tests were carried out to prove its claims as a safer alternative to paraffin wax. The results supported the claims that soy candles are more economical and produced lesser soot than the paraffin candles.***

Keywords: Soybeans, Soxhlet extraction, Oil extract, solvent, Yield

I. INTRODUCTION

Candles are widely used for illumination of the environment such as homes, offices among others. Although, due to advancement in technology various other advanced illuminating devices have been introduced as its substitute [1]. Candle is mostly used for religious events and special occasion such as decorations during holidays. Traditional candles are mostly made of wax materials. Although, such candles emit trace of organic compounds when burned this include naphthalene, acrolein, formaldehyde and acetaldehyde [2]. Considerable amount of candles release lead which is a major source of concern in candle emissions for public health environments [3].

Different types of pollutants occur indoors under atmospheric conditions due to sources within or from the external environments. Most pollutants have negative consequences that are capable of causing various complications and nuisance [4-7]. Some pollutants can also be informed of solid waste materials which have to be removed either by physical or chemical means or by recycling by conversion into useful materials [8, 9, 10, 11]. Mankind have continuously experience various forms of insomnia and psychological stress due to the stress experienced in present-day life (be it imagined or real) [12]. Therefore, numerous treatments have been proposed to supply psychological relief accompanying the healing process [3, 14-16]. Several treatments such as the application of scented candles have earned significant increase in the request for indoor air fresheners and room décor. The annual rapid growth in scented candles market in the U.S. is evaluated to be approximately 2 billion USD [3]. Although, some other sources have contributed to the amount of indoor air pollution. For example, pollutants such as odorants, polycyclic aromatic hydrocarbons (PAH) and metals are major components released from charcoals used during cooking process [16-21]. Combustion of these scented candles in an interior area result in the release of different aromatic constituents which can linger on within a building. The compounds identified include several alcohols, hydrocarbons and aldehydes. Also, various PAHs recognized as carcinogens such as pyrene, anthrancene and naphthalene were noted [21-25]. Besides, several other activities taking place indoors promote ultrafine and fine particulates emissions, igniting scented candles can stimulate emission of particulate matter and several other gaseous pollutants [25, 26]. The amount of ultrafine density of particles from ignition of pure wax candles are up to about 241,000 particles/cm^3 [27]. Distinctive odour and enormous quantity of volatile organic compounds has been liberated from scented candles due to additives added such as aroma oil and fragrance [28]. Other pollution includes hydrocarbons which occur as result of onsite or transportation spillage in the environment [29-32]. The process of combustion is mostly characterized by the presence of small sized particles, this has a negative effect on the wellbeing of living organisms due to its deposition in the alveolar, its inflammogenic potential, high reactivity on the surface and chemical decomposition [33].

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* Correspondence Author
Modupe E. Ojewumi*, Chemical Engineering Department, Covenant University, P.M.B 1023, Canaan Land, Sango, Ogun State, Nigeria.
e-mail: modupe.ojewumi@covenantuniversity.edu.ng
Ogirima O. Olanipekun, Chemical Engineering Department, University of Lagos, Akoka. Lagos.
Oyinlola R. Obanla, Chemical Engineering Department, Covenant University, P.M.B 1023, Canaan Land, Sango, Ogun State, Nigeria.
Emmanuel O. Ojewumi, Food Science and Technology Department, Federal University of Technology, Akure, Ondo State. Nigeria.
Ruth S. Bassey, Chemical Engineering Department, Covenant University, P.M.B 1023, Canaan Land, Sango, Ogun State, Nigeria.

Particulate matter usually contain PAHs which can generate development of large DNA mutations and adducts [34]. The occurrence of lung tissue damage and inflammation aggregate result to a considerable rise in proteins accumulation in the alveolar region. Moreover, production of excess oxygen reactive species by the immune cells or particles may result into oxidative destruction to biomolecules (e.g. DNA) [35]. Air pollution particles is related stress, inflammation and high levels of DNA oxidative are destroyed in cultured cells, humans and animals [35, 36]. Combustion processes of most candles have surpass the USEPA's growth risk for formaldehyde and acetaldehyde, it has also surpass the acrolein Reference Concentration (R_fC) [26].

The objective of this project considers the production of candles from soybean oil extract which release less toxic substances into the environments. Studies such as Johnson [37] prepared candles by adding a binding agent to specific quantity of paraffin wax; the temperature of the paraffin wax and binding agent is increased, Soybean oil was added to the hot mixture of paraffin wax and binding agent; the mixture of paraffin wax, binding agent and soybean oil was increased to a very high temperature, where a specific quantity of candle scent was added to the hot mixture, the mixture was added to water absorbing (wicked) containers for the manufacture of candles. Other studies by Baumer [38], Dieter Tischendorf [39], Jaeger [40], MacLaren [41] have also produced candles from various types of vegetable oils. This study considers the use steric acid on soy bean extract to produce wax, which are used for candle making. The product release less hazardous materials. Model is a diagnostic tool that helps researchers in taking decision when dealing with issues that can be used to optimize the extraction procedure to reduce the number of experimental run [28, 29, 42, 43, 44].

