DEMOCRATIC REPUBLIC OF CONGO MORINGA SEEDS OIL EXTRACTION: KUNYIMA METHOD APPLICATION.

ABSTRACT

Background: The poisoning, one of the nowadays most serious problem of public health in Democratic Republic of Congo since two decades, has made many victims because of the lack of information and because of the population impoverishment unable to accede to health care. The Democratic Republic of Congo has a very rich and diversified vegetable patrimony with known therapeutic properties needing only appropriate technology to deal with the extraction process of oils or active principles.

Aim and objective: The overall purpose pursued is to endue the country with appropriate (home) technology to solve somewhat the public health problem in DRC. The kinetic study of oil transfer from liquid- solid extraction has been undertaken in view of the phenomenon uptake in order to make possible home technology of reactors sizing, nowadays absent in underdeveloped countries. This is a technical work related to the extraction, modeling and quantification of moringa seeds oil.

Methodology: KUNYIMA method has been successfully extended to the moringa seeds oil extraction in petroleum ether using Soxhlet device to assess its validity. The figures have been plotted by means of Origin 8 program.

Results: When $log\frac{1}{m_{0_e}-m_e}$ is plotted as a function of time, linear behavior has been obtained at constant temperature (56 °C) in dilute medium. The global kinetic constant of this time dependent phenomenon has been calculated $[(k = 1.2607 \pm 0.0591)h^{-1}]$ to make possible the reactor building for the oil production. The comparison of some parameters of extraction $(m_e, k, ...)$ between gourd seeds oil and moringa seeds oil measured and calculated in the same experimental conditions shows in petroleum ether a greater kinetic activity of solvent for gourd seeds oil than for moringa seeds oil followed by significant extraction of gourd seeds oil as fast as the time advanced $(k_{GSO} > k_{MSO})$.

This observation suggests the existing difference of structures between the two species as it is hereby discussed. Moreover it has been pointed out previously that if the difference Δm in absolute value is not of the same errors magnitude order it would interpret the solvent effect. It should be noted however it has been observed the ratio $\frac{m_s}{m_e} > 1$ where the kinetic constant is high (gourd seeds oil) and $\frac{m_s}{m_e} < 1$ where the kinetic constant is low (moringa seeds oil) and this ratio might likewise better give information on solvent effect. Prediction is done of getting possibility of sigmoid curve in the case of the presence of different solvation equilibria. Also the sigmoid obtaining depends likely on both the structure of extractant solvent and the structure of extracted material. In that case the kinetic constant will be calculated in the upright region of sigmoid curve.

Conclusion: Kunyima method has been successfully used in the case of moringa seeds oil extraction. Kunyima method consists in best uptake of the phenomenon, in expressing it in suitable mathematical model in order to determine its velocity through its kinetic constant before sizing the experimentation reactor. The reactor volume depends on both the sizing factor and the desired volumic debit.

Keywords: KUNYIMA method, Appropriate (home) technology, Moringa seeds, Sizing factor, Solvent effect, Sigmoid curve.

ABBREVIATIONS: Kinetic constant Gourd seeds oil (k_{GSO}), Kinetic constant Moringa seeds oil (k_{MSO}), Reactor volume (V_r), Volumic debit (Q).

1. INTRODUCTION

Moringa oleifera has been extensively studied (leaves, seeds, pods, stems, flowers, roots, etc.). There is abundant literature where it is reported its benefits [1,2,3,4]. Its high rates in vitamins A, B and C; its important contents in minerals and chemical elements such as iron, zinc, calcium, copper, potassium, magnesium, manganese, phosphorus, sulfur, selenium, sodium, molybdenum,etc.; the total absence of cholesterol; its impressive amount in fibres and the presence of essential amino acids make it called "the life tree" utilized in various fields of science such as medicine (phytotherapy), water science, stock breeding, agriculture, cosmetics and perfume, nutrition, thin paint and so forth. Moringa seeds contain 40% of super quality oils like olive oil with 73% of oleic acid [5,6,7,8].

