BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Volumul 69 (73), Numărul 1, 2023
Secţia
CHIMIE şi INGINERIE CHIMICĂ
DOI: 10.5281/zenodo.7767181

BENCHMARKING ON *ALOE VERA* GEL EXTRACTION

BY

ABDOURAMANE NSANGOU[1], DOINA SIBIESCU[2,*], PIERRE MARCEL ANICET NOAH[1], NKEMAJA DYDIMUS EFEZE[3], FABIEN EBANDA BETENE[1], BENJAMIN II CASTRO MPAH EKOUME[1] and VALERY HAMBATÉ GOMDJÉ[4]

[1]Department of Mechanical Engineering, ENSET, University of Douala, Cameroon
[2]“Gheorghe Asachi” Technical University of Iaşi, “Cristofor Simionescu” Faculty of Chemical Engineering and Environmental Protection, Iaşi, Romania
[3]HTTTC Bambili-University of Bamenda, Cameroon
[4]Departments of Textile and Leather Engineering, ENSPM, University of Maroua, Cameroon

Received: December 15, 2022
Accepted for publication: February 10, 2023

Abstract. *Aloe vera* gel is composed of more than 70% saccharide and polysaccharides is the transparent mucilage contained in the parenchymal cells of the fresh *Aloe vera* leaf. This study objective was to produce a comparison of a set of extraction methods of *Aloe vera* in the literature. The methodology used is the synthesis of a set of scientific articles, theses, dissertations dealing with the issue of *Aloe vera* gel extraction. The databases used are (Science Direct, Google Scholar, and ResearchGate). This work studied 6 types of extractions (traditional extraction, Soxhlet extraction, Organic solvent extraction, Ultrasonic extraction, Supercritical extraction and Microwave). These types of extractions were evaluated on several parameters, namely: extraction principles, solvents, extraction time, yield, liquid ratio, gel efficiency and number of extractions.

The analysis shows that the quality and yield of *Aloe vera* gel depends on the type of extraction it undergoes, organic solvent extraction which are: yield, which is 20.67 per kg, liquid ratio 1:15, number of extraction 2 times. Although other extraction methods have some information like traditional extraction the efficiency of gel is poor, the same *Aloe vera* can undergo three times traditional

*Corresponding author; *e-mail*: dsibiesc@tuiasi.ro

extraction then Soxhlet extraction the efficiency is improved. Ultrasonic extraction has a high efficiency, 98.06% compared to organic solvent extraction whose yield is 90% and microwave extraction in ethanol solvent with yield of 80%. Each type of extraction has its own principle and the solvent to be used.

Keywords: *Aloe vera* gel, benchmarking, extraction.

1. Introduction

Aloe vera gel is the transparent mucilage as the color of clean water contained in the parenchymal cells (Soriano, 2016, Nsangou *et al*., 2022a).

Aloe vera is a green plant of the Liliaceae family with fleshy, cactus-like leaves (Roullier, 2015; Chandegara *et al*., 2014). There are no less than 420 species in the world, the most widely used of which are Socotra Island Aloe (*Aloe succotrina*), *Cape Aloe* (*Aloe africana*), *Aloe saponaria*, *Aloe sinensis*, *Aloe arborescens*, *Aloe ferox* and of course *Aloe vera* (Haller, 1990). The composition of *Aloe vera* is not yet fully established. It is very difficult to give the exact composition of this gel because it is composed of more than 200 substances (The Angiosperm Phylogeny Group, 2005) and depends on the living environment of the plant (climate, region, pesticides...) as well as on the method of obtaining the gel (Soriano, 2016). *Aloe vera* gel, with a pH between 4 and 5, contains about 98.5% water, the cuticle containing "only" 90%. The total solids content is 0.66% of the gel, while the soluble solids content is 0.56%, considering seasonal fluctuations (Soriano, 2016; Roullier, 2015; Haller,1990). *Aloe vera* gel is composed of more than 70% saccharides and polysaccharides (Schmelzer *et al*., 2008) and in particular of linear glucose and mannose chains called polymannans because of the high presence of mannose. They can range from a few units to thousands and have great heterogeneity. They can also be partially branched or acetylated. These polysaccharides form the colloidal system responsible for the viscosity and opacity of the gel (Roullier 2015). Apart from polysaccharides, it consists of phenol (1%), lipid (1%), protein (7%), mineral salts (16%) and sugar (16%), various acids, saponins, lignin, phthalate esters, growth hormones, anthraquinones ((Roullier, 2015; Ro *et al*., 2000; Hutter *et al*., 1996). *Aloe vera* gel is an antimicrobial (Soriano, 2016; Roullier, 2015; Ramesh *et al*., 2019; Vega-Galvez *et al*., 2012). The antimicrobial test on several microbes was favorable. The antifungal activity of *Aloe vera* has also been tested in various studies, and it has been shown to be effective against different types of fungi including *Candida albicans* and *Trichophyton rubrum* leaf (Soriano, 2016; Jia *et al*., 2008; He *et al*., 2011). Other tests on microbes have been favorable namely: *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Trichophyton mentagrophytes*, *Trichophyton schoeleini*, *Canine Microsporum* and *Candida albicans* (Agarry *et al*., 2005). It

