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Full Length Research Paper

Sodium chloride concentration on the rheological and dynamic properties of aloe vera gel

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Aloe vera gel is a highly medicinal gel which is in high demand in the cosmetics and pharmaceutical industry. Mathematical models were developed to simulate the rheological and dynamic properties of aloe vera gel in relation to the addition of sodium chloride (NaCl – common salt) at various concentrations. The result from the investigation shows the effect of sodium chloride concentration on the density, viscosity, shear rate, shear stress and flow concentration of the aloe vera gel; hence, giving the manufacturers of aloe vera products an insight and awareness of aloe vera gel rheology and dynamic properties. The mucilaginous fluid samples were obtained from aloe vera bardadensis miller leaves, washed and wiped dry and mechanical analysis were conducted on the samples for the purpose of separation of aloe juice and aloe gel from the sample. Increase in the concentration of sodium chloride result to a change in the concentration of aloe vera gel mixture (viscosity and density). The result obtained from the analysis revealed the sudden change in aloe versa gel concentration alongside with rheological and dynamic characteristics of the aloe vera gel mixture were attributed to increase in salt added. The developed models obtained from the investigation were found useful in monitoring and predicting the quality of aloe vera products.

Key words: Modeling, sodium chloride concentration, rheology, dynamic property, aloe vera products.

INTRODUCTION

The study of modeling the effect of sodium chloride concentration on the rheological and dynamic properties of aloe vera gel is of great concern to the engineers, as a result of the effect of rheological and dynamic characteristics on the quality of aloe vera products by the cosmetics and pharmaceutical industry (Perry and Maloney, 1997; Douglas, 2004). Gels are among the numerous fluids that are of great importance to mankind. Gel is define as a colloidal dispersion that may be jelly-like (for example, gelatin) or not (for example, silica gel), usually formed by coagulation for example, by cooling or evaporation (Arends, 1965; Fujioka, 1969; Beck and Muttzall, 1980; Osipora, 1987; Kapel, 1988). Among the gels of importance to man is aloe vera gel. The name aloe vera is derived from the Arabic work "Aloe" meaning shinning bitter substance. Aloe vera is a species of the genus "Aloe", a member of the lilianceae family of which over two hundred species exist of all these aloe vera Barbadensis miller is the most potent and is widely used in commercial quantity. Aloe vera is a succulent with green, fleshy, lanceolated spiked leaves which grow from the base in a rosette pattern. And it is best known for its healing properties, which is most evident when the plant is at least four years old. Its leaves can be separated to give two basic products such as aloe gel and aloe juice (Hoffman, 1974; Schangraw and Mattocks, 1961; Ukpaka and Oboho, 2006).

The science that deals with the mechanical behaviour of fluids is called rheology. The rheology of fluid is usually described by its measure of the fluid resistance to flow and hence, quantifying this parameter is of great importance to assessing or predicting the function at press drop in various parts of a flowing system (Osipora, 1987; Casson, 1959; Goodwin, 1975; Herschel and Bulkley, 1926a). All fluids exhibit a certain viscosity (Beck and Muttall, 1980). A fluid is often termed as being either thick (having a high viscosity) or thin (having a low viscosity) (Kapel, 1988). For more quantitative description of viscosity two more physical parameters – shear stress and shear rate have to be defined "shear stress (τ) is the force required to overcome a fluid resistance to flow divided by the area that the force is acting upon" or "force per unit area" and is expressed in Newton's per meter square (N/m^2) or ($dynes/cm^2$).

Several research conducted (Dennis, 1982; Perry and Maloney, 1997; Donald 1998; Douglas et al., 2004; Herschel, Bulkley, 1926b; Pal and Maliyah, 1990. On flow behaviour index of power law fluid reveal that when n < 1 the liquid is said to be pseudoplastic, n = 1 Newtonian liquid and > 1 the liquid is said to be dilatant (Radford and Kichardson, 1974; Grimm, 1976). Many liquids of interest to the process and chemical engineers do not exhibit Newtonian behaviour, that is strict proportionality between shear stress and shear rate (rate of strain) (Grimm et al., 1976; Ukpaka, 2005). Investigation conducted reveals that for a fluid to enter the pump, it must have sufficient energy to force itself towards the inlet, but in this research work such system is been influenced by the sodium chloride concentration (Ukpaka, 2005). Similarly investigation carried out by John on engineering materials showed that the shear rate, shear stress, velocity distribution, density, viscosity and flow, head and power coefficients of aloe vera gel and sodium chloride concentration affect the quality of the product.

MATHEMATICAL MODEL FORMULATION

For fluid obeying Newton's law of viscosity, taking the direction of motion as the x-direction and V_x as the velocity of the fluid in the x-direction at a distance y from the boundary, the shear stress in the X-direction is given as

$$\tau_x = \mu \frac{dv_x}{dy} \qquad (1)$$

Let F_g = mass flow rate
L = distance

Therefore $$\mu\left(\frac{Kg}{ms}\right) = \frac{mass\ \ flow\ rate\ (kg/s)}{\text{distance (m)}} \qquad (2)$$

$$\frac{dVx}{dy} = \frac{I}{\mu}\tau \qquad (3)$$

Also in terms of species involved in the reaction (i) the above equation is written as

$$\frac{dVx}{dy} = \frac{I}{\mu}\tau_i \qquad (4)$$

Model I

The expression for the velocity distribution of fluid flow through a long tube of radius R, considering steady state condition and the force balance on a cylindrical element of aloe vera gel mixture (aloe vera gel/sodium chloride) interms of radius is given as

$$2\pi r L \tau_x = (p_1 - p_2)\pi r^2 \qquad (5)$$

Rearranging Equation (5) yields

$$\tau_x = \frac{(p_1 - p_2) r}{2\pi L} \qquad (6)$$

Model II

The rheological test on aloe vera gel mixture (aloe vera gel/Sodium chloride) provide data which indicate that it shear stress/shear rate characteristic can be represented accurately by the equation

$$\tau = -\phi \left|\frac{dv}{dy}\right|^{\lambda-1} \frac{dv}{dy} \qquad (7)$$

where ϕ and λ are constants

Resolving Equation (7) using the necessary mathematical technique yields

$$\tau = \phi \left[\frac{-dv}{dy}\right]^{\lambda} \bullet \left[\frac{dv}{dy}\right]^{-1} \bullet \left[\frac{dv}{dy}\right] \qquad (8)$$

