EXTRACTION OF SAPONIN FROM *ALOE VERA* : OPTIMIZATION AND KINETICS STUDIES

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ABSTRAK

Sementara beberapa penelitian telah membuktikan bahwa Aloe Vera mengandung banyak senyawa aktif alami sebagai antibacterialagent, seperti Saponin, pemanfaatannya saat ini belum optimal. Ekstraksi padat-cair digunakan untuk mengekstrak Saponin dari Aloe Vera. Penelitian ini membahas penentuan kondisi operasi ekstraksi dan juga kinetika pemodelan untuk menentukan desain nilai parameter. Selain itu, uji pendahuluan aktivitas antibakteri dari ekstrak Aloe Vera dilakukan. Hasil yang diperoleh kondisi operasi optimum ekstraksi Aloe Vera dengan aquadest sebagai pelarut selama 90 menit dan suhu 100^oC. Nilai parameter desain yang diperoleh dari proses ekstraksi yang kc = 14,76 cm. menit-1, De = 1.97 x10-6 cm2.minutes-1, dan H = 0,4435. Ekstrak ini juga terbukti menghambat aktivitas bakteri dengan daerah yang diperoleh dari zona jelas 0,0044 cm^2.

Kata Kunci : Aloe Vera, Saponin, Ekstraksi, Antibakteri.

1. INTRODUCTION

Aloe Vera is known as the healing plant and has many benefits to humankind in particular for wound healer and anti-inflammatory agent (A. Surjushe, R. Vasani and D.G. Saple, Indian J Dermatol.). Therefore, *Aloe Vera* has been used in a variety medical products. *Aloe Vera* contains 75 active substances including vitamins, enzymes, sugars, lignin, saponins, salicylic acids, and amino acids which have different functions (A. Surjushe, R. Vasani and D.G. Saple, Indian J Dermatol.). Saponin is non-ionic detergent–like which has one or more attached sugar and also has the antibacterial and anticancer properties (M. Arabski, A. Węgierek-Ciuk, G. Czerwonka, A. Lankoff, and W. Kaca; G.F. Killeen, C.A. Madigan, C.R. Connolly, G.A. Walsh, C. Clark, M.J. Hynes, B.F. Timmins, P. James, D.R. Headon). Saponin is a glycoside-shaped compound that is widely spread on high level plants. Saponin forms colloidal bond in water and by shaking will form stable foams which won't vanish with the addition of acid (V.E. Tyler, L.R. Brady and J.E Robbers). Two kinds of saponins are known, which are triterpenoid glycoside and steroid structure glycoside, both of which dissolve in water and ethanol, but do not dissolve in ether (M.A. Lacaille-Dubois and H. Wagner).

Extraction of saponinfrom *Aloe Ver*a through leaching is the most widely used method. Leaching process is aimed to take out solute from the solid or purify solid from contaminating liquid. Leaching process is carried out in three stages, which are the namely phase transformation of the solute when the solvent permeates, diffusion of the liquid in the solid particle, and mass transfer of the solute from the solid to the solvent (Geankoplis, C.J). A number of factors may influence an extraction process such as particle size, solvent type, temperature, fluid mixing, the ratio of solvent and solute weight. The rate of solid-liquid extraction depends on two main stages, which are diffusion in the solid towards the solid surface and mass transfer from solid surface into liquid. Although extraction of *Aloe Vera* has been reported in the present literature (N. Shafi, L. Khan, G. A. Khan, Jour.

Chem.Soc.Pak), a study on kinetic modeling of *Aloe* Vera extraction is still scarce in literature.

The objective of this work is to study the optimum operating condition of solid-liquid extraction of Saponin from *Aloe Vera* and followed by a kinetic modeling study to study mass transfer parameters. The batch extraction process was performed to identify the influence of several parameters, such as types of solvent, reaction time, and temperature. The design parameters, such as mass transfer coefficient (k_c), effective diffusivity (De), and Henry constant (H) were also evaluated.

2. METHODOLOGY

2.1. Materials And Methods

The dry *Aloe Vera* leaves powder was obtained from *Aloe Vera* cultivation in Kulon Progo, Yogyakarta. Initially, the leaves were dried then crushed with blender and screened to obtain 50 mesh fine powder. The subsequent step was extraction process by varying solvent types (aquadest, ethanol, and acetone), duration of extraction between 15-120 minutes with 15 minutes time intervals, and temperature variations of 55, 70, 85, and 100 ^{o}C. The extract content analysiswere carried out by taking 2 mL sample, vaporizing the solvent, and weighing the obtained extract. The total saponin extract content was determined by soxhlet extraction using aquadest.

