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Kunyima Method Validity in Sesame Seeds Oil Extraction "Democratic Republic of Congo"

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Authors' contributions

This work was carried out in collaboration among all authors. Author ABK designed and supervised the study, wrote the protocol and wrote the first manuscript. Author HMK is the experimentalist of the results of this paper, perfomed the statistical analysis of this paper, he did the references and is the master student in the Laboratory of Physical Organic Food Chemistry and Physical Cardiochemistry (LACOPA-PCC). Author SNL discussed the results of the study, managed the reading of manuscript. Author CKM managed the proof reading and correction of manuscript. Author BMA is the experimentalist of the results of this paper and managed the literature searching. She is a senior student in the (LACOPA-PCC). All authors read and approved the final manuscript.

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ABSTRACT

Background: The very rich vegetable patrimony of Democratic Republic of Congo (DRC) demands a local abundant production of its fruits, roots and seeds by means of appropriate technology to relieve somewhat the problem of population health because indeed those fruits, seeds, roots and leaves are reputed to have very excellent virtues in various fields such as medicine, pharmacology,

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cosmetic products, food and so forth. Prior to this work papers have been published on Gourd seeds oil and Moringa seeds oil extractions in order to size a continuous stirrer pilot tank of extraction. KUNYIMA method has been successfully used and is still successfully used in this present article concerning sesame (*Sesamum indicum* L.) seeds oil extraction in dilute medium.
Aim and Objective: In this paper it can be seen the reasoning leading to KUNYIMA method is relevant and can be used to size commercial tank giving thus home rational technology.
Methodology: The Soxhlet extraction of oil from sesame (*Sesamum indicum* L.) seeds has been performed in dilute medium using petroleum ether as solvent.
Results: The obtained results are satisfactory and are perfectly in agreement with the proposed model. Commercial tank construction on rational calculation is now possible.
Conclusion: KUNYIMA method once more is valid and allows to calculate the sizing factor needful to determine the reactor optimal volume.

Keywords: Kunyima method; sesame seeds; sizing factor; appropriate (home) technology; soxhlet extraction.

1. INTRODUCTION

The vegetable oils play an irreplaceable role in human feeding, being indispensable for the organism good acting. They secure a nutritional function by furnishing a considerable quantity of energy and constitute a well-spring of needful fatty acids such as linoleic acids and α - linolenic acids. Moreover, they contribute to improve the organoleptic quality of the products by bringing a smooth texture, a shiny aspect and specific flavor [1,2,3,4].

Democratic Republic of Congo has a very rich and diversified vegetable patrimony among which the sesame has extraordinary therapeutic properties for human health. It has the reputation to maintain and to restore the vitality, to rouse the production of maternal milk at breastfeeding women, to contribute to bones rehabilitation after Cerebral Vascular Accident (CVA) and to help to combat stress and to relieve muscular pains [5,6,7,8,9].

Sesame seeds are rich in oil ($\approx 50\%$), in proteins (23%) and in vitamins. This oil is characterized by its important percentage in linoleic acids (39 – 44%) and a remarkable stability by the presence of some compounds such as lignanes (sesamine and sesamoline) and tocopherols (vitamin E) which are mighty natural antioxygenics [10,11]. Sesame oil contains many fatty acids such as palmitic acid (9 – 11.7%), stearic acid (4 – 5.2%), arachidonic acid (0.4 – 0.6 %), palmitoleic acid (0.1 – 0.3%), oleic acid (37 – 41.4%), linoleic acid (39,4 – 44.1%) and linolenic acid (0.4 – 0.6%) [12,13,14].

Sesame seeds contain also numerous compounds such as vitamins (A, C, K, B1, B2 and B12), minerals (calcium, phosphorus, iron, magnesium, etc.), tocopherol (vitamin E). Sesame (*Sesamum indicum* L.) seeds meal can be used to make breads, porridge and crackers [12,13,14].

2. MATERIALS AND METHODS

2.1 Materials

Drying oven, analytical balance (Ohaus, Germany), watch glass, dessicator, heating skullcap, spade, beaker, cellulose porous cartridge (33 × 205 mm), thermometer, aluminium paper, rotary evaporator (type: Heizbad Hei-vap, series: 021413809), crushing machine, burettes, distillate water, petroleum ether, chronometer, thermostat, a thrice necked balloon – flask, soxhlet extractor and sesame seeds have been used [15,16,17]. All the materials have been delivered in laboratory by NEO-TECH.

Fig. 1a, 1b and 1c show sesame seeds, sesame powder and sesame seeds oil, DRC (Picture taken on experimentation samples three days after).

2.2 Methods

2.2.1 Extraction protocol

Sesame seeds have been pulverized by means of crushing machine and the obtained powder has been preserved in a dessicator. Ten grams of powder have been introduced in cellulose porous cartridge of 33×205 mm and all has been put in Soxhlet extractor. In one 1000 mL thrice necked balloon – flask fitted of

thermometer, 450 mL of petroleum ether (40 – 60°C, ρ = 0.65 kg/L) have been introduced as solvent. The fitting out of Soxhlet has been done on heating skullcap (mark thermo scientific) in fixing temperature at 54°C in balloon – flask during a given extraction time. To maintain the temperature constant during the experiment, the heating skullcap has been covered of aluminium paper as heat insulating. The ambient temperature has been 22-23°C [18,19,20,21].