Similarly, Equation (8) can be written as

$$\tau = \phi \left[\frac{-dv}{dy}\right]^{\lambda} \qquad (9)$$

Equation (9) can be expressed as

$$\frac{\tau}{\phi} = \left[\frac{-dv}{dy}\right]^{\lambda} \qquad (10)$$

Multiplying both side of Equation (10) with power index of $\frac{1}{\lambda}$ and rearranging yields

$$\frac{dv}{dy} = -\tau^{1/\lambda} \Big/ \phi^{1/\lambda} \qquad (11)$$

Where

$$dv = -\ \tau^{1/\lambda} \big/ \phi^{1/\lambda}\ dy \qquad (12)$$

integrating Equation (12) yields

$$\int_o^v dv = -\tau^{1/\lambda} \big/ \phi^{1/\lambda} \int_o^y dy \qquad (13)$$

$$[V]_0^V = -\tau^{1/\lambda} \big/ \phi^{1/\lambda}\ [Y]_0^y \qquad (14)$$

$$V = -\ \tau^{1/\lambda} \big/ \phi^{1/\lambda}\ y_o + c \qquad (15)$$

since V = 0 for y = y_o, then substituting the boundary conditions into Equation (15) and rearranging yields

$$0 = -\tau^{1/\lambda} \big/ \phi^{1/\lambda}\ y_o + c \qquad (16)$$

Therefore

$$C = \frac{\tau^{1/\lambda}\ y_o}{\phi^{1/\lambda}} \qquad (17)$$

substituting Equation (17) into Equation (15) yields

$$V = -\frac{\tau^{1/\lambda}}{\phi^{1/\lambda}}\ y + \frac{\tau^{\ 1/\lambda}}{\phi^{1/\lambda}}\ y_0 \qquad (18)$$

$$V = -\frac{\tau^{1/\lambda}}{\phi^{1/\lambda}}\ (y - y_o) \qquad (19)$$

Equation (19) can also be written as

$$\tau^{\frac{1}{-1}} = -\frac{V\phi^{1/\lambda}}{(y - y_o)} \qquad (20)$$

therefore substituting Equation (6) into Equation (20) yields

$$\left[\frac{(p_1 - p_2) r}{2\pi L}\right]^{1/\lambda} = -\frac{V\phi^{1/\lambda}}{(y - y_o)} \qquad (21)$$

where

$$\phi = \tau_x^{1-\lambda} \left[\frac{\mu\ \infty}{1 - \frac{4\ \beta}{3\ \tau_x}\ 1 + \left(\frac{\beta}{\tau_x}\right)^{4/3}}\right]^{\lambda} \qquad (22)$$

$$\lambda = \left[1 - \frac{4\ \beta}{3\ \tau_x} + 1 - \left(\frac{\beta}{\tau_x}\right)^{4/3}\right] \Big/ 1 - \left(\frac{\beta}{\tau_x}\right)^{4} \qquad (23)$$

Hence rearranging Equation (21) yields

$$V = -\frac{(p_1 - p_2)}{2\pi L\ \phi^{\frac{1}{\lambda}}}\ r^{1/\lambda}\ (y - y_o) \qquad (24)$$

Since

$$\text{viscosity}\ \ \mu = \frac{shear\ \ stress}{shearrate}\ \ \frac{\tau_x}{\beta} \qquad (25)$$

Also assuming that in a ideal situation where $\phi\ and\ \frac{1}{\lambda} = 1$ Equation (24) reduces to

$$V = -\ \frac{(p_1 - p_2)\ r\ (y - y_o)}{2\pi\ L} \qquad (26)$$

Dividing through Equation (26) by (y-yo) yields

$$\frac{V}{y_1} = -\frac{(p_2 - p_1)\ r}{2\pi\ L} \qquad (27)$$

where $y_1 = y - y_0$

Hence Equation (27) can be written as

$$\tau = \frac{(p_2 - p_1)r}{2\pi L} \quad (28)$$

Where $\upsilon = (p_2 - p_1)r$ (28a)

For υ = flow concentration

$V_R = 2\pi L$ (28b)

But in terms of space time and space velocity

$$\tau_t = \frac{\upsilon}{V_R} \quad (28c)$$

$$\tau_v = \frac{V_R}{\upsilon} \quad (28d)$$

And since $\tau_t = \frac{1}{\tau_v}$ (28e)

Therefore $\tau_v \quad \frac{2\pi L}{(p_2 - p_1)r}$ (28f)

where τ_t = space time, τ_v = space velocity since D = 2r, hence r = D/2. Substituting r = D/2 into Equation (28) yields.

$$\tau = \frac{(p_2 - p_1)D}{4\pi L} \quad (29)$$

Models III

Since the flow rate characteristics for the flow of a viscous liquid through a tube can be predicted from the rheogram for that liquid using the expression as presented by Arcadia et al. (1991).

$$Q = \frac{-\pi R^3}{\tau_w^3} \int_0^{\tau_w} \tau_x^2 \; f(\tau_x) d\tau_x \quad (30)$$

where $f(\tau_x) = -\frac{\tau_x}{\mu}$ (31)

therefore substituting Equation (31) into Equation (30), yields.

$$Q = \frac{-\pi R^3}{\tau_w^3} \int_0^{\tau_w} \tau^2{}_x \; f\left(\frac{-\tau_x}{\mu}\right) d\tau_x \quad (32)$$

resolving Equation (32) mathematically yields

$$Q = \frac{-\pi R^3}{\tau_w^3} \left(\frac{\tau_x{}^4}{4\mu}\right) \tau_w \quad (33)$$

$$= \frac{\pi R^3 \tau_w^3}{4\mu} \quad (34)$$

But $\tau_w = R/2 \; \frac{\Delta P}{\Delta L}$ (35)

Therefore $Q = \frac{\pi R^4 \Delta p}{8\mu \Delta L}$ (36)

But pressure can be express mathematically as

$p = \rho g L$ (37)

Therefore

$\Delta p = \rho g \Delta L$ (38)

Substituting Equation (38) into Equation (36), becomes

$$Q = \frac{\pi R^4 \rho g \Delta^L}{8\mu \Delta L} \quad (39)$$

$$Q = \frac{\pi R^4 \rho g}{8\mu} \quad (40)$$

$$\therefore Q = \frac{\pi D,^4 \rho g}{128 \mu} \quad (41)$$

Similarly, expressing Equation (40) in terms of $\rho = m/v$, hence Equation (30) becomes

$$Q = \frac{\pi R^4 mg}{8\mu V} \quad (42)$$

Table 1. Experimentally determined physical properties of aloe vera gel + sodium chloride mixture of two different samples collected in Niger Delta area.