heals burns, surgical wounds, and ischemic wounds (Soriano, 2016; Roullier, 2015; Haller,1990; Nsangou *et al*., 2021a; Hetal *et al*., 2020; Nsangou *et al*., 2022b). The study objective is to perform a comparison of a set of *Aloe vera* extraction methods in the literature.

The ultimate goal is to facilitate tools to better benefit from *Aloe vera* extractions to improve our sustainable development.

2. Methodology

2.1. Knowledge synthesis on *Aloe vera* extraction

An information source for the benchmarking is a set of articles, theses, thesis with the issue of *Aloe vera* gel extraction. The databases used are (Science Direct, Google Scholar, and ResearchGate). A series of keywords were used to conduct the information search. These keywords are:

- *Aloe vera* gel,
- Extraction of *Aloe vera* gel.

2.2. Comparison criteria

The paper works that have been retained in this benchmarking are to compare the extraction methods of *Aloe vera* gel. The evaluation parameters were extraction method, extraction time, extraction product, extraction machines and yield. These studies provide a formal methodology to gather and analyze data from different studies selected on transparent criteria.

3. Results

A total of 10 studies offered accessible results and all of them presented usable numerical data, *i.e.* evaluated the extraction methods for *Aloe vera* gel. This evaluation will be done by studying the principles of extraction, the product obtained, the extraction time, the yield. These extraction methods (Table 1) (traditional extraction, Soxhlet extraction, Organic solvent extraction, Ultrasonic extraction, Supercritical extraction and Microwave) were studied in contrast to the work of Dinesha and collaborators which compares manual and machine extraction of *Aloe vera* gel. He found that the efficiency of the gel is 100% when extracted manually and 98.06% by machine (Chauhan and Kumar, 2020; Dinesha *et al*., 2019; Mohan *et al*., 2022; Kumar *et al*., 2022). In their comparison of *Aloe vera* gel extraction, the principle remained that of traditional extraction. Their work shows that all types of extraction can be mechanized or better automated.

Table 1

Principle, products and extraction time for each type of extraction of Aloe vera gel

Types Extractions of *Aloe vera* gel	Principles	Products used (solvents)	Extraction time	References
Traditional extraction	Similar stages consisting of: crushing, adding excess solvent, mixing and allowing the deposit to settle, without heating.	Water and crushed *Aloe vera*	3 days	Dinesha *et al.*, 2019
Extraction Soxhlet	Milling and in the Soxhlet extractor and a small amount of solvent added to the round bottom flask and heated in a water bath and after centrifugation	Water crushed *Aloe vera* lead	3 to 4 days	Chandegara *et al.*, 2014; Dinesha *et al.*, 2019
Organic solvent extraction	The principle is to add the product to a different solvent forming a mixture that will then be heated and filtered	Ethanol or ethylene acetate	2 days	Dinesha *et al.*, 2019; Nsangou *et al.*, 2021b; Arnnok *et al.*, 2012
Ultrasonic extraction	Using ultrasonic wave cavitation to increase the frequency and velocity of material molecules	Methanol	40 minutes	Dinesha et al., 2019; Arnnok *et al.*, 2012
Supercritical extraction	When the fluid is in the supercritical state, it has characteristics of a gas (e.g. high permeability, low viscosity) and liquid phase for the solubility of the material)	CO_2	30 minutes	Dinesha *et al.*, 2019
Microwave	Water evaporates on site, causing pores and cracks in the cells and the gel is easily released and extracted	Ethanol	3 minutes	Dinesha *et al.*, 2019; Wang *et al.*, 2011

In the types of extraction, traditional extraction and Soxhlet extraction use water and other types of extraction such as supercritical extraction which uses carbon dioxide which has a negative effect on the ozone layer, have a major impact on the environment.