With respect to the medical side, moringa intervenes in the prevention and treatment of diabetes, hypertension, cardiovascular diseases, sleep, hairs and skin problems [2,5]. Several bioactive compounds isolated from:
- seed like glucosinolates and isothiocyanates, hemagglutinins possess anti-cancer, antibiotic, anti-inflammatory and agglutinogenic effects [9].
- moringa leaves such as glucosinolates, thiocarbamates and carbamates as well as other nitrile groups are responsible for several beneficial effects such as: hypotensive, hypolipidemic and antiatherosclerotic, hypoglycemic, antifungal, regulation of the thyroid status [10,11,12,13,14].

The action of the roots is mainly antiseptic, anti-inflammatory, sedative, cardiotonic, potentiator of some analgesic and antidepressive drugs. These actions are mostly due to the presence of alkaloids such as Moringin, Moringinine a powerful fungicide, bactericide Pterygospermine or Anthonin and Spirochine [15,16].
This medical aspect of moringa seeds has interested our laboratory (LACOPA) because indeed it has been already tried successfully to use moringa as an antipoison. Its effect has been highly appreciated. By adjunction curcuma to moringa seeds the antipoison effect has been extraordinarily enhanced.

The tests are continuing and will wait for a fit required scientific sample to be published. Anyway the preoccupation of Laboratory is to make possible the heart normal acting beyond one century without any problem by improving and stabilizing the cardiac exergetic yield. Indeed one of the tackled topics in our laboratory is "physico-chemical and thermoexergetic foundations of heart acting" in which many publications have been already carried out [17,18].

It has been searching how to maintain the elasticity of cardiac muscle beyond one century and how to save heart against poison because it is really the public health problem in the country even though it is not officially declared by the specialists. It is known that when a poison is introduced in the body, the most fragile parts are noble organs: heart, brain, kidney, lungs, liver and pancreas [19].

It is needed to solve the heath problem, in the country where technology is missing. It has been decided to turn the research to phytotherapy.

In this paper it is shown how the country can have its appropriate technology (reactor building) called here home technology in order to produce the important amounts of matters. It has been tried to extract moringa seeds oil and to show how to produce it industrially (home technology). This is a technical work related to the extraction, modeling and quantification of moringa seeds oil. This oil contains many chemical compounds [20] giving it the potential property of antipoison. Furthermore, it has been already demonstrated the antipoison property of moringa leaves against arsenic [21].

This property has been tested in our laboratory (in vitro and in vivo), the results are positive but, not enough to be published for the moment; it will demand several days before confirmation.

MATERIALS AND METHODS

2.1. Materials

Drying oven, Balance (mark OHAUS), watch glass, desiccator, heating skull cap, spade, beaker, cellulose cartridge (33 × 205 mm), thermometer, gel of silicone, aluminium paper, thermostat, rotary evaporator, chronometer, mortar and pestle, burettes, distillate water and petroleum ether have been used. Origin 8 program (software) has served in this work. Moringa seeds collected in Kinshasa

Province and conditioned during one week (May 2018) before use with the following characteristics have been used in this research [20,22,23]:

Reign: *Plantae*
Family: *Moringaceae*
Division: *Magnoliophyta*
Order: *Capparales*
Class: *Magnoliopsida*
Gender: *Moringa*
Species: *Oleifera*

Fig.1. Moringa Tree

Fig.2. Moringa Seeds

Fig.3. Moringa seeds Powder

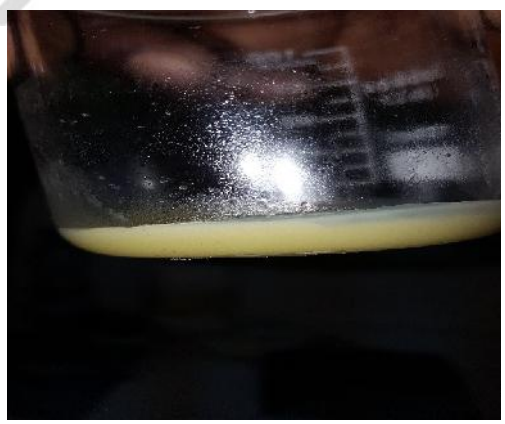

Fig.4. Moringa seeds oil at 27 °C

2.2. Methods

Oil extraction protocol

Moringa seeds have been husked, afterwards dried at 50 °C for four days in the drying oven (memmert model). These seeds were pounded (porcelain mortar and porcelain pestle) and the obtained powder was preserved in a desiccator. 10 g of this powder were introduced in cellulose ˈous ca pon × 205 mm and put in Soxhlet extractor. artridge of 33