Mass of sodium chloride (common salt)	Viscosity (cp)		Mean viscosity (cp kg/m.h)	Mass of sample + salt (mg)	Volume of sample + salt (ml)	Density of sample + salt (mg/ml)		Mean density (mg/ml)
	A_1	A_2				A_1	A_2	
0	57.4	58.6	58.0	96.23	100	0.9623	0.9273	0.9146
10	43.6	44.4	44.0	109.10	102	1.0696	1.1002	1.0834
30	44.5	57.8	46.2	115.00	106	1.0848	1.9973	1.5067
60	55.2	57.3	56.3	151.59	112	1.3535	1.3865	1.3729
90	53.2	56.8	55.0	188.59	120	1.5716	1.4996	1.5986
100	44.9	44.5	44.7	194.49	122	1.5902	5.843	1.6175

$$:.\ Q = \frac{\pi D^4 mg}{128 \mu V} \quad (43)$$

EXPERIMENT AND METHODS

Sampling procedure/collection of samples

Aloe vera (Barbadensis miller) leaves samples were collected from two communities (Obite and Obagi) in Niger Delta Area of Nigeria. The leaves of the Aloe vera (Barbadensis miller) were transferred into glass bottles for transportation to the laboratory for analysis.

The research work was carried out by using the following materials and equipment such as, aloe vera (Barbadensis miller) leaves, sodium chloride (common/table salt) beakers, measuring cylinder, spatula, chemical balance, Brookfield, viscometer, spoon and knife.

Procedure

Aloe vera (Barbadensis miller) leaves were harvested, washed and wiped dry. The leaves were then slashed with a sharp knife to expose the gel. The gel, which is the dear mucilaginous fluid in the central part of the leaf, was then scooped with a spoon into a sample container. It is important to note that the mechanical separation of aloe juice and aloe gel is not always complete so aloe juice can be found in aloe gel. The temperature of the aloe vera gel in the sample container was measured and recorded. Six empty beakers were weighed with a chemical balance and their weight were recorded and 100 ml of aloe vera was measured and put into each of the six beakers. The following mass of sodium chloride (common salt) were measured 10,30,60,90 and 100 g using spatula and chemical balance each of these salt quantities was added to the five other samples containing 100 ml aloe vera gel. The viscosity of each of the sample was then determined using a Brookfied viscometer at a speed of 100 RMP. The viscosity of the sample was determined after the salt and aloe vera gel in each beaker was properly stirred for some time to allow mixing of the two substances. Similarly, the densities of the aloe vera gel were measured with the aid of hygrometers.

RESULTS AND DISCUSSION

Physical properties of aloe vera gel mixture (aloe vera gel/sodium chloride) samples obtained from a mixture of 100 ml of aloe vera gel added with 10,30,60,90 and 100 g of sodium chloride (common salt) in Nigeria environment as listed in Table 1 to confirm their effect on the viscosity and density. The viscosities and densities were measured with the aid of Brookfield viscometer and hydrometer respectively.

The developed models were simulated by using the following parameters change in pressure ($p_1 - p_2$) = 172 N/m^2 , length (L) = 5 to 25 m, radius (r) = 0.3 m, acceleration due to gravity (g) = 9.81 m/s^2.

The data obtained were fed into the model computer using the developed mathematical expression in Equations (6), (28), (28d) and (40) by considering various incremental steps as specified in Table 1.

Rheology of aloe vera gel with sodium chloride

Figures 1 and 2 shows the variation of the viscosity and density with increase in the mass of sodium chloride concentrations. It should be noted that viscosity increase from 10 to 60%, and the mass of sodium chloride added are 10, 30 and 60 g and decreases from 90 to 100%, and the mass of sodium chloride added are 90 and 100 g for both A_1 and A_2 samples. Whereas density increases from 10 to 100%, and the sodium added are 10, 30, 60, 90 and 100 g. The aloe vera gel flow concentration increases as the mass of sodium chloride concentration increase ranging from 10 to 60% and decreases within the range of 90 to 100% as shown in Figure 6. It is evident that the addition of sodium chloride to the aloe vera gel increases the density and viscosity (10 to 60%, for 10, 30 and 60 g) and decreases (90 to 100%, for 90 and 100 g) as shown in Figures 1 and 2. Figure 1 shows that after a rapid increase in sodium chloride added, the viscosity decrease with increasing shear stress (Figures 12 and 13). Close examination of Figures 12 and 13 reveals that after decreasing to a minimum, the viscosity begins to increase with the shear stress, the aloe vera

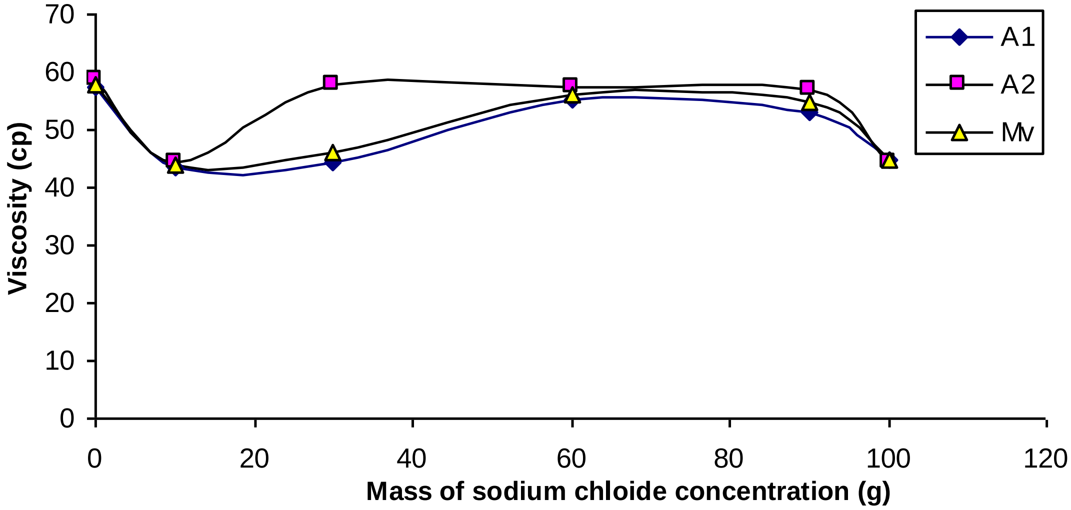

Figure 1. Viscosity versus mass of sodium chloride concentration.