Fig. 1a. Sesame seeds

Fig. 1b. Sesame powder

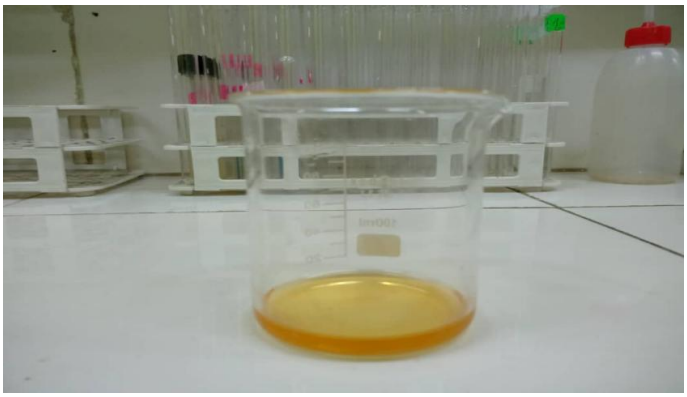

Fig. 1c. Sesame seeds oil

After a given extraction time, the cartridge is taken up to be dried in the drying oven at 50°C during 24 hours in order to remove solvent traces.

The oil – solvent mixture collected in 1000 mL thrice necked balloon – flask is submitted to rotary evaporator to get rid of solvent and the balloon – flask with extracted oil is introduced in the drying oven during 2 hours to eliminate totally all the traces of humidity and solvent. After this step the balloon – flask with oil is cooled in a dessicator and weighed. The difference between the balloon – flask containing oil and the empty one determines the extracted oil mass at t time in gram.

2.2.2 Work formula

It can be recalled that KUNYIMA method in short is the reasoning leading to understand a phenomenon and to mathematize it. So, the study of extraction of oils has been mathematized for the first time by Dr. Anaclet KUNYIMA BADIBANGA, Ordinary Professor, Faculty of Sciences, University of Kinshasa (UNIKIN) through the formula (1) below [18,19].

Equations (1), (2) and (3) have been used [18,19,22]:

$$\log\left(\frac{1}{m_0 - m_e}\right) = \frac{k}{2.3}t + \log\frac{1}{m_0} \quad (1)$$

$$A = \frac{\gamma}{k(1-\gamma)} \quad (2)$$

$$V_r = AQ \quad (3)$$

where m_0 is the total experimental mass of oil extracted by solvent in gram ; m_e represents the experimental mass of oil extracted by solvent in gram at ***t*** time expressed in hours; *A* has been called sizing constant or sizing factor, k is kinetic constant in h^{-1} and γ is the conversion rate of oil obtained from $\gamma = \frac{H}{m} \times 100$ where H is a mass of oil extracted in gram and m is the mass of powder of sesame seeds used in grams ; V_r is the reactor volume in liter and Q is the desired volumic debit of oil (Lh^{-1}).

3. RESULTS AND DISCUSSION

Each value in Table 1 is a mean value of three measures.

The evolution of the experimental extracted mass as a function of time is given in Fig. 2 where a stationary zone, neither increasing nor decreasing, has been observed giving the value of m_0 in petroleum ether as solvent.

When $\log(\frac{1}{m_0 - m_e})$ is plotted versus extraction time in hours, a straight line is observed whose slope gives the kinetic constant (k) and the intercept allows to determine m_0 in experimental errors limits as it is shown in Fig. 3 by using origin 9.2 program.

The Fig. 4 shows the plot of V_r versus Q by means of origin 9.2 program.

As it can be seen in this figure linear dependence between V_r and Q has been observed.

Table 1. The measured and calculated parameters for sesame seeds oil

Time (h)	$m_e\ (g)$	$m_0(g)$	$m_0 - m_e$ (g)	$\frac{1}{m_0 - m_e}$	$log\frac{1}{m_0 - m_e}$	$log\frac{1}{m_0}$
0	0.0000±0.0000	5.3911±0.1753	5.3911	0.1855	−0.7317	−0.7317
0.5	2.0773±0.3029	5.3911±0.1753	3.3138	0.3018	−0.5203	−0.7317
1	4.7635±0.2632	5.3911±0.1753	0.6276	1.5934	0.2023	−0.7317
1.5	5.1920±0.1853	5.3911±0.1753	0.1991	5.0226	0.7009	−0.7317
2	5.2522±0.1770	5.3911±0.1753	0.1389	7.1994	0.8573	−0.7317
2.5	5.2916±0.1859	5.3911±0.1753	0.0995	10.0502	1.0022	−0.7317
3	5.3337±0.1753	5.3911±0.1753	0.0574	17.4216	1.2411	−0.7317
3.5	5.3711±0.1753	5.3911±0.1753	0.0200	50.0000	1.6990	−0.7317
4	5.3911±0.1753	5.3911±0.1753	0.0000	–	–	–