ecka thre le necked ba oon - flask fitted of a thermometer, 450 mL of petroleum ether (40 – 60 °C, -1) = 0.65 1 kg -1 solven t were used for the extraction.

The fitting out of Soxhlet was done on heating skull cap (series EM 0500/CE, M357440) in fixing the temperature at 56 °C. To maintain constant the temperature during experiments, the heating skull cap was covered of aluminium as a heat insulator. The ambient temperature has been kept at 24 – 25 °C [24,25,25,27].

After a given extraction time, the cartridge was dried in a drying oven at 50 °C for 24 hours in order to get rid of traces of solvent. The solvent in the oil – solvent mixture was separated using a rotary evaporator (Hei-VAP 1.0) at 60 °C and the oil placed finally in drying oven at 60 °C during two hours to get totally rid of solvent traces. After this, the balloon flask with oil has been cooled in a desiccator and weighed. The difference between the balloon flask containing oil and the empty one determines the extracted oil mass at a ***t*** time.

Equation (1) was used in calculation [24].

$$\log\left(\frac{1}{m_0 - x}\right) = \log\left(\frac{1}{m_{0e} - m_e}\right) = \frac{k}{2{,}3}t + \log\frac{1}{m_0} \qquad (1)$$

$x = m_e$ = experimental extracted mass of Moringa seeds oil.
$m_o = m_{o_e}$ = total experimental extractible mass of Moringa seeds oil.

For the sizing of extraction reactor, the equation (2) was used [24,28]:

$$V_r = \frac{\gamma}{k(1-\gamma)}Q = AQ \qquad (2)$$

where *A* is the sizing factor and γ the conversion degree [24].

The data were compared to gourd (*Cucurbita pepo*) seeds oil extraction values obtained in previous works of the group [24].

2. RESULTS AND DISCUSSION

The extraction phenomenon depends on physical properties of extractant solvent such as its dielectric constant, its polarity, its polarizability, its refractive index and on the structure of the extracted material. Also the experimental conditions such as temperature, medium pH, committed concentrations and sampling should be taken into account.

In any extraction process two steps are to be considered: solubilization and transfer (diffusion). The spontaneous phenomena of solubilization occur when $\Delta G < 0$ (generally an exothermic phenomenon). There exist however the spontaneous endothermic phenomena promoted usually by the increase of temperature.

Table 1. Measured and calculated parameters of moringa seeds oil extraction.

Time (h)	m_e (g)	m_{o_e} (g)	$m_{o_e} - m_e$ (g)	$\frac{1}{m_{o_e} - m_e}$	$\log\frac{1}{m_{o_e} - m_e}$	$\log\frac{1}{m_{o_e}}$
0	0.0000±0.0000	2.6105±0.2901	2.6105	0.3831	−0.4167	−0.4167
0.5	1.6457±0.1767	2.6105±0.2901	0.9648	1.0365	0.0156	−0.4167
1	2.0361±0.2650	2.6105±0.2901	0.5744	1.7409	0.2408	−0.4167
1.5	2.2611±0.0960	2.6105±0.2901	0.3494	2.8620	0.4567	−0.4167
2	2.3550±0.1454	2.6105±0.2901	0.2555	3.9139	0.5926	−0.4167
2.5	2.5244±0.2889	2.6105±0.2901	0.0861	11.6144	1.0650	−0.4167
3	2.5635±0.3031	2.6105±0.2901	0.0470	21.2765	1.3279	−0.4167
3.5	2.5831±0.3080	2.6105±0.2901	0.0274	36.4964	1.5622	−0.4167
4	2.6105±0.2901	2.6105±0.2901	0.0000	–	–	–

m_e is experimental extracted mass of moringa seeds oil

m_{o_e} is total experimental extractible mass of moringa seeds oil for a given solvent

The Figure 5 below shows the results of this Table 1 in petroleum ether for the sample studied.