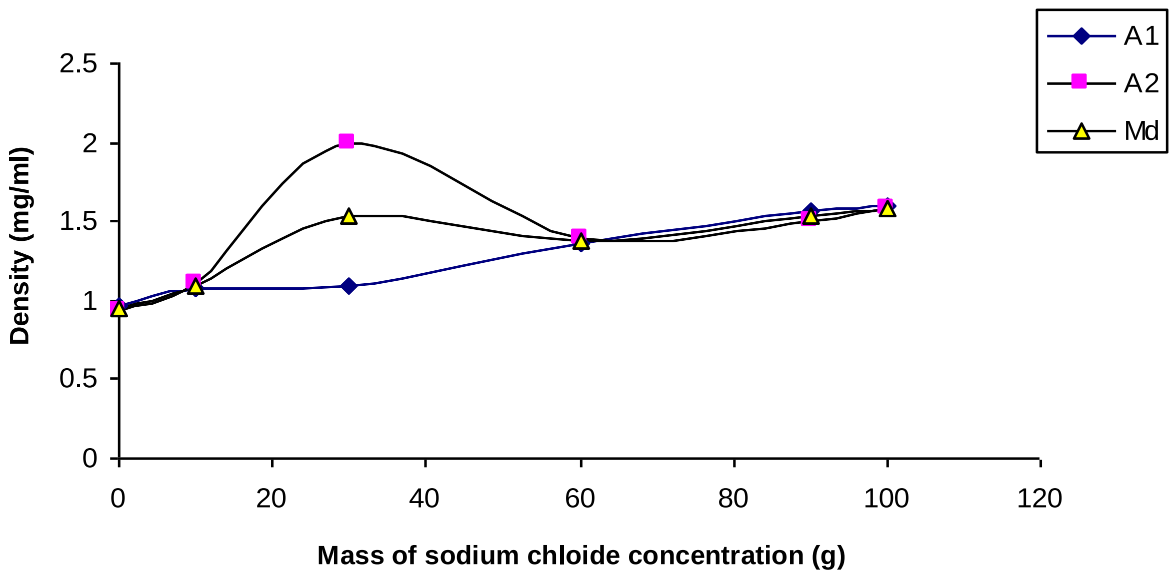

Figure 2. Density versus mass of sodium chloride concentration.

gel/sodium chloride mixture exhibit dilatant behaviour. It is to be noted from Figures 12 and 13 that the dilatant behaviour becomes more noticeable as the mass of sodium chloride concentration increases. Comparison of Figures 12 and 13 indicates that both aloe gel of sample A_1 and A_2 exhibit the dilatant behaviour.

Rheology of aloe vera gel without sodium chloride

Figure 10 shows the variation of the viscosity (A_1 = 57.4cp, A_2 = 58.6cp and M_v = 0.9448 mg/ml) of the same species of aloe vera bardadensis miller leaves samples collected in two areas of Niger Delta. It can be seen that the viscosity of the aloe vera gel decreases without sodium chloride concentration. The aloe vera gel exhibit shear thinning behaviour at low shear stress. At high shear stress, the aloe vera gel becomes essentially Newtonian with a slight increase in the viscosity with shear stress. The aloe gel used by this investigation was of high softening characteristics, such that at room temperature the aloe vera gel flows were essentially rigid. The aloe vera gel used in the present study is similar in terms of physical and chemical properties.

In the absence of sodium chloride concentration, the rheological and dynamic behaviour of the sample becomes rigid, as shown in Table 1 with viscosity values of A_1 = 57.7 cp, A_2 = 58.6 cp and m_v = 58.0 cp, with density values of 0.9623, 09273 and 0.9448 mg/ml, in which the viscosity values for A_1, A_2 and m_v are higher than others when sodium chloride is added into the system. The flow characteristic decreases with increase in viscosity and decrease in density for both A_1 and A_2 samples.

Effect of flow concentration on the viscosity of aloe vera gel/sodium chloride mixture

Figures 7 and 8 shows a comparison of the viscosity of aloe vera gel/sodium chloride mixture containing sample A_1 and A_2. Figures 7 and 8 show the flow concentration increases with viscosity and decreases with increase in the tube length Figure 9. This process is characterized by a decrease in the viscosity as the shear rate is increased. When the shear rate increases up to a critical value, the flow concentrations begin to disrupt and flow concentration is disturbed and the product quality as well being reduced (Table 3). Thus, the viscosity begins to increase with the shear rate (that is, dilatant behaviour).

There are various explanations in the literature concerning shear rate, shear stress, which all tend to rely on some kind of change base on the type of samples. According to Goodwin, (1975) and Hoffman, (1974), a change in the flow pattern takes place when dilatancy occurs. From Figure 3, it shows that the shear rate decreases with increase in length; this therefore shows that there is a very low shear rate, indicating that the viscosity is high as shown in Figure 4. Similarly, in Figure 10, it is noted that the shear stress decreases with increase in tube length as shown in Figure 10. Consequently, the aloe vera gel and the sodium chloride concentrations are additive for the evaluation of the viscosity of the aloe vera gel plus sodium chloride mixture (Table 4). Therefore, care must be taken when one calculates the viscosity of an aloe vera get plus sodium chloride mixture.

Effect of tube length on the shear rate and flow concentration of aloe vera gel plus sodium chloride

Figure 3 shows the variation of shear rate with increases in tube length with variation in viscosity. From Figure 3, it is noted that shear rate decreases with increase in tube length, therefore affecting the viscosity of the aloe vera gel/sodium chloride mixture as well as the quality of the product produced.An analysis of the data obtained from the application of varying the length highlighted different length-dependent behaviour for the system examined. Figures 3 and 10 shows different stress by system A_1 and A_2 samples at a given viscosity.

Several rheological models (Herschel and Bulkley, 1926a, 1926b; Casson, 1959; Shangraw et al., 1961; Robertson and Stiff, 1976) have been taken into consideration for the correlation of the experimental shear-stress-shear rate data with the purpose of selecting one equation suitable for describing the shear dependent behaviour of all the system examined. Accordingly, the comparison of the different systems (A_1 and A_2 sample) and evaluation of the aloe vera gel/sodium chloride mixture, the concentration dependence of the rheological properties can be based upon a limited set of rheologica parameter like the yield stress and the infinite – shear rate viscosity μ_∞.

Effect of tube length on the shear stress

In Figure 11, it is noted that shear stress decreases with increase in tube length. The shear stress can be used in predicting the rheological and dynamic properties of aloe vera gel; and the quality of the product obtained after production. Also, the manufacturer needs to acknowledge the effect of shear stress on the compatibility of the product (Table 2).

Figure 5 shows the variation of shear rate with increase in shear stress. From Figure 5, it is noted that shear stress increases with increase in shear rate. Several literature (Goodwin, 1975; Hoffman 1974; Grimm et al., 1976; Douglas et al., 2004) reveals that the characteristics of shear rate and shear stress affects the flow pattern when dilatancy occurs.

Conclusion

The rheological and dynamic properties of aloe vera gel are studied by the experimental determinations of the viscosity and density of the gel. Different quantities of common salt were added separately to a given volume of aloe gel. The viscosity of the pure gel dropped on addition of salt. Increasing the quantity of salt added to the aloe gel led to an increase in the viscosity of the gel. The viscosity of the gel increases, gets to a maximum and declines. There was an observed continuous increase in the density of the gel with increase in the quantity of salt added.