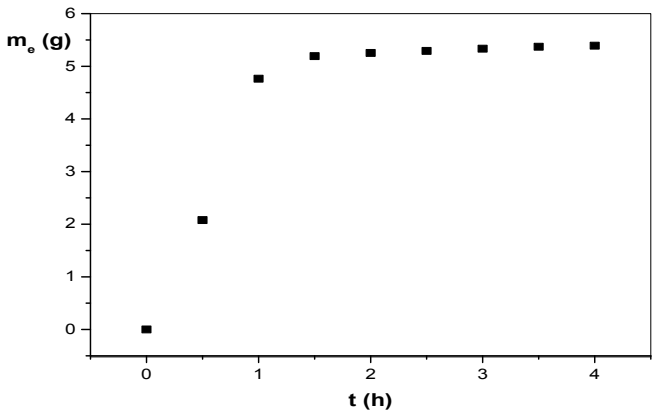

Fig. 2. Extracted experimental mass of sesame seeds oil as a function of time (h)

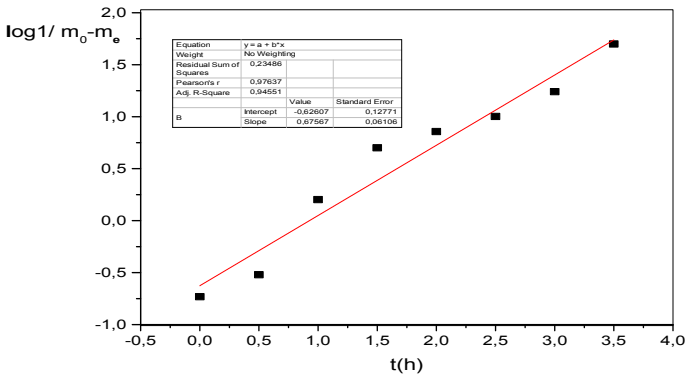

Fig. 3. $\log(\frac{1}{m_0 - m_e})$ **versus time (h)**

In this figure $k = 1.5540 \pm 0.1404$ *and the intercept* $\log\frac{1}{m_0} = -0.62607 \pm 0.1277$

Table 2. Evolution of reactor volume (V_r) as a function of desired volumic debit of sesame seeds oil (Q)

Q (Lh^{-1})	**V_r (L)**
0	0.0000±0.0000
0.5	0.3752±0.0595
1	1.7503±0.2778
1.5	1.1254±0.1786
2	1.5006±0.2381
2.5	1.8758±0.2977
3	2.2509±0.3572
3.5	2.6260±0.4167
4	3.0012±0.4762
4.5	3.3764±0.5358
5	3.7515±0.5954

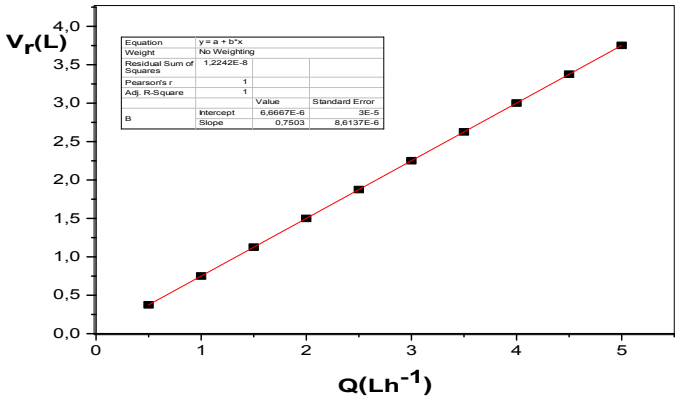

Fig. 4. V_r **versus** Q

4. CONCLUSION

Considering the interest offered by sesame seeds oil the preoccupation has been emphasized on the technology of its local production.

The sesame seeds oil extraction has been successfully performed by means of Soxhlet with petroleum ether as solvent and the conversion rate of (0.5383 $\pm$ 0.0170) has been obtained. The application of KUNYIMA method to extraction kinetic of sesame seeds oil has given satisfactory results from which kinetic constant has been calculated ($k = 1.5540 \pm 0.1404$) using origin 9.2 program.

Those two very important parameters, kinetic constant and conversion rate, allowed to determine the sizing factor (A) leading to calculate the reactor volume as a linear function of desired volumic debit of sesame seeds oil.

The way is now open to build commercial reactor of sesame seeds oil extraction for the local production (home technology). This crude oil must undergo refining before to be used.

It is very briskly recommended to Democratic Republic of Congo government to undertake the sesame crop at the same time with cassava, maize, rice, peanut, garlic, onion, curcuma, potato, yam, gourd, soja, diversified fruits trees, etc because Democratic Republic of Congo is a terrestrial paradise where the climate is a major trump during all the year.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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