IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

EFFECTS OF SORGHUM ADDITION ON THE PROPERTIES OF WATER BASED DRILLING FLUIDS

Shams Alflah A. A. Balola*, Ahmed A. Ibrahim, Abdulla H. Wagialla
Sudan University of Science and Technology - College of Petroleum Engineering and Technology – Petroleum Engineering Department, Sudan.
University of Khartoum – Engineering Faculty – Petroleum Department, Sudan.

ABSTRACT

This research paper covers the effect of powder corn stalks ("*Sorghum*") in improving the properties of the drilling fluid (apparent viscosity, Plastic viscosity, yield point, Gel Strength and Filtration loss) with water base drilling fluid; which consists of water, the substance Bentonite and PAC level. Five samples were prepared from the drilling fluid using five proportional weights of the Sorghum powdered material Several laboratory experiments were conducted by changing temperatures between 30 ° -100 ° C at a constant high pressure (6.9Mpa).The results that were obtained showed that the properties of the drilling fluid will be at its optimum stability when percentage 0.57% and 2.78%-of powdered Sorghum is used

KEYWORDS: Sorghum, Optimize, drilling fluid and properties fluids.

INTRODUCTION

Sorghum in Africa is processed into a very wide variety of delicious and nutritious traditional foods, such as semi – leavened bread *Kisra*, couscous, dumplings and fermented and non-fermented porridges,. It is the grain usually used for brewing traditional African beers. Sorghum is also the grain of 21st century Africa. New products such as instant soft porridge and malt extracts are great successes. In the Sudan, Sorghum is widely cultivated and harvested in large quantities and also widely used as animal feed, (JRN Taylor, 2000).
Sorghum has a great potential both on the domestic and international markets due to its increasing demand for the production of food and feed products, alcoholic and non- alcoholic beverages. Sorghum flour proteins as is the case with maize and millet were not considered to have a large role in creating textures in foods (Babiker and Kato, 1998). Grain Sorghum is a major staple for a large portion of the world. The Crop ranks fifth among the cereals world –wide with respect to its importance for food and feed applications. To this end, the grain harvested from Sorghum and the millets provides an important source for dietary calories and protein for approximately one billion people in the semi-arid regions of the world (Linda Dykes and Lloyd Rooney, 2006). Sorghum grain is the basic food in many parts in many parts of Africa, Asia and it is the third largest cereal crop in the United States. Worldwide it is exceeded in acreage only by wheat, rice maize and barley. The genetic potential to improve the protein quality of green sorghum was realized in the early 1970s. Several strains of sorghum with high lysine content were identified (Navin J. Chemm, 1980).

Clssification And Characterization Of Sorghum

All Sorghums and millets contain phenol acid. Phenolic acids consist of Hydroxy Benzoic acid (including Gallic, P-hydroxyl benzoic, Vanillic, Syringes and prorogate chuic acids among others) and Hydroxyl Cinnamon acids (C_6 – C_3 structure and include coumaric, Caffeic, ferulic and Sinapic acids), (Linda Dykes, 2006). Some species of sorghum can contain levels of hydrogen cyanide, hordenine and nitrates. The sorghum can be founded as:

A: Para sorghum: Callus obtuse, awns < 65 mm in length.
B: Strip sorghum: Callus pointed awn > 65mm in length.

Para sorghum includes about five species found in the eastern hemisphere and Central America, while strip sorghum contains two species found in Australia. The Subgenera Sorghum includes the cultivated Sorghums. Classification schemes since then have been based on this monumental work. Simplified classification schemes since then have been based on this monumental work, (Wayne, 2000).

 ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

The main components of whole grain Sorghum and millets are Carbohydrates, Protein and lipids. Lesser quantities of fiber, vitamins and minerals are also present. The main nutrient composition of Sorghum and millets and various other cereals is presented. Sorghum and pearl millets have naked Caryopses hulls, but other millets usually have cave red caryopsis which explains their higher fiber and ash content, generally, the protein of Sorghum and millet is similar to that of rice and wheat although the quality of the farmer is somewhat inferior. In sorghum and millet lysine is the primary limiting amino acid. However, that the protein Composition of pear L millet, finger millet and code millet is nutritionally superior to normal sorghum. The polyamine of finger millet eleusine has a high biological value, with a good content of Cystine, tyrosine, tryptophan and methionine, which are important in the prevention of kwashiorkor, (Etuk, 2012). Sorghum known as Durra, as a grass can be classified into different parts. The main parts are the grains, the stalks/stem and the roots. The grain is small, ranging from 3 to 4 mm in diameter. The stalks are usually very tall, typically between 1- 2 meters tall. The basal circumference of the stem of cultivated sorghum plants is about 2 to 3 centimetres. The stem grows erectly and is solid, although the core may be spongy and have cavities in the centre. Directly above the attachment of the leaf sheath at each node there is a meristematic layer which contains primordia which is arranged in 1 to 3 concentric circles around the nodes. The roots of an adult sorghum plant are all secondary adventitious roots the root system of the sorghum plant spreads to at least 1 to 5 meters around the plant and is most dense in the top 90 centimeters of the soil, (JRN Taylor, 2000).

Sorghum (Dura) In Sudan

Sorghum is grown in Sudan in the autumn within vast areas in most of Sudan. One of the most growing areas is Alfaw, Gedaref area and areas of Elbutana, especially the area between the Blue Nile and the borders of the states of the East, and also areas of Southern Blue Nile. The different kinds of corn crops (foot bath, Aldapr, hybrid, Afattrita, Elsafara burner and Almayo) are of the most important resources of human and animal food. The population of these areas go into agriculture during this season to produce (Dura) to meet the annual needs. After cutting the grain head (Qandoul), the stalks and tillers are collected in the form of large heaps to be transported to the markets. These stalks and tillers are used as livestock feed. In many farm projects after harvesting, the sorghum stalks are often left on the farmland until the next season when it could be cheaper and readily available. In this research paper, the stalks of Sorghum (which is referred to in this research simply as "*Sorghum*") was the part used .This was due to its mechanical, chemical, tensile properties and also due to economical considerations.

MATERIALS AND METHODS

Sorghum Additive In Drilling Fluid

This additive was to be used for the first time in Petroleum drilling industry, the *sorghum* was used with the aim to improve the required properties of water base drilling fluid. Certain tests were conducted and measurements were carried out under constant pressure (0.6 9 MPa) and different temperature conditions (30° to 100°C). The apparatuses used in the tests are tabulated as table (1).

Table (1): Laboratory Apparatuses

No	Apparatus	Unit of measurement	Function
1	Electrical Scale	g	Measurement of Weight of Material
2	Mud Balance	g/cm^3, Lb/gal	Measurement of Density
3	HPHT Dynamic	MPa, °C, rpm	Put the sample under acondition(temperature, pressure and rotation)similar to the well condition
4	Hydration Dispenser Paper	-	Measurement of pH (Colour visualization on graded paper)
5	PH Meter	-	Measurement of pH
6	Six Speed Viscometer	rpm	Measurement of speed
7	Four–cups mud Water loss Instrument	MPA-time	Measurement of fluid filtration
8	Viscosity factor meter	min/round, angle	Viscosity Factor of the mud cake
9	Lost Circulation Test device	MPA-Time	Measurement of lost fluid quantity

The procedures for this laboratory test involve sample preparation, mixing, HP-HT, density, speed, PH determination, filtration and angle of friction. Five samples of Drilling Fluids were prepared for the *Sorghum* samples. Each drilling fluid sample consists of water, Bentonite, PAC-LV and *Sorghum*. The percentages of *Sorghum* in the five drilling fluid samples are as follows: (0.57%, 1.13%, 1.69%, 2.24%, and 2.78%). Other constituents i.e. water, Bentonite, PAC- LV have constant mass and volume composition (constant density). These percentages of Sorghum were chosen because 0.57% was the minimum percentage when the effect of the *Sorghum* becomes apparent. Other percentages were then chosen as multiple weight proportions of the minimum percentage. The above chosen percentages are regarded as a weighted percentage of the whole sample weight. The rest of the sample also has a stable density which equals 8.8lb/gal. The experiments were then carried out on the samples of *Sorghum*. From each of the five drilling fluid samples, additional eight samples will be taken to measure the effect of temperature variation, thus making a total of forty test samples of *Sorghum*.