2.2. Estimating Design Parameter Through Modelling

Mass transfer coefficient (k_c) and effective diffusivity (De) cannot be directly measured, but can be evaluated using the suitable mathematical model describing mass transfer processes. The data obtained in the laboratory was a concentration of total saponin (A) as a time function.

Some assumptions were taken for model construction such as :

1. The solid was spherical.
2. The process was carried out under isothermal condition.
3. Solid volume and solvent mass were constant.
4. The mixing in the tank was perfectly mixedthus no solute concentration gradient in the solution.

To approach the mathematical model of solid-liquid extraction, the solid was sieved to resemble the shape of a spherical with radius R, resulted a proposed mathematical model :

$$\frac{\partial^2 X_A}{\partial^2 r} + \frac{2}{r}\frac{\partial X_A}{\partial r} = \frac{1}{De}\frac{\partial X_A}{\partial t} \quad \text{......................(1)}$$

With boundary conditions :

Initial Condition (IC) : $X_A(r,0) = X_{A0}$.........(2)

Boundary Condition : $X_A(0,t)$ = definite.(3)

or $\frac{dX_A}{dr}(0,t) = 0$

$-De\frac{dX_A}{dr}(R,t) = kc(X_{Af}^{*} - X_A)$..........(4)

Scilab computer program to solve the partial differential equation and optimize k_c and De values. The equation was solved using Finite Difference Approximation and SSE minimization.

3. RESULTS AND DISCUSSIONS

3.1. Effect of Solvent Types

The amount of saponin extractthat can be obtained by varying the solvent types at their boiling points is shownin figure 1.

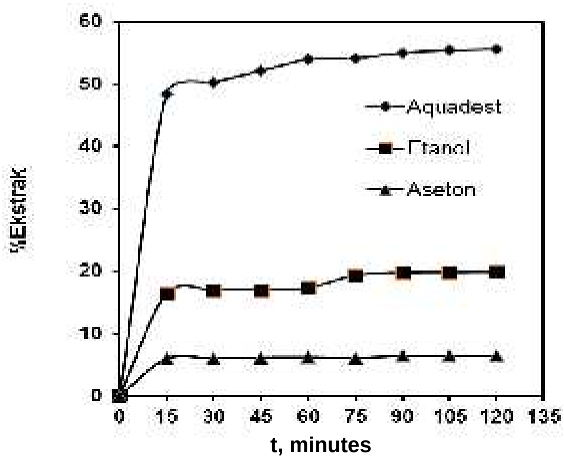

Figure 1. Graphical Relationship between Solvent Variation and % of Saponin Extract.

As seen here, aquadestgave the highest total saponin extract content as much as 55.6%, meanwhile acetone gave the least yield with 6.5%. Solvent type and the amount of saponin extract can be related to the solvent`s polarity. Both aquadest and saponin are polar substances and hence it can be inferred that polar covalent substances will dissolve easily in polar solvents and thus gave higher yield.

3.2. Effect of Extraction Time

The amount of saponin extract obtained with various extraction time with 15 minutes interval using aquadest as a solvent is shown on figure 2. In general, it can be seen that the amount of total saponin extract increased along with extraction time. However, after 90 minutes, the amount of total saponin extract started to level out which indicates the extraction process is in equilibrium stage. Figure 2 also shows that the optimum extraction time was approximately 90 minutes.

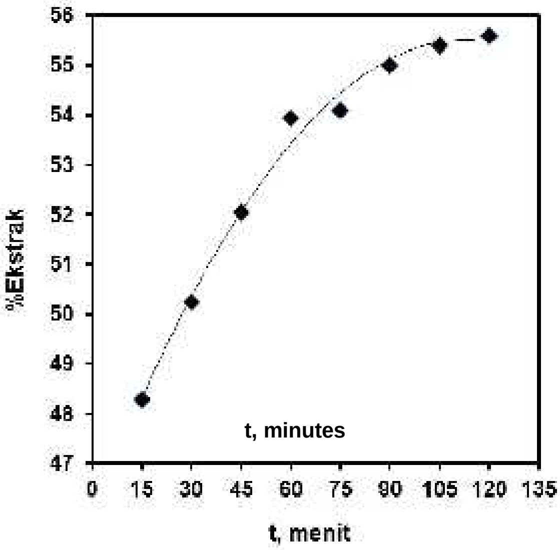

Figure 2. Graphical Relationship between Extraction Time Variation and % of Saponin Extract.