Generally, the viscosity of aloe vera is high. This is attributed to the presence of high molecular weight long chain compound (shears). It is important to note that the essence of the addition of salt is to thin down the gel to have a certain viscosity for easy pumping or flow characteristics during aloe vera processing. The addition of salt to aloe vera gel can be used to control and monitor the quality of the gel based on the characteristics of the rheological and dynamics properties of the samples under investigation.

The following conclusion was drawn from the research work:

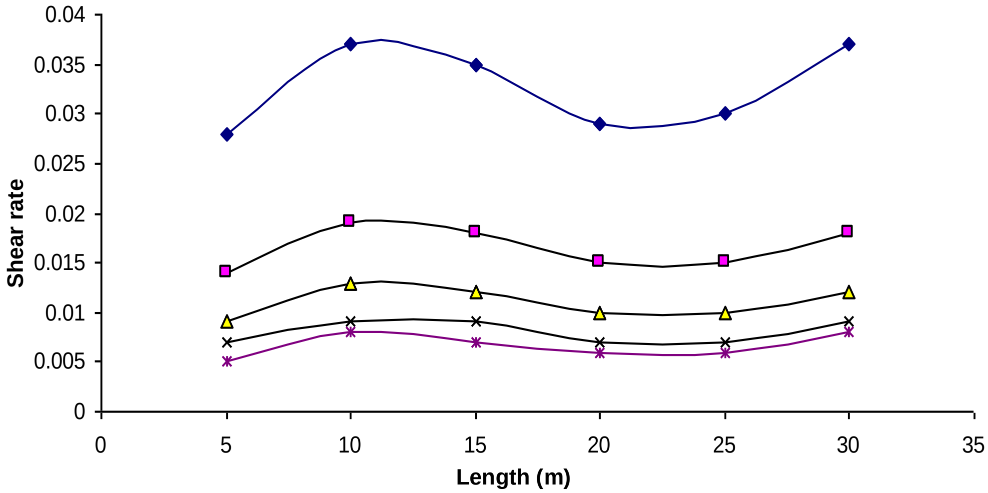

Figure 3. Shear rate versus length.

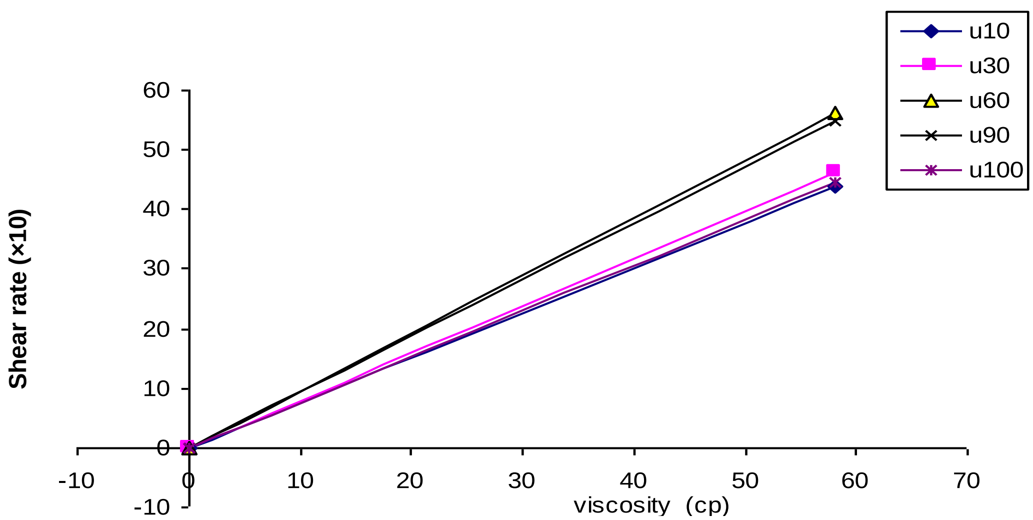

Figure 4. Shear rate versus Viscosity,

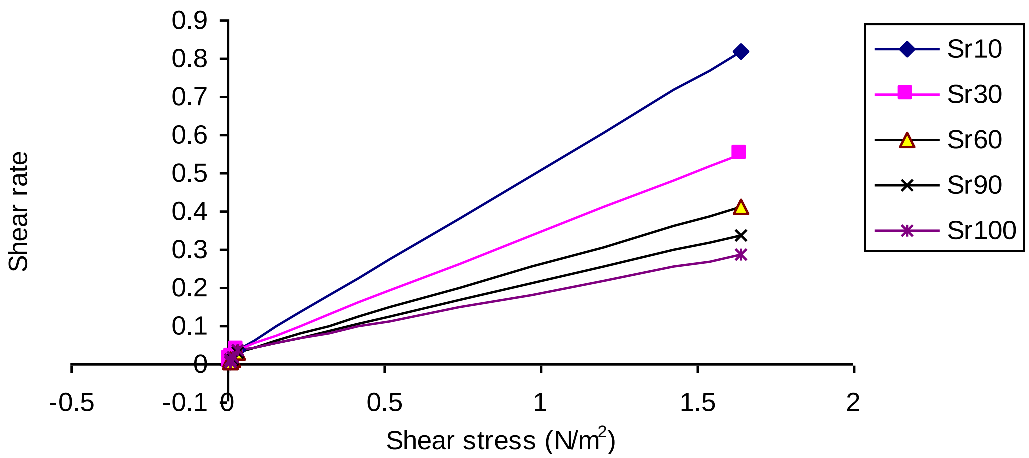

Figure 5. Shear rate versus shear stress.

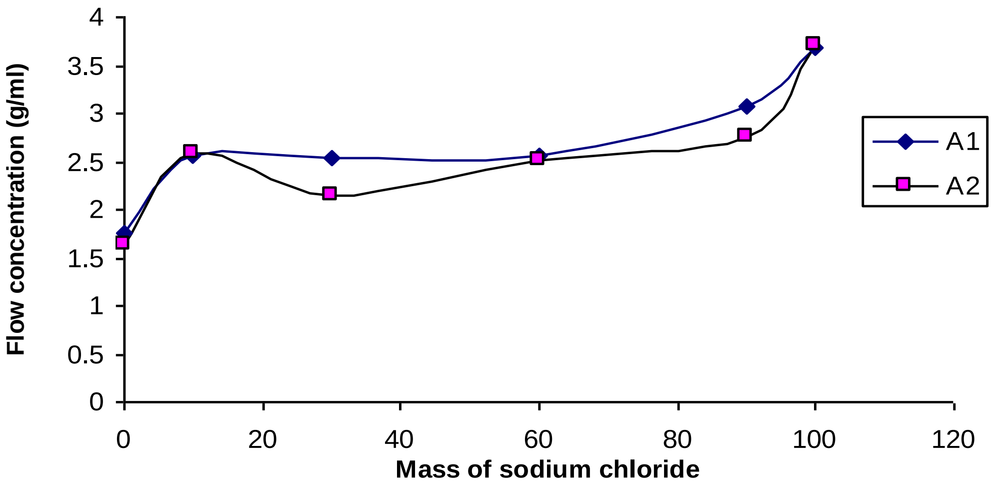

Figure 6. Flow concentration versus mass of sodium chloride.