Since ethanol for example contributes to the reduction of greenhouse gases. Traditional extraction differs from Soxhlet extraction through amount of solvent (water), heating and even final mechanism. For the first method, water in larger quantity, is not heated again the separation of the cake gel is done by settling, while for the second method, the water must be quantity smaller, device Soxhlet must be heated and the gel is separated from the cake by centrifugation, and the process is complex, wasting more time than the traditional extraction process. The gel obtained by Soxhlet extraction is purer than that obtained by traditional extraction. According to Table 1, the extraction of organic solvent is better than the first two in terms of product quality and extraction time control.

Table 2

Yield, liquid ratio, gel efficiency for representative types of extractions

Extraction types of *Aloe vera* gel	Performance	The effectiveness of the gel	Number of extractions	References
Manual extraction	the quantity of gel is 100%, but too much solvent (water) consumed in extraction	Weak ingredient and purity is not high	3 times	Chandegara *et al.*, 2014; Arnnok *et al*., 2012; Dinesha *et al*., 2019
Soxhlet extraction	79%	The product efficiency is improved, and the heating can break down the product	2 times	Dinesha *et al*., 2019
Microwave	80%	Product efficiency is improved	1 time	Wang *et al*., 2011; Dinesha *et al*., 2019
Organic solvent extraction	liquid ratio 1:15; extraction rate of ethanol is higher than that of ethyl acetate 90%	Product efficiency is improved	2 times	Nsangou *et al.*, 2021b Arnnok *et al.*, 2012;
Ultrasound extraction	98%	The product has the best efficiency	2 times	Dinesha *et al*., 2019

The fastest extractions are supercritical and microwave extraction followed by ultrasound extraction. It is important to know the yield of each type of extraction, the liquid ratio.

On the parameters to be studied in Table 2 (yield, liquid ratio, gel efficiency, number of extractions, optimal condition), the literature offered the complete information of organic solvent extraction which are: yield, which is 20.67 per kg, liquid ratio 1:15, number of extraction 2 times. Although other extraction methods have some information like traditional extraction the efficiency of gel is poor, the same *Aloe vera* can undergo three times traditional extraction then Soxhlet extraction the efficiency is improved. Ultrasound extraction has a very good yield of 98.06% compared to extraction with organic solvent whose yield is 90% and microwave extraction in ethanol solvent whose yield is around 80% (Wang et *al*., 2011). Table 2 suggests that the organic solvent extraction is the extraction with known parameters.

4. Discussion

According to the results obtained from Tables 1 and 2, the quality and yield of the gel depends on the type of extraction it undergoes. The organic solvent extraction which is: yield, which is 20.67 per kg, liquid ratio 1:15, number of extraction 2 times. Although other extraction methods have some information like traditional extraction the efficiency of gel is poor, the same *Aloe vera* can undergo three times traditional extraction then Soxhlet extraction the efficiency is improved. Ultrasonic extraction has a high efficiency (98.06) compared to organic solvent extraction 90% and microwave extraction in ethanol solvent the yield is 80% (Wang *et al.*, 2011). Each type of extraction has its own principle and solvent used. Traditional extraction differs from Soxhlet extraction in the amount of solvent (water), heating and even extraction. In the first case, the water is in excess, the Soxhlet is not heated and the separation of the gel from the cake is done by decantation, whereas in the second case, the water must be in part, the Soxhlet must be heated, and the gel is separated from the cake by centrifugation, and the process is more complex and time-consuming than in the traditional extraction process. The gel obtained by Soxhlet extraction is purer than that obtained by traditional extraction. According to Table 1, organic solvent extraction is better than the first two in terms of the quality of the product obtained and the control of the extraction time. The fastest extractions are supercritical and microwave extraction followed by ultrasonic extraction. It is important to know the yield of each type of extraction, the liquid ratio.

5. Conclusions

The objective of this work was to benchmark the types of *Aloe vera* extractions existing in the literature to give ample information to the future user,

allowing them to make a good choice on the type of extraction. This work studied 6 types of extractions (traditional extraction, Soxhlet extraction, Organic solvent extraction, Ultrasonic extraction, Supercritical extraction and Microwave).

These types of extractions were evaluated on several parameters, namely: extraction principles, solvents, extraction time, yield, liquid ratio, gel efficiency, number of extractions and optimal conditions. The analysis shows that the quality and yield of *Aloe vera* gel depends on the type of extraction it undergoes. organic solvent extraction which are: yield, which is 20.67 per kg, liquid ratio 1:15, number of extraction 2 times. Although other extraction methods have some information like traditional extraction the efficiency of gel is poor, the same *Aloe vera* can undergo three times traditional extraction then Soxhlet extraction the efficiency is improved.