The first sample (*Sorghum 0.57%*) was put in a mixer and mixed well for twenty minutes. After that, a quantity of 250 ml from the well mixed sample was taken to determine its density using the Mud balance. This is to ensure that the density is fixed at a value of 8.8 lb/ml to ensure all the samples have constant density. Then the sample was put in the Dynamic HP-HT device at a starting temperature of 40°Centigrade, at a pressure of 0.69 MPa and at a rotation speed of about 137 rpm; for thirty minutes. This testing condition was chosen so as to put the sample under conditions similar to the conditions of the well during drilling operations. This makes it possible for changes in the properties of the drilling fluid, as the well temperature changes, to be calculated. After that, the speeds were measured (Θ_{300}, Θ_{600}, Θ_3, Θ_6, Θ_{100}, Θ_{200}, $\Theta_{3\ 10sec}$, $\Theta_{3\ 10min}$). Next, the pH of the sample was measured with the pH Meter and pH paper to ensure a pH of about 8-10. The sample was then put on the filtration device for thirty minutes at the pressure of 0.69 Mpa so as to determine the volume of filtration loss. After that the filtration paper was taken to measure the angle of friction using the Viscosity factor meter, and from this, the friction co-efficient was found from the device guide.

The above procedures were repeated for other quantities of the samples and at different temperatures (30°, 50°, 60°, 70°, 80°, 90° and 100°). After the test with the first sample (*Sorghum*, 0.57%) was concluded, similar tests with the same procedures were carried out for the four remaining samples of *Sorghum* (1.13%, 1.69%, 2.24% and 2.78%). The results of the above tests, PH, filtration loss and angle of friction were clearly recorded, table (2). The speeds were used to calculate the apparent viscosity (AV), the plastic viscosity (PV), the yield point (YP) and the gel strength using the following equations:

$$AV = \theta600/2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$PV = \theta600 - \theta300 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$Yp = \theta_{300} - PV \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$\text{Gel Strength} = \theta_{\mathbf{3\ 10sec}} / \theta_{\mathbf{3\ 10min}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Additionally, by using the previous results for all the samples, Bingham Plastic Model and Power Law Model were used to calculate the shear stress and the shear rate. This was then used to show the behavior of the fluid. The resulting curves and shapes, figures (1 to 9) were analyzed and the high and low percentages of the *Sorghum* were determined. Thus optimum stability in the characteristic of the fluid with the temperature changes and the different percentage of the *Sorghum* was determined.

Figure:

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

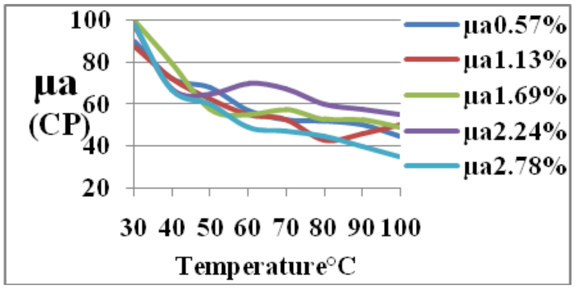

Figure 1:Apparent viscosity vs. Temperature

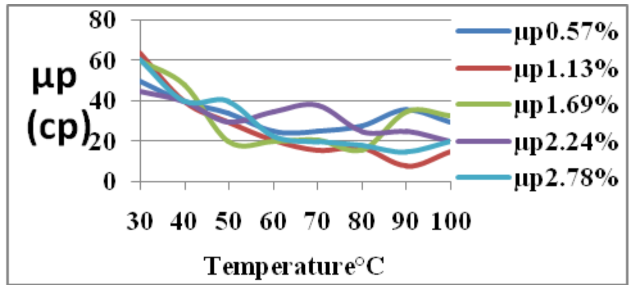

Figure 2 : Plastic viscosity vs. Temperature

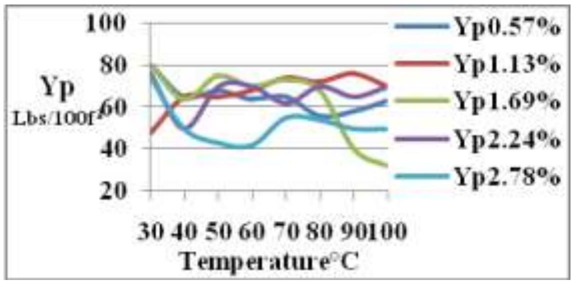

Figure 3: yield point vs. Temperature

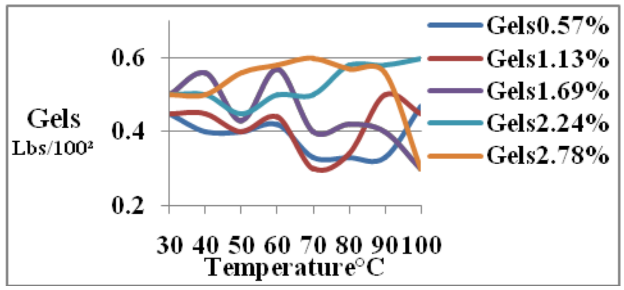

Figure 4 : Gel Strength vs. Temperature

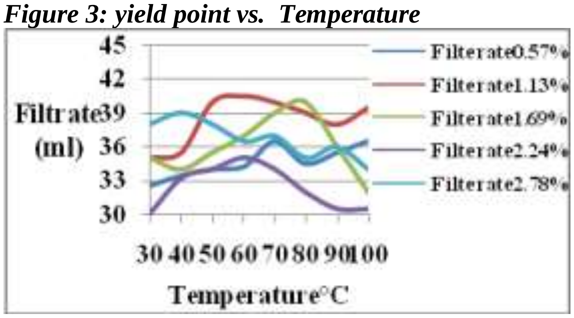

Figure 5:Filtration Volume vs. Temperature

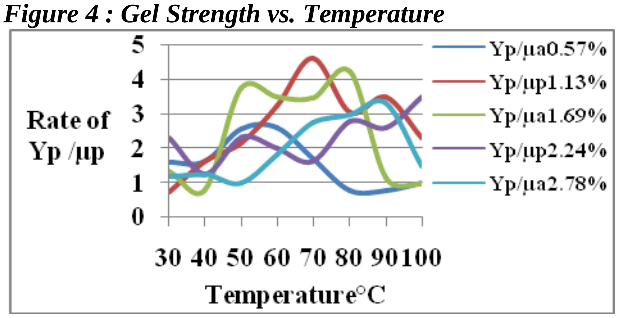

Figure 6: Rate of Yp/μp vs. Temperature

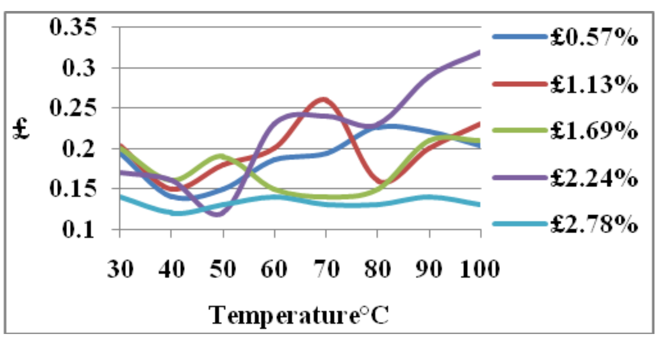

Figure 7: Co efficient of friction (£) vs. Temperature

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

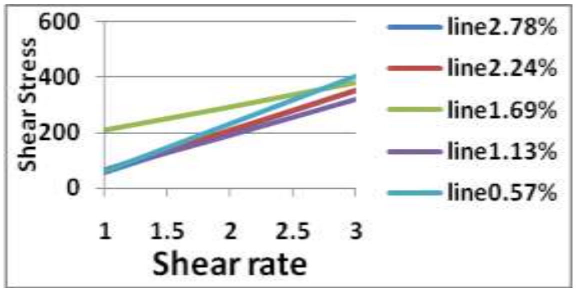

Figure (8): Bingham Plastic model fluid Behavior

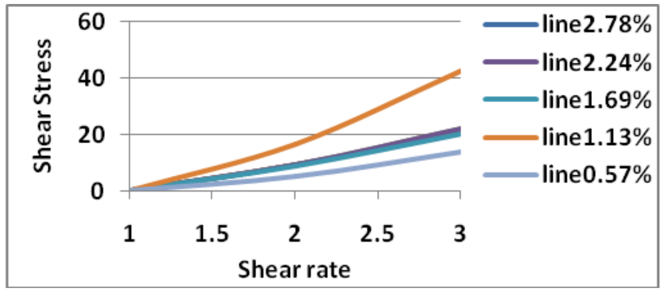

Figure (9): Power Law model fluid Behavior

RESULTS AND DISCUSSION

Table (2): Rheology calculated results of Sorghum (0.57%, 1.13%, 1.69%, 2.24% and 2.78%)

Temperature (T°C)		30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C
Properties	**Percentages**								
Apparent Viscosity (AV)	**0.57%**	90	72.5	68	57	52.5	52	50	45
	1.13%	88	72.5	62.5	55	53	43	46	50
	1. 69%	100	80	57.5	55	57.5	53	52.5	49
	2.24%	100	80	57.5	55	57.5	50	52.5	49
	2.78%	98	67	60	49	47.5	45	40	35
Plastic Viscosity (PV)	**0.57%**	50	40	34	25	25	28	36	30