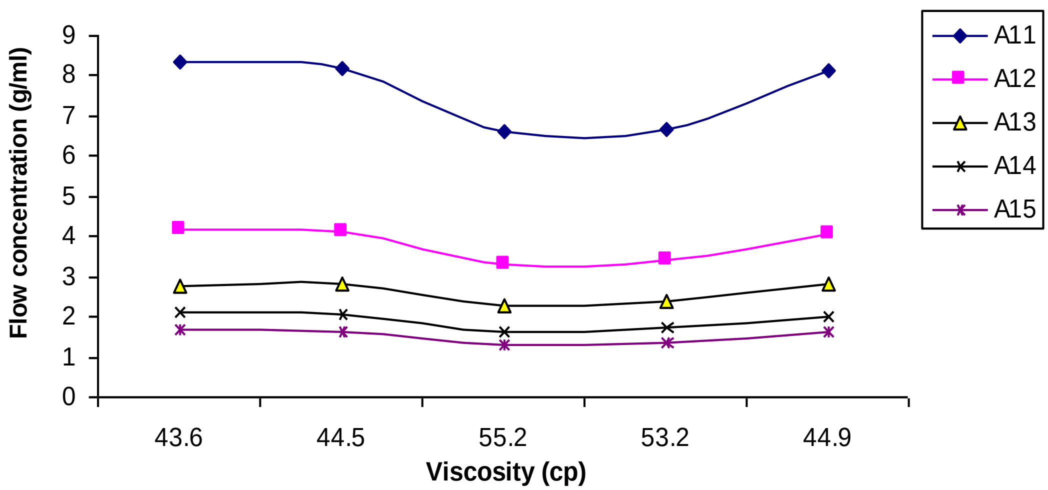

Figure 7. Flow concentration versus viscosity.

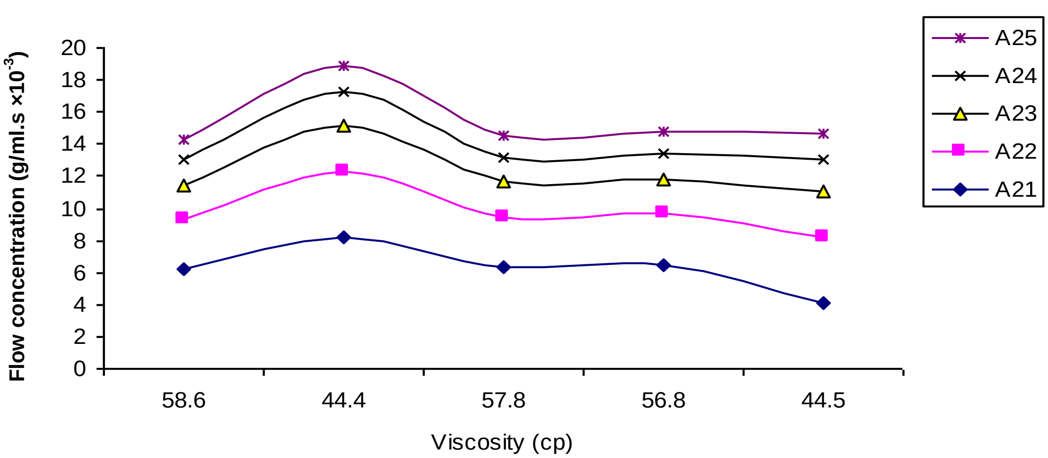

Figure 8. Flow concentration versus viscosity for A2.

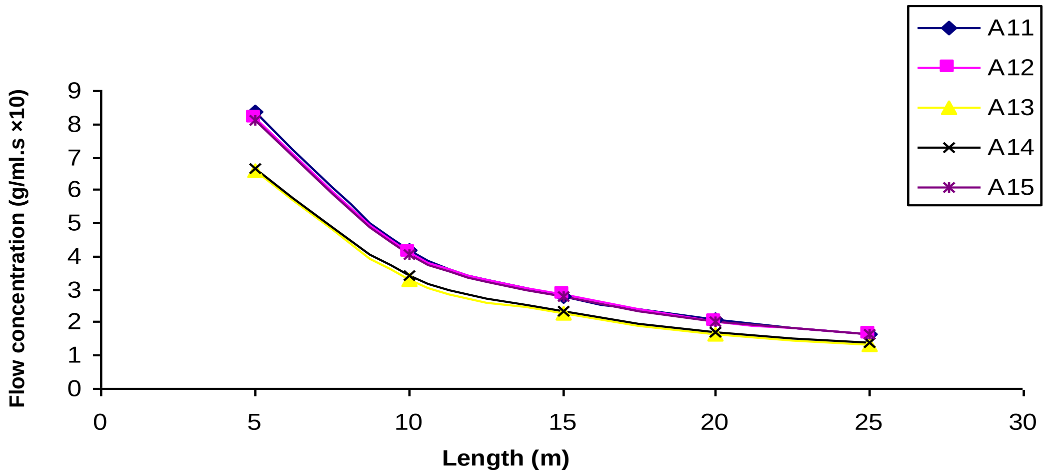

Figure 9. Flow concentration versus length for A1.

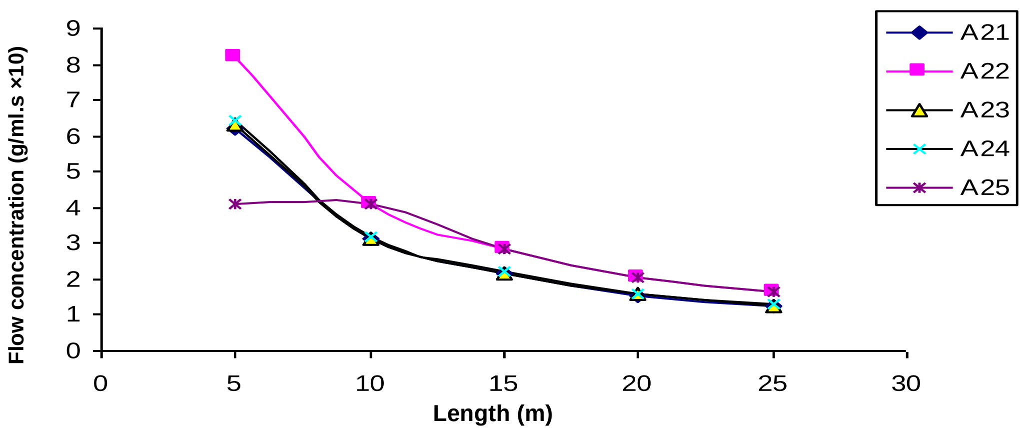

Figure 10. Flow concentration versus length A2.