3.3. Effect of Temperature

The amount of total saponin extract was also studied by varying temperatures. The measurement was conducted using aquadest as solvent with temperature intervals of 15°C as shown in figure 3. Figure 3 shows that the yield generally increased with the increase of extraction temperature. This might be due the increase of solubility with the increase of temperature which is beneficial for extraction process. As depicted in Figure 3, the optimum extraction temperature was 100 °C.

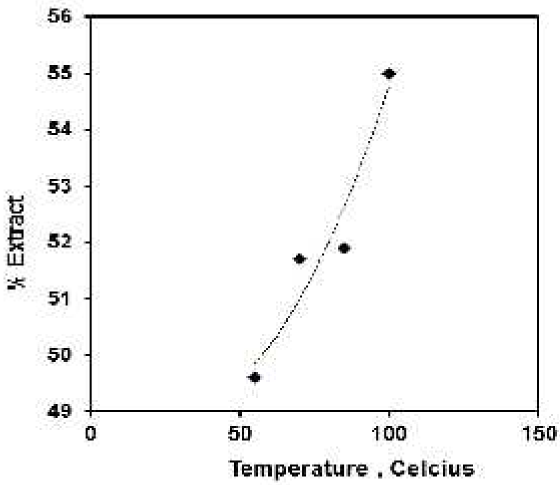

Figure 3. Graphical Relationship between Extraction Temperature Variation and % of Saponin Extract.

3.4. Solid - Liquid Equilibrium Relationship

Henry Constant was evaluated from the experimental data of solute concentration in solvent at equilibrium condition. The experimental data in Figure 2 indicates that the solute concentration in the solvent reached equilibrium condition at ca. 0.0550 gram/ml. By estimating the solute concentration on the solid surface with the aid of equation (8), we can estimate the Henry Constant. It was found that at this operating condition was 0.4435.

3.5. Estimation of Mass Transfer Coefficient

Evaluation of kc and De values was carried out with the optimum setting: aquadest as solvent and operating temperature of 100°C. The experimental data of total saponin extract as a function of time can then can be fitted. Comparison of C_{Af} data from both experimental data and simulation show good agreement which indicates that the proposed mathematical model fits the solid-liquid extraction process well. Based on the data in Figure 4, the values of k_c and De on the operating condition was obtained using Scilab computer program to solve the partial differential equation and optimize k_c and De values. The equation was solved using Finite Difference Approximation and SSE minimization. The parameter values of kc and De obtained from simulation are 14.76430 cm/min and 1.9666×10^{-6} cm^2/min, respectively.

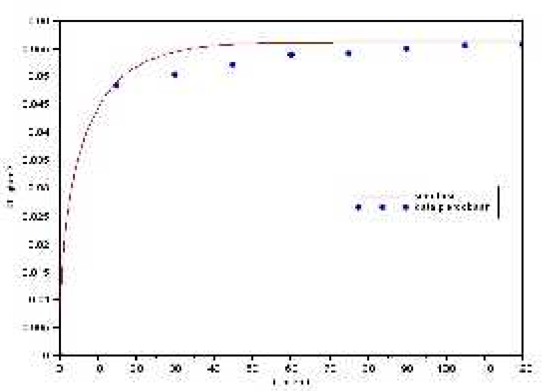

Figure 4. Graphical Relationship between Data C_{Af} and Simulation C_{Af} with Aquadest Solvent at 100°C.

4. CONCLUSIONS

A kinetic model to describe total saponin extraction from Aloe Vera has been developed. It was found that by varying the solvent type, aquadest appeared to be the best solvent compared to ethanol and acetone. By using aquadest as solvent, extraction time of 90 min was found to be optimal before reaching the equilibrium point. In addition, the optimum temperature setting of 100°C. Eventually, a number of parameters can be estimated from the present modeling work such as Henry equilibrium constant, external mass transfer coefficient (kc) and effective diffusivity (De) of 0.4435, 14.76430 cm/min and 1.9666×10^{-6} cm^2/min, respectively.

Nomenclatures

C_{Af} = Substance concentration per liquid volume (gram/mL).

X_{A0} = Initial concentration of substance in the material (gram of substance/gram of material).

X_A =Concentration in the material (gram of substance/gram of A).

De = Effective diffusivity, cm^2/minutes

k_c = Mass transfer coefficient, cm/minutes.

R = Radius of solid particle, cm.

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