	1.13%	64	40	30	21	16	17	8	15
	1. 69%	60	48	20	20	21	16	35	33
	2.24%	45	40	30	35	38	25	25	20
	2.78%	61	40	40	23	20	18	15	20
Yield Point (YP)	**0.57%**	80	65	68	64	65	56	58	63
	1.13%	48	65	65	68	74	72	76	70
	1. 69%	80	64	75	70	73	68	40	32
	2.24%	76	50	70	70	62	70	65	70
	2.78%	74	50	43	42	55	54	50	50
Gel Strength	**0.57%**	0.45	0.4	0.4	0.42	0.33	0.33	0.33	0.47
	1.13%	0.45	0.45	0.4	0.44	0.3	0.34	0.5	0.45
	1. 69%	0.5	0.56	0.43	0.57	0.4	0.42	0.4	0.3
	2.24%	0.5	0.5	0.45	0.5	0.5	0.58	0.58	0.6
	2.78%	0.5	0.5	0.56	0.58	0.6	0.57	0.56	0.3
Filtration	**0.57%**	32.5	33.5	34	34.3	36.5	34.5	35.5	36.5
	1.13%	32.5	33.5	34	34.3	36.5	34.5	35.5	36.5
	1. 69%	35	34	35.5	37	39	40	36	32
	2.24%	30	33.3	34	35	34	32	30.5	30.5
	2.78%	38	39	38	36.5	37	35	36	34
Rate of Yp/μp	**0.57%**	1.6	1.63	2.56	2.6	1.7	0.78	0.78	1
	1.13%	0.75	1.63	2.17	3.24	4.63	3.06	3.5	2.33
	1. 69%	1.33	0.8	3.75	3.5	3.48	4.25	1.14	0.96
	2.24%	2.33	1.25	2.33	2	1.63	2.8	2.6	3.5
	2.78%	1.2	1.25	1	1.83	2.75	3	3.33	1.5
Co efficient of friction(£)	**0.57%**	0.19	0.14	0.15	0.185	0.19	0.23	0.222	0.204
	1.13%	0.2	0.15	0.18	0.2	0.26	0.16	0.2	0.23
	1. 69%	0.2	0.16	0.19	0.15	0.14	0.15	0.21	0.21
	2.24%	0.17	0.16	0.12	0.23	0.24	0.23	0.29	0.32
	2.78%	0.14	0.12	0.13	0.14	0.13	0.13	0.14	0.13

From Figures (1 to 9) and the subsequent graphical analysis that follows; the effects of Sorghum on fluid properties were founded to be as explained below.