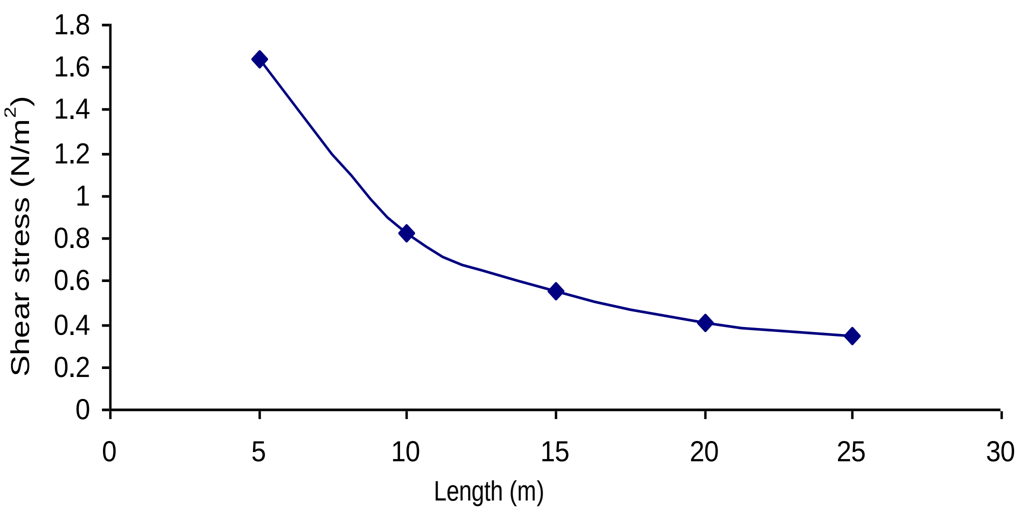

Figure 11. Shear stress versus length.

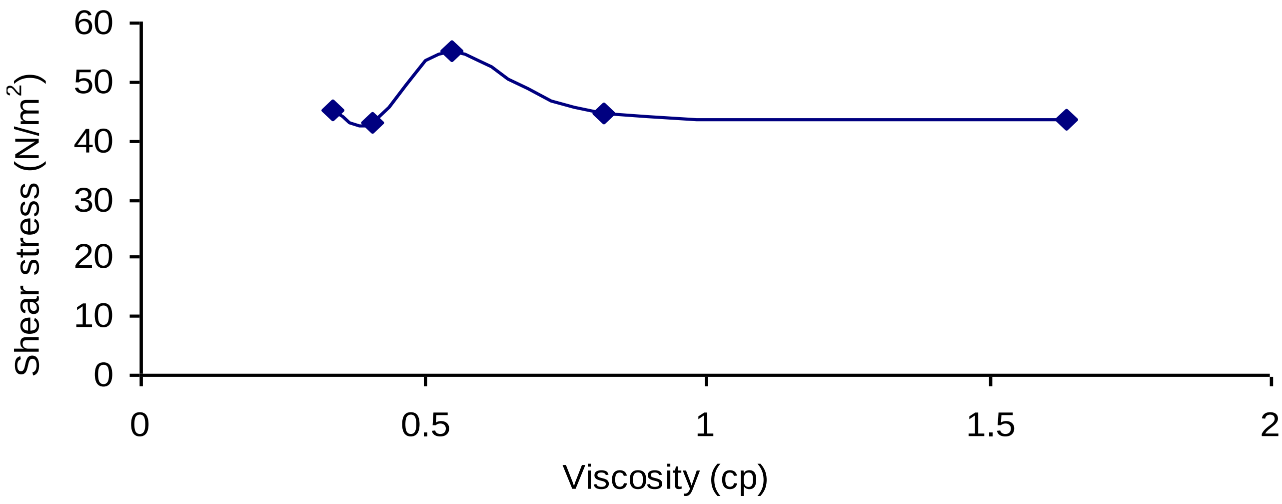

Figure 12. Shear stress versus viscosity for A1.

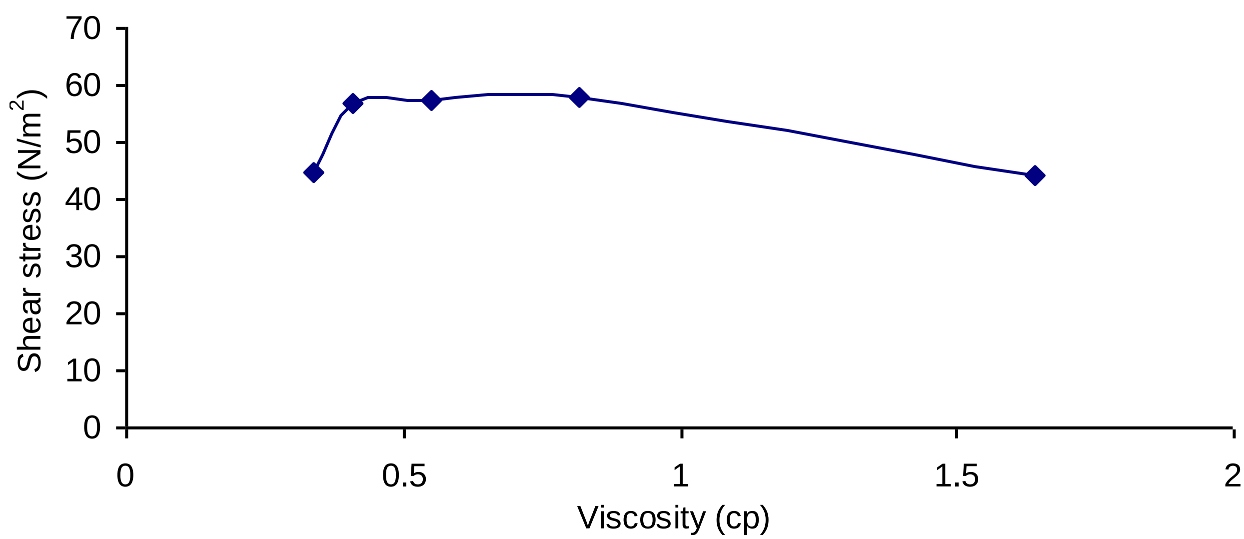

Figure 13. Shear stress versus viscosity for A2.