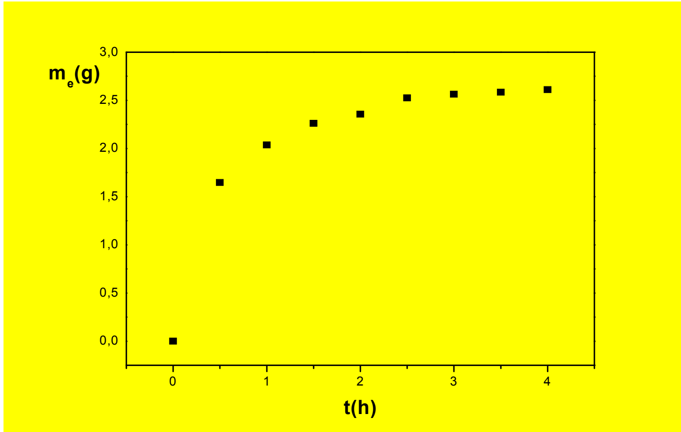

Fig.5. Experimental extracted oil mass as a function of time.

In this Table 1 each value is a mean value of three measurements. When $log\frac{1}{m_{o_e}-m_e}$ is plotted versus time using origin 8 program a right line is obtained; its slope gives the kinetic constant, a measure of kinetic activity of solvent, and its intercept gives m_{o_s} called total statistical experimental extractible mass of moringa seeds oil in petroleum ether and for a given sample different from m_{o_e} as it is shown in Figure 6.

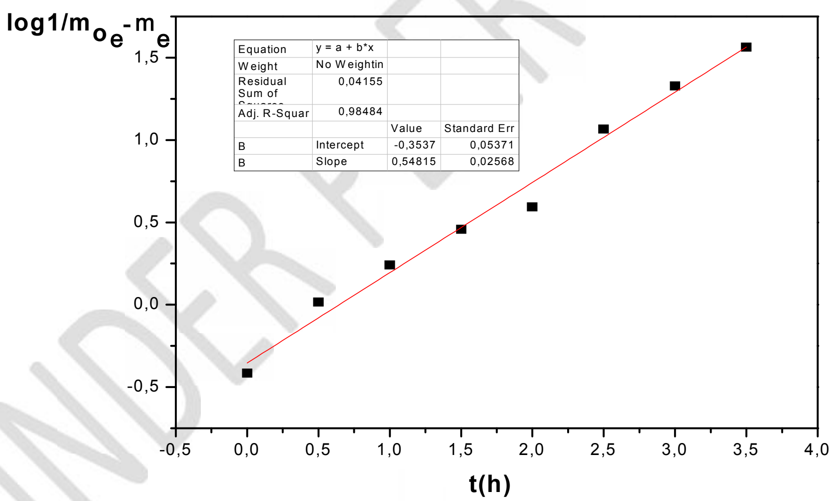

Fig.6. Graphic of $log\frac{1}{m_{o_e}-m_e}$ vs time

The kinetic constant has been found $k = (1.2607 \pm 0.05691)$h^{-1}. The intercept allows to calculate m_{o_s} as follows.

$$\log m_{os} = 0.3537 \pm 0.0537$$

$$\overline{m}_{os} = \overline{m}_{o_{th}} = 10^{(0.3537 \pm 0.0537)}$$

$$m_{o_{1s}} = m_{o_{1th}} = 10^{(0.3537 + 0.0537)} = 2.55541$$

$$m_{o_{2s}} = m_{o_{2th}} = 10^{(0.3537 - 0.0537)} = 1.9954$$

$$\overline{m}_{os} = \overline{m}_{o_{th}} = \frac{m_{o_{1s}} + m_{o_{2s}}}{2} = 2.2754 \quad (3)$$

$$\overline{m}_{os} = 2.2754 \pm 0.2800$$

The index **th** means theoretical, it has been introduced to be congruent with the previous work [24].