II. METHODOLOGY

A. Source of raw materials

Raw soybean was obtained from an open market.

Fig. 1. Soybean seed

B. Preparation of Soybeans for extraction

The beans were handpicked to remove foreign materials such as stone, leaves etc. The handpicked beans were washed in water and dehulled with palms to remove the cotyledon [45, 46-50]. The washed and dehulled clean beans were oven dried at 70ºC for 48 days prior to extraction. The seeds were cracked in the mortar and pestle to weaken the binding power of the seeds and increase the surface area.

C. Extraction of Soybean oil using Hexane

Oil was obtained from the seeds using a Soxhlet extraction process. 20g of sample was weighed and put into the extractor (the sample was wrapped in a filter paper shaped in a cuplike manner). A condenser was placed on the extractor and properly connected to a water tap [41-42, 44-46]. The total yield of oil was expressed in percentage. The entire setup was repeated, varying extraction times for 2, 4, 6, 8 and 10 hours. Hexane used was recovered by a simple batch distillation process, using a reflux condenser [40, 41]. The setup is depicted below

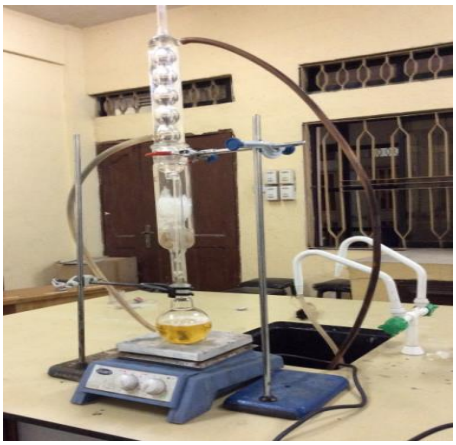

Fig. 2. Solvent Extraction Setup

D. Solidification of the extracted Soybean oil with stearic acid

The crude oil extract was subjected to reaction with stearic acid to solidify it to wax. Other beautifying additives were incorporated into it after characterization such as fragrances and colour.

Fig. 3. Heating oil sample for solidification using stearic acid

E. Comparisons with a petroleum-based wax e.g. paraffin wax:

The produced soy candle was compared with regular paraffin candle on certain physical parameters.

F. Physical Comparison

Both samples of same length were burned for a period of 20 minutes. At the end of 20 minutes, the samples were analyzed on

a. Length left after burning (by observation)
b. Quantity of soot produced (by observation)
c. Colour of flame (by observation)

III. RESULT AND DISCUSSION

- Determination of oil yield by varying extraction time, weight of sample and quantity of solvent.

The oil yield for the extraction of soybean oil with hexane for 2, 4, 6 and 8 hours is shown in the table below Table 1.

Table - 1: Table for the extraction

StdOrder	Run Order	PtType	Blocks	Weight of seed [X_1]	Time of Extraction [X_2]	Quantity of Solvent used [X_3]	% Oil yield [Response]
7	1	2	1	10	6	160	12.67
15	2	0	1	25	6	130	16.56
3	3	2	1	10	10	130	14.55
12	4	2	1	25	10	160	22.25
6	5	2	1	40	6	100	18.5
11	6	2	1	25	2	160	14.44
8	7	2	1	40	6	160	18.5
14	8	0	1	25	6	130	16.56
1	9	2	1	10	2	130	10.59
10	10	2	1	25	10	100	22.25
4	11	2	1	40	10	130	24.24
2	12	2	1	40	2	130	16.7
9	13	2	1	25	2	100	14.44
13	14	0	1	25	6	130	16.56
5	15	2	1	10	6	100	12.66

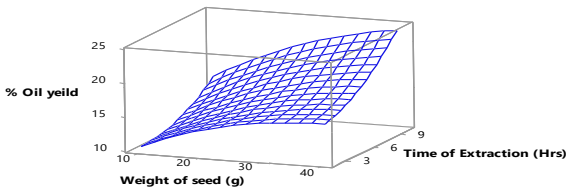

Fig. 4. Surface Plot of % Oil yield against Time of extraction (hrs) and Weight of seed (g)

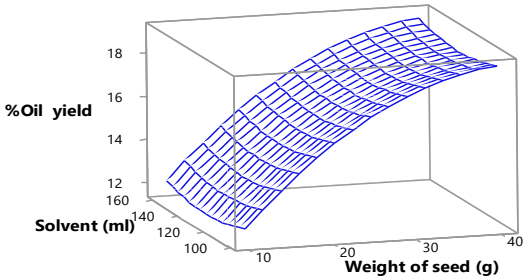

Fig. 5. Surface Plot of Oil yield against Solvent (ml) and Weight of seed (g)

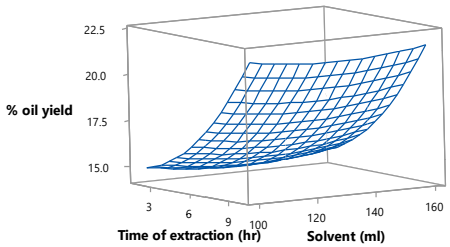

Fig. 6. Surface plot of Oil yield against Solvent (ml), Time of extraction (hrs)

IV. RESULTS FROM PHYSICAL OBSERVATION

A sample of each candle was lit and observed. After a period of 5 minutes, the following observations were made.