Ultrasound extraction has a very good yield of 98.06% compared to extraction with organic solvent whose yield is 90% and microwave extraction in ethanol solvent whose yield is around 80%.

Each type of extraction has its own principle and solvent to use. Traditional extraction differs from Soxhlet extraction in the amount of solvent (water), heating and even extraction. For the first one, water is in excess, no heating is required and the separation of the gel from the cake is done by decantation, whereas for the second one, water must be in part, the Soxhlet must be heated, and the gel is separated from the cake by centrifugation and the process is complex and time consuming compared to the traditional extraction process.

REFERENCES

Agarry O.O., Olaleye M.T., Bello-Michael C.O., *Comparative antimicrobial activities of Aloe vera gel and leaf*, African Journal of Biotechnolog, **4 (12)**, 1413-1414, http://www.academicjournals.org/AJB ISSN 1684–5315, (2005).

Arnnok P., Ruangviriyachai C., Mahachai R., Techawongstien S., Chanthai S., *Determination of total phenolics and anthocyanin contents in the pericarp of hot chilli pepper*, International Food Research Journal, **19(1)**, 235-243, (2012).

Chandegara V.K., Varshney A.K., *Effect of Centrifuge Speed on Gel Extraction from Aloe Vera Leaves*, J Food Process Technol, **5(295)**, doi:10.4172/2157-7110.1000295, (2014).

Chauhan P., Kumar A., *Development of microbial coating for cellulosic surface using Aloe vera and silane, Carbohydrate polymer technologies and applications, Elsevier*,**1**, 100015, (2020).

Dinesha D.T., Ramachandra C.T., Udaykumar N., Sharanagouda H., Prakash K.V., *Performance evaluation of roller type Aloe vera gel extraction machine*, Journal of Pharmacognosy and Phytochemistry, **8(4)**, 1987-1992, (2019).

Haller Jr. J.S., *A drug for all seasons, medical and pharmacological history of Aloe*, Bulletin of the New York Academy of Medicine, **66(6)**, 647-659, (1990).

He C.L., Fu B.D., Shen H.Q., Jiang X.L., Wei X.B., *Fumaric acid, an antibacterial component of Aloe vera*, African, J. Biotechnol, **10(15),** 2973-2977, Doi 10.5897/AJB10.1497, (2011).

Hetal M., Suman M., Anju T., *Antibacterial treatment on cotton fabric from Aloe vera*, SSRG International Journal of Polymer and Textile Engineering (SSRG-IJPTE), **7(1)**, 54-58, https://doi.org/10.14445/23942592/IJPTE-V7I1P107, (2020).

Hutter J.A., Salmon M., Stavinoha W.B., Satsangi N., Williams RF., Streeper RT., *Anti-inflammatory C-glucosyl chromone from Aloe barbadensis*, J. Nat., **59**: 541-543, DOI: 10.1021/np9601519, (1996).

Jia Y., Zhao G., Jia J., *Preliminary evaluation: The effects of Aloe ferox Miller and Aloe arborescens Miller on wound healing*, J. Ethnopharmacol, **120**, 2, 181-189, https://doi.org/10.1016/j.jep.2008.08.008, (2008).

Kumar S., Kalita S., Das A., Kumar P., Singh S., Katiyar V., Mukherjee A., *Aloe vera: A contemporary overview on scope and prospects in food preservation and packaging*, Progress in Organic Coatings, **166**, 106799, (2022).

Mohan Raj R., Navaneethan Duraisamy, Raj V., *Drug loaded chitosan/ Aloe vera nanocomposite on Ti for orthopedic applications*, Materials Today: Proceedings, **51** (4), 1714-1719, (2022).

Nsangou A., Nkemaja D. E., Anicet P. M. N., Betene F. E., Valery H. G., Yaka Nsasso R. C., Mewoli A., *Antibacterial properties of plant-Based Textile*, SSRG International Journal of Polymer and Textile Engineering **8**(2), 1-5, (2021a).

Nsangou A., Nkemaja D.E., Pierre M., Anicet N., Soppie A.G., Amba C., Assomo A.M., Fouyou A.V., Elong E.E.F.K., Ngum L.N., Fabien E.B., Hambaté G.V., *Meta-analysis on the Retting of Plant Fibres*, **7**, 3, doi:10.14445/23948884/IJMSE-V7I3P103, (2021b).