Apparent and Plastic Viscosity: The Apparent and Plastic Viscosity exhibited similar behavior as a result; the shapes of the two graphs are similar Figures (1 and 2). For l**ow temperature range (30°C-50°C)** the apparent viscosity and plastic viscosity started with higher values, but decreased between points 30°C to 50°. The capacity of the drilling fluid at this range is poor in lifting the cuttings. **Medium temperature range (50°C -80°C)** it was noticed that the apparent viscosity and plastic viscosity were stable (so the rate of flow of the fluid was stable- a good condition for cleaning the well) However, fluid 1.13% showed a considerable decrease in apparent viscosity and fluid 2.24% has unstable plastic viscosity. **High temperature range (80°C -100°C)** the apparent viscosity was generally stable while the plastic viscosity was semi stable, showing slight increase or decrease. The increase was due to the low decrease in the concentration of solids of the drilling fluid.

Yield Point: It is clear from figure (3) for **low temperature range (30°C -50°C)** an initial decrease was observed for all the percentages except percentage 1.13 that showed an increase. The decreased yield point is due to decreased strength of attraction between the solid particles in the drilling fluid and the increased viscosity of the fluid. **Medium temperature range (50°C -80°C)** the yield point was stable, maintaining a good degree of stability despite the increase in the temperature. **High temperature range (80°C -100°C)** the yield point was observed to be stable but fluid 1.69% showed dramatically decreased.

Gel Strength: from Figure (4), **low temperature range (30°C -50°C)** The Gel strength was stable for all the curves except fluid 1.69% was unstable. **Medium temperature range (50°C -80 °C)** the gel strength increased then decreased showing instability. However fluid 0.57% and 2.78% were stable. **High temperature range (80°C -100°C)** most of the fluids were stable but 1.15% and 2.78% decreased while $\text{Gels}_{0.57\%}$ increased.

Filtration volume: From figure (5), l**ow temperature range (30°C -50 °C**) the filtration volume of the drilling fluid was stable between points 30° to 50°C for all the curves except 1.13% and 2.24% that showed an initial increase. **Medium temperature range (50°C -80°C**) the filtration loss remained steady and stable, notably 0.57%, , and 2.78%. Although 1.13%was unstable and 1.69% showed increase in the filtration volume. **High temperature range (80°C -100°C)** the Filtration volume was stable, but 1.69% give increase in filtrate volume 2.24% decreases.

Ratio of Yp / µp: looking at figure (6), l**ow temperature range (30°C -50°C**) the ratio of Yp/ µp showed different behavior 0.57% and 2.78% were stable, 1.69% and 2.24% were unstable and 1.13% increased. **Medium temperature range (50°C -80°C**) the Yp/µp ratio was unstable, increasing and decreasing. The increase was well pronounced for 2.78% while the decreased was for 0.57%. **High temperature range (80°C -100°C)** for 0.57% it was clearly stable while the other curves were relatively unstable, showing different levels of increase and decrease.

Co efficient of Friction: Figure (7) showed that at **Low temperature range (30°C -50°C)** there was stability of the coefficient of friction for all the curves except curve $£_{13.44\ \%}$ that showed an increase. **Medium temperature range (50°C -80°C**) there was stability for all the curves, though with fluctuations, except for 1.13% that was unstable. **High temperature range (80°C -100°C) t**here was **s**tability for curves 0.75% and 2.78% while other curves showed an increase.