So the statistical mass (m_s) of moringa seeds oil as a function of time has been calculated by means of the relation

$$m_s = m_{o_s}(1 - e^{-kt}) \quad (4)$$

All those values have been inscribed in Table 2 and compared to gourd seeds oil extraction values [24].

Table 2. Comparison of the extraction parameters at 56 °C between gourd seeds oil and moringa seeds oil.

	Gourd seeds oil					Moringa seeds oil				
Time (h)	m_e (g)	m_s (g)	Δm (g)	m_s/m_e	k (h^{-1})	m_e (g)	m_s (g)	Δm (g)	m_s/m_e	k (h^{-1})
0	–	–	–	–	1.6411±0.0712	–	–	–	–	1.2607±0.0591
0.5	–	–	–	–		1.6457±0.1767	1.0640±0.1567	0.5817	0.6465	
1	4.0485±0.8790	4.8339±0,8432	0.7854	1.1940		2.0361±0.2650	1.6304±0.1464	0.4057	0.8007	
1.5	4.6640±0.5862	5.4843±0.9174	0.8203	1.1760		2.2611±0.0960	1.9320±0.1388	0.3291	0.8544	
2	5.1423±0.5888	5.7706±0.9399	0.6283	1.1222		2.3550±0.1454	2.0926±0.1334	0.2624	0.8886	
2.5	5.2212±0.3131	5.8966±0.9453	0.6754	1.1294		2.5244±0.2889	2.1781±0.1296	0.3463	0.8628	
3	5.2587±0.3562	5.9521±0.9458	0.6934	1.1318		2.5635±0.3031	2.2236±0.1644	0.3399	0.8674	
3.5	5.2950±0.4075	5.9765±0.9451	0.6815	1.1287		2.5831±0.3080	2.2478±0.1256	0.3353	0.8702	
4	5.3118±0.4193	5.9872±0.9444	0.6754	1.1272		2.6105±0.2901	2.2607±0.1246	0.3498	0.8660	

When this Table 2 is analyzed, it can be observed that the kinetic activity of petroleum ether is greater in gourd seeds oil than in moringa seeds oil ($k_{GSO} > k_{MSO}$). Secondly the extracted oil as a function of time in gourd seeds is large amount compared to moringa seeds oil. This observation suggests the existing difference of structures between gourd seeds and moringa seeds. Anyway the difference of kinetic constants of these two species under study implies likely much more the difference in their structures in which their oils are imbedded than both the difference in the composition and structure of these oils. Indeed, in a crystal the molecules are organized. In amorphous compound, there is no organization. In melting, a crystal is converted from an organized state to an unorganized one.

They are intermediate states between crystalline state and amorphous state called mesomorph substances that can be divided into two classes according to the type of organization namely smectic compounds, where the molecules are oriented in parallel and arranged in well-defined planes, and nematic compounds where the molecules are oriented in parallel without any order. Concerning some substances, there are successive transitions [29,30]:

Crystal ⟶ Smectic state ⟶ Nematic state ⟶ Amorphous state

The organic materials with long chains arise generally from mesomorph structure (smectic and nematic structures) for example ammonium oleate.

So, gourd seeds can be likely identified to amorphous compound while moringa seeds to mesomorph material [31]. Furthermore, it has been previously [29,30] signalized that if $\Delta m = m_s - m_e$ in absolute value is not of the same order of magnitude of errors it would give information on the solvent effect. It should be noted however that the observation of this table 2 shows the ratio $\frac{m_s}{m_e} > 1$ for gourd seeds oil where the kinetic constant is high while $\frac{m_s}{m_e} < 1$ for moringa seeds oil where the kinetic constant is low. This ratio might be used likewise to diagnose the solvent effect. Prediction can be raised on the possibility of obtaining sigmoïd curves in the case of the presence of different solvation equilibria.