Nsangou A., Sibiescu D., Nkemaja D.F., Noah P.M.A., Betene F.E., Hambaté G.V. *Aloe vera gel as a biomordant in the finishing of vegetable textiles: a review*; Bul. Inst. Polit. Iaşi, **68(72)**, *4*, s. Chimie şi Inginerie Chimică., 31-36, (2022a).

Nsangou A., Sibiescu D., Nkemaja D.F., Noah P.M.A., Betene F.E., Hambaté G.V., *Preliminary study on the interaction of skin microbes in the development of cosmetic and textile products: a review*, Bul. Inst. Polit. Iaşi, **68(72)**, *3*, s. Chimie şi Inginerie Chimică, 47-53, (2022b).

Ramesh K., Amit K.S., Ashutosh G., Anupam B., Abhay K.P., *Therapeutic potential of Aloe vera – A miracle gift of nature*, Phytomedecine, **60**, (2019).

Ro J.Y., Lee B., Kim J.Y., Chung Y., Chung M.H., Lee S.K., Jo T.H., Kim K.H., Park Y.I., *Inhibitory mechanism of aloe single component (Alprogen) on mediator release in guinea pig lung mast cells activated with specific antigen-antibody reactions*, J Pharmacol Exp Ther, **292**(1), 114-121, (2000).

Roullier M., *Le gel d'Aloe vera en usage topique et ses vertus cicatrisantes*, These pour le Diplome d'Etat de Docteur en Pharmacie. Universite de Picardie Jules Verneufr De Pharmacie, (2015).

Schmelzer G.H., Gurib-Fakim A., Arroo R., Bosch CH., de Ruijter A., Simmonds M.S.J., Oyen L.P.A., *Ressources végétales de l'Afrique Tropicale*, **11(1)**, Plantes médicinales 1, Wageningen, Fondation PROTA, 869, (2008).

Soriano L., *Aloe vera, Monographie*, Universite Quebec a Chitoutimi, Dess Cosmétologie, (2016).

Vega-Galvez A., Giovagnoli C., Perez-Won M., Reyes J.E., Veraga J., Miranda M., Uribe E., Scala D.K., *Application of high hydrostatic pressure to Aloe vera (Aloe barbadensis Miller) gel: microbial inactivation and evaluation of quality parameters*, Innovative food Science Emerging Technologies, **13**, 57-63, (2012).

Wang GuiHua, Su Ping, Zhang Fan, Hou Xiang Yan, Yang Hi, Guo Zhenku,*Comparison of microwave assisted extraction of Aloe-emodin in Aloe with Soxhlet extraction and ultrasound- assisted extraction*, Science China Chemistry, **54(1)**, 231-236, (2011).

*** The Angiosperm Phylogeny Group, An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APGIII. Botanical Journal of the Linnean Society, 2009.

STUDIU PRIVIND OPTIMIZAREA METODELOR DE EXTRACŢIE ALE GELULUI DE *ALOE VERA*

(Rezumat)

Gelul de *Aloe vera* este compus din mai mult de 70% zaharide, iar polizaharidele sunt mucilagiul transparent conținut în celulele parenchimale ale frunzei proaspete de *Aloe vera*. Obiectivul acestui studiu a fost acela de a produce o comparație a unui set de metode de extracție pentru *Aloe vera* utilizând literatura de specialitate. Metodologia folosită este sinteza unui set de articole științifice, teze, disertații care tratează problema extracției gelului de *Aloe vera*. Bazele de date utilizate sunt (Science Direct, Google Scholar și ResearchGate). Această lucrare a studiat 6 tipuri de extracții (extracție tradițională, extracție Soxhlet, extracție cu solvenți organici, extracție cu ultrasunete, extracție supercritică și extracție cu microunde). Aceste tipuri de extracții au fost evaluate considerând mai mulți parametri, și anume: principii de extracție, solvenți, timp de extracție, randament, raport lichid, eficiență gel și număr de extracții.

Calitatea și randamentul obținerii gelului de *Aloe vera* depind de tipul de extracție la care este supus. Pentru metodele de extracție tradiționale, eficiența de obținere a gelului este slabă, iar metodele moderne cresc randamentul de obținere a gelului. Extracția cu ultrasunete are o eficiență ridicată, 98,06% în comparație cu extracția cu solvent organic al cărui randament este de 90% și cu extracția cu microunde în solvent cu etanol, cu un randament de 80%. Fiecare tip de extracție are propriul său principiu și solventul care trebuie utilizat.