CONCLUSION

The use of Sorghum in drilling fluids with water-based fluid, which consists of Bentonite as a basic material has shown an impact on the properties of the drilling fluids. The following points explain the properties improvement observed of the drilling fluid.

1- Apparent viscosity and plastic viscosity decreased between 30°C to 50°C, with a major increase of flow rate and a low pump pressure, but between 50°C and 80°C ,these two properties were stable with high degree of hole cleaning and the best fluids functioning. And between points 80°C to 100°C these properties -apparent and plastic viscosity- were low (i.e. decreased**)** with semi stability condition.

2- Yield point was decreased between 30°C to 50°C, This decrease leads to adequate suspension of cuttings, but the Yield point was at stability between points 50°C to 100°C.

3- The Gel Strength property was at stability between points 30°C to 50°C which leads to high efficiency of fluid performance. It was observed that Sorghum as an additive had the tendency to bear pressure. Between points 50°C to 80°C the Gel strength was not stable, although 0.57%, 1.69% 2.78% were stable. But between 80°C to 100°C it was highly stable with high efficiency of fluid performance.

4- Filtration property was stable between 30°C to 100°C for the 0.57 % and 2.78% while Others shown an increase tending to cause problems such as formation damage, hole collapse, caving, fracturing, and dispersion of clays and may also lead to pipe sticking.

5- The ratio of YP/µp was at stability between 30°C to 100°C with slight instability and a decrease for 2.78% and 1.13%. While the coefficient of friction (£) property was at stability though it showed an increase between the three ranges of temperature and unstable for 1.13%. Bingham Plastic and Power Low Models showed the extent of pseudo plastic stability fluids behavior.

Finally, the overall conclusion drawn from the above is that the percentage 0**.**57**%** represents the least optimum point while 2.78% represents the high optimum point. From what has preceded, it is clear that *Sorghum* is a very good additive when used in drilling fluid for different temperature ranges. Therefore *Sorghum* could be recommended to be used as an additive for water based fluids. Not to forgot it is also highly recommended to study the behavior of *Sorghum* in oil base muds.

Addendum: It was observed that when Sorghum was used as an additive in water based drilling fluid; it showed the ability to absorb the temperature and pressure, which could reduce the incidence of problems related to the fracture of earth, a consequence of the pressure and change in the properties of the drilling fluid due to high temperatures. This absorption behavior is recommended to be the subject of further research.

ACKNOWLEDGEMENTS
I thank the Ministry of Oil and the Sudanese companies operating in the oil industry in Sudan

REFERENCES

1. JRN Taylor, "IMPORTANCE OF SORGHUM IN AFRICA, OVERVIEW", Department of Food Science , University of Pretoria , www. jtaylor@postino.upac.za, South Africa, page (3), 2000.
2. Babiker, E. E. and Kato, A., "Improvement of the functional properties of Sorghum Protein", Nahrung , Page 4, 1998.
3. Linda Dykes, Lloyd W. Rooney, "Sorghum and millet phenols and antioxidants", Cereal Quality Laboratory, Department of Soil and Crop Sciences, Texas , PP- 239-241, 2006.
4. Navin J., "Chemical composition of different Varieties of grain Sorghum", Journal of Agricultural and Food chemistry U.S.A, Volume 28(1), PP- 19-21, 1980.
5. C. WAYNE SMITTH , EDITOR RICCHARDA, FREE DERIKSEN and WILEY Series, IN CROP SCIENCE "Sorghum" ; Printed in the United States of America, New York, chapter (6) , page 499, 2000.
6. Rooney, L. W. and D. S. Murty, "Evaluation of Sorghum Food Quality", Proceedings Symposium on Sorghum, Patna cheru, India, PP- 571, 1982.
7. Etuk E. B., Ifeduba A. V., OKataa U. E., Chiaka L, OKoli C., Okeudo N. J., Esonu B.O., udedibie A. B. I. and Moreki J. C., "Nutrient Composition and Feeding Value of Sorghum for Live Stock and Poultry", Review J. Animal Science Advances, Volume 2(6), Nigeria, PP: 197-199; 2012.