Also, the sigmoïd getting may depend likely on both the chemical structure of extractant solvent and the mixture structure of the extracted material. The structure containing the extracted oil and the committed concentrations should be taken into account.

In that case the kinetic constant will be calculated in the upright region of sigmoid curve. Now it is possible to calculate the sizing factor and to size a discontinuous stirrer vat reactor of oil production by the below-mentioned equation [24,28,32]:

$$V_r = \frac{\gamma}{k(1-\gamma)} Q$$, as it is shown in Table 3 and Figure 7.

γ has been found 26.0827 ± 1.1212 %.

Table 3. Reactor volume (V_r) as a function of desired volumic debit (Q)

Q (Lh^{-1})	V_r (L)
0	0.0000±0.0000
0.5	0.1399±0.0147
1	0.2798±0.0294
1.5	0.4197±0.0440
2	0.5596±0.0587
2.5	0.6995±0.0734
3	0.8394±0.0881
3.5	0.9793±0.1028
4	1.1192±0.1174
4.5	1.2591±0.1321
5	1.3990±0.1468

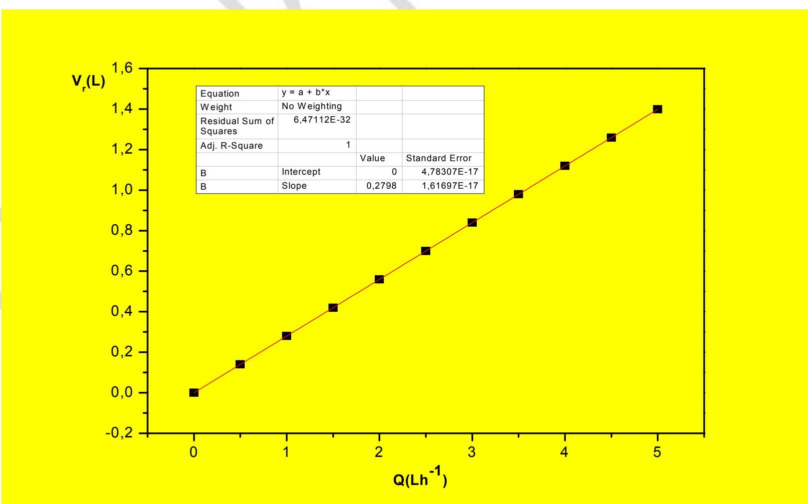

Fig.7. Graphic of Reactor volume (V_r) vs *desired volumic debit (Q)*

It is important to note that the observed linear behavior between the reactor volume (V_r) and volumic debit (Q) depends on the desired volume of oil per hour it is needful to produce.

3. CONCLUSION

Kunyima method has been successfully used in the case of moringa seeds oil extraction. The laboratory is interested in extraction of medicinal plant oil in order to better the heart acting which is one of the serious problems of public health in Democratic Republic of Congo. The calculated kinetic constant of petroleum ether shows a low activity of this solvent in moringa seeds oil extraction compared to gourd seeds oil extraction.

Once again moringa seeds oil extraction is time dependent phenomenon and submits to the proposed equation.

The comparison of kinetic constants between moringa seeds oil extraction and gourd seeds oil extraction suggests the difference of texture between two species. Moringa seeds oil can be likely identified to mesomorph structure while gourd seeds are made of amorphous texture. This comparison has been done in order to confirm the reliability of the Kunyima method.

The reactor volume (V_r) is depending linearly on both desired volumic debit (Q) and sizing factor as in the case of gourd seeds oil extraction.

Suggestions are made to study antipoison activity of moringa seeds oil, to accelerate the research on Curcuma, Ginger, Garlic, Arachis hypogaea oil and so forth and their conjunction in different proportions because the preliminary experiments in our laboratory have shown extraordinary healing properties.

According to its wonderful properties, moringa (leaves, seeds, pods, stems, flowers, roots, etc.) would be a potential mighty antipoison particularily for heart and for entire body in general.

Also, the research of appropriate (home) technology should be an obsession for under equipped countries.

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