Table- II: Results from Observation

	Paraffin wax	Soy wax
Colour of flame	Predominantly yellow	An obvious combination of blue and yellow
Soot production	Noticeable	Negligible
Length after 5 minutes	Obviously shorter	Slightly shorter

Test for Gas Emissions

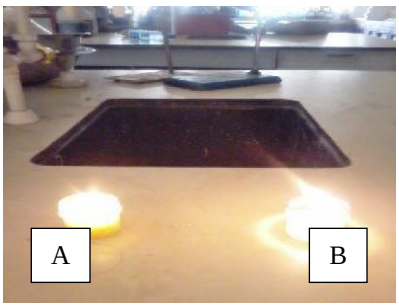

Fig.7. Soybean candle

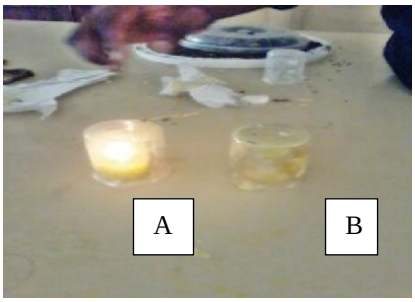

Fig. 8. Paraffin wax

V. DISCUSSION OF RESULTS

The Effect of time on the %yield of Oil

Soybean oil is about 30% of the total soybean content. The process of solvent extraction of this oil was carried out in the laboratory using hexane as a solvent and varying the extraction time. The extraction table (Table 1) shows more yield came from samples extracted for 10 hours with sample weight of 25 and 40 g which gave oil yield of 22.25 and 24.24% respectively. Solvent quantity had little or no effect on percentage oil yield during extraction process.

Figures 4, 5 and 6 shows the surface plot relationship between the three variables considered (Weight of sample[X_1], time of extraction [X_2] and solvent quantity [X_3]).

The simple mechanism of this extraction is that the oil dissolves readily in hexane solvent and is washed down from the powdered seeds by the flowing hexane. This explains the change in colour of hexane from a clear solution to yellow during the extraction process. More contact of the hexane with the seeds indicates dissolution of more oil from the seeds, thus the increase in oil yields at longer contact periods.

Comparisons by Observation:

***Color of flame*:** From our observation, the flame from paraffin wax was predominantly yellow while that of soy wax was an obvious blue and yellow mixture. The yellow flame is a result of incomplete combustion of the wax, meaning there is no proper air to wax ratio, causing the generation of fine soot particles and other gases into the atmosphere as seen in the chemical equation.

An inference drawn here is that though both candles emit gases, the soy candles emit less incombustible gases than the paraffin candles.

***Quantity of soot produced*:** The colour of the gas flame rightly explains the variation in soot production. More soot is produced from the predominantly yellow flame while lesser soot is produced from the predominantly blue flame. This explains that it is safer to burn soy candle for domestic use than the paraffin candle we use.

Length left after burning for 5 minutes: This is explained by the fact that a paraffin wax has a melting point that is higher than soy wax, thereby causing it to 'burn out' faster than the soy wax. This explains that using soy wax gives better yield for money, making it more economical. Since the soy candles produced are made inside containers, burning it only results in melting of the oil, only to harden at room temperature and form a new candle. Hence, soy candles 'burn in' while paraffin candles 'burn out'.

VI. CONCLUSIONS

The yield of soybean oil depended on time of extraction; this was the major determinant of the oil yield in this research. From the flame Colour observations, soy wax is considered a healthier alternative to the paraffin wax, hence soy candles are more eco-friendly than the paraffin candles in the sense that there are lesser or no toxic gases given off when burning soy candles. It is safe to burn paraffin candles in open space due to the rapid release of incombustible toxic gases. On the other hand, soy candles are preferable for lighting in enclosed space because they do not release much of toxic gases into the environment. Nigeria could take on large scale soybean cultivation for food and soy wax production. The returns are promising as soybeans mature between 45-100 days.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORS PROFILE

Modupe Elizabeth Ojewumi [Ph.D], is a Researcher and Lecturer in Covenant University, Ota, Nigeria. Her areas of core competence includes: Biotechnology/Biochemical Engineering, Health/Environmental Engineering and New products Development.

Dr. Olawole Ogirima Olanipekun, is a lecturer at Department of Chemical & Petroleum Engineering of the University of Lagos, Nigeria. He lectures Biochemical and Biotechnology. He's trained in Bioremediation and he has over 20 publications in both locally and internationally journals. Currently

Oyinlola Obanla holds first and second degree in chemical Engineering. A versatile Researchers that specializes in Polymer Engineering.