Table 2. Determination of shear rate at a given length and viscosity.

Length (m)	Shear stress $\tau_x = \frac{(p_1 - p_2)}{2\pi L}$	Viscosity (cp)					
		$\mu_0 = 58.0$	$\mu_{10} = 44.0$	$\mu_{30} = 46.2$	$\mu_{60} = 56.3$	$\mu_{90} = 55.0$	$\mu_{100} = 44.7$
	2π	τ_{R0}	τ_{R10}	τ_{R30}	τ_{R60}	τ_{R90}	τ_{R100}
5	1.64	0.028	0.037	0.035	0.029	0.030	0.037
10	0.82	0.014	0.019	0.018	0.015	0.015	0.018
15	0.55	0.009	0.013	0.012	0.010	0.010	0.012
20	0.41	0.007	0.009	0.009	0.007	0.007	0.009
25	0.34	0.005	0.008	0.007	0.006	0.006	0.008

Table 3. Determination of the flow concentration at different mass of sodium chloride, viscosity and density.

Mass of sodium chloride common salt (g)	Viscosity reading (cp)		Density reading (mg/L)		Flow concentration (g/ml.s)	
	A_1	A_2	A_1	A_2	A_1	A_2
0	57.4	58.6	0.9623	0.9273	1.7440×10^{-3}	1.6457×10^{-3}
10	43.6	44.4	1.0696	1.100	2.5513×10^{-3}	2.5766×10^{-3}
30	44.5	57.8	1.0848	1.1973	2.5354×10^{-3}	2.1543×10^{-3}
60	55.2	57.3	1.3535	1.3865	2.5500×10^{-3}	2.5165×10^{-3}
90	43.2	56.8	1.5716	1.4996	3.0723×10^{-3}	2.7457×10^{-3}
100	44.9	44.5	1.5902	1.5843	3.6883×10^{-3}	3.7026×10^{-3}

Table 4. Determination of flow concentration of the aloe vera gel + sodium chloride at a given mass and at a different length.

Length of tube (m)	Flow concentration (g/ml.s)										
	u = 57.4	μ=43.6	μ=44.5	μ=55.2	μ=53.2	μ=44.9	μ_{PH}=58.6	μ_{PH}=44.4	μ_{PH}=57.8	μ=56.8	μ=44.5
5	$6.3552 x10^{-3}$	$8.3665 x10^{-3}$	$8.1973 x10^{-3}$	$6.6083 x10^{-3}$	$6.6568 x10^{-3}$	$8.1243 x10^{-3}$	$6.2249 x10^{-3}$	$8.2157 x10^{-3}$	$6.3111 x10^{-3}$	$6.4222 x10^{-3}$	$4.0987 x10^{-3}$
10	$3.1775 x10^{-3}$	$4.1833 x10^{-3}$	$4.0987 x10^{-3}$	$3.3042 x10^{-3}$	$3.4284 x10^{-3}$	$4.0621 x10^{-3}$	$3.1125 x10^{-3}$	$4.1079 x10^{-3}$	$3.1555 x10^{-3}$	$3.2111 x10^{-3}$	$4.0987 x10^{-3}$
15	$2.1183 x10^{-3}$	$2.7888 x10^{-3}$	$2.8299 x10^{-3}$	$2.2813 x10^{-3}$	$2.3671 x10^{-3}$	$2.8047 x10^{-3}$	$2.1490 x10^{-3}$	$2.8363 x10^{-3}$	$2.1787 x10^{-3}$	$2.2171 x10^{-3}$	$2.8299 x10^{-3}$
20	$1.5888 x10^{-3}$	$2.0916 x10^{-3}$	$2.0493 x10^{-3}$	$1.6521 x10^{-3}$	$1.7142 x10^{-3}$	$2.0311 x10^{-3}$	$1.5562 x10^{-3}$	$2.0539 x10^{-3}$	$1.5778 x10^{-3}$	$1.6055 x10^{-3}$	$2.0493 x10^{-3}$
25	$1.2710 x10^{-3}$	$1.6733 x10^{-3}$	$1.6395 x10^{-3}$	$1.3217 x10^{-3}$	$1.3714 x10^{-3}$	$1.6249 x10^{-3}$	$1.2450 x10^{-3}$	$1.6431 x10^{-3}$	$1.2622 x10^{-3}$	$1.2844 x10^{-3}$	$1.6395 x10^{-3}$

1. Sodium chloride (NaCl) concentrations influence the rheological behaviours of the aloe vera gel.
2. The density and viscosity is the functional parameters that influence the quality product obtained by using aloe vera gel for the product of aloe vera soap, cream etc.
3. The effectiveness of the aloe vera gel dependents on its maturity for medical purpose.
4. The shear stress and the shear rate which is a function of Young modulus influence the characteristics of aloe vera gal in process plant.
5. The flow characteristic is also other parameters that influence the biochemical composition of the aloe vera gel in term of input and output composition.
6. The aloe vera gel obtained from the two communities from Egi clan in Niger Delta area of Nigeria can be used in the manufacturing of aloe vera cream, soap, used in it natural state for medical herbs and treatment of wounds.
7. The additional of the sodium chloride (NaCl) increases the rheoloical characteristics of the aloe vera gel as well as an activator to the microorganisms presented in it.

Nomenclature: $\mathbf{P_1}$, Initial pressure (N/m^2); $\mathbf{P_2}$, final pressure (N/m^2); $\mathbf{V_R}$, reactor volume (m^3); $\mathbf{\Delta L}$, change in length (m); **G,** acceleration due to gravity (m/s^2); **D,** diameter (m); **R or r,** radius (red); $\mathbf{m_v}$, mean viscosity (cp); $\mathbf{m_{ad}}$, mean density (mg/ml); $\mathbf{A_1}$, aloe vera samples collected from Obite in Niger Delta Area; $\mathbf{A_2}$, aloe vera samples collected from Obagi in Niger Delta Area; **L,** distance (m); **C,** integration constant; **Q,** flow concentration (g/ml.s); **V,** volume (m^3); μ**,** viscosity (cp); τ_x**,** shear stress (N/m^2); τ_R**,** shear rate; τ_t**,** space time (s); τ_v**,** space velocity (1/s); τ_w**,** shear stress at the wall (N/m^2); β**,** rheological constant (dimensionless); ϕ**,** constant (dimensionless); υ**,** flow concentration or flow rate (g/ml.s); ρ**,** density (mg/ml); λ**,** constant (dimensionless); **X,** direction (dimensionless); **T,** time (s); 1, 2…, etc. = numbers.

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