Antisickling properties of two *Calliandra* species: *C. portoricensis* and *C. haematocephala* (Fabaceae)

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ABSTRACT

**Aim:** To investigate the antisickling potentials of two *Calliandra* species *C. portoricensis* (Jacq) Benth and *C. haematocephala* Hassk *in vitro*

**Study design:** Evaluation of antisickling activities of medicinal plants on human sickled red blood cells *in vitro*

**Place and duration of study:** Research Laboratory of Drug Research and Production Unit, Faculty of Pharmacy Obafemi Awolowo University, Ile Ife, Nigeria. September 2010 to November, 2011

**Methodology:** After obtaining ethical clearance, fresh blood samples (5ml) each were collected from confirmed sickle cell anaemia patients who were in a steady state and attending the routine clinic. Water and 70% ethanol were used separately for the extraction of the leaves and roots of the two plants. The extracts were assessed for their antisickling activities using the inhibitory and reversal methods *in vitro*.

**Results:** It was observed that there was linear increase in inhibitory and reversal activities of the ethanolic and aqueous extracts of the parts used as the concentration increased. The ethanolic root extract of *C. portoricensis* exhibited the highest activity for inhibitory (90.19%) and reversal activities (92.63%) both at 4mg/ml.

**Conclusion:** *Calliandra* species possessed antisickling properties *in vitro* with *C. portoricensis* being the more active plant.

**Key Words:** Antisickling, *Calliandra haematocephala*, *C. portoricensis*, Inhibitory, Reversal, Sickle cell disorder.

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INTRODUCTION

Sickle cell disorder is a common genetic condition due to a haemoglobin disorder resulting from inheritance of mutant haemoglobin genes from both parents. This disorder is caused by a point mutation in the $\beta$-globin chain of haemoglobin, causing the hydrophilic amino acid glutamic acid to be replaced with the hydrophobic amino acid valine at the sixth position (Hall, 2011). Sickle cell disorder results in anaemia and crisis that could be of many types including the vaso-occlusive, aplastic sequestration, hyperhaemolytic and other crises (BestBets 2010). Over the years, several research works have been done and chemical agents for inhibiting or reversing sickle shaped red cell in vitro have been proposed. The use of phytomedicines such as Piper guineensis, Pterocarpa osun, Eugenia caryophyllala and Sorghum bicolor extracts for the management of sickle cell disease have been reported (Wambebe, 2001). An investigation into the usage of aqueous extracts of the reddish brown freshly fallen leaves of Terminalia catappa reported that the plant can exhibit antisickling activity on Sodium metabisulphite induced sickling (Moody et al., 2003). The ability of a compound to increase the gelling time of human HbSS could be taken as a measure of the antisickling potential of the compound and this determined its effectiveness in sickling inhibition and retarding of the aggregation of HbSS erythrocytes in the potential’s blood vessels (Ejele and Njoku, 2008). The extracts of Xylopia aethiopica (guinea pepper) and seeds of the African nutmeg were evaluated for in vitro antisickling activity (Uwakwe and Nwaoguikpe, 2010). The researchers found that irrespective of whether they used the water, chloroform, methanol or butanol extract of these spices, the extracts were able to prevent red blood cells becoming sickle in shape to varying extents – from 70 per cent to 90 per cent in 15 minutes. Since sickle cell disease is a genetic disorder, no cure had been found but the disease is managed through the use of vitamins and good nutrition. However, of late research
has been intensified in order to discover new drugs that will be able to ameliorate the crises
conditions associated with this disorder.

The genus *Calliandra* belongs to the family Fabaceae, subfamily Mimosoideae. It is a large
greatotropical genus from South Africa to the Southern United States. It is also a native of
humid or sub-humid regions of Central America and the warmer parts of South America,
including Argentina and Chile. Some species are also found in India, Madagascar and West
Africa. The genus comprises of about 200 species of frequently unarmed flowering plants,
which include herbaceous perennial plants, shrub and rarely small trees growing to a
maximum height of 12m and a maximum basal stem diameter of 20 cm (Macqueen, 1991).
They are normally straggling, highly branched plants with bipinnate (compound) leaves,
which have a tendency to fold at night. *Calliandra portoricensis* is a shrub or small tree of
about 6 m tall with evergreen small bipinnate leaves, whitish-pink scented and globose
flowers, which look like small snowballs and Fruits are pods, which are about 4 in (10 cm)
long (Burkill, 1985). *Calliandra portoricensis* is also known as ‘tude’ in Yoruba and is used
in ethnomedicine as anticonvulsant (Akah and Nwaiwu, 1988, Adesina, 1982), anti-diarrheal,
antispasmodic, antipyretic, anti rheumatic and analgesic activities in human beings (Aguwa
and Lawal, 1988). The preliminary phytochemical analysis of the extract of *Calliandra
portoricensis* reveals that the plant possesses saponins, steroids, tannins, glycosides,
alkaloids, anthraquinones, cardiac glycosides, fatty acids, gallic acid, methyl gallate,
myricitrin, quercitrin, afzelin, isoquercitrin, caffeic acid, betulinic acid and other related
compounds (Akah and Nwaiwu, 1988). *Calliandra haematocephala* is similar to *C
.portoricensis* the major difference is in the colour of the flower. The flower is reddish-pink
and fruit color is brown (Crushes and Edwards, 1998). Flowers are clustered in globose
heads, up to 7 cm across; stamens are long and silky, pink to red. Fruit is a dehiscent pod. *C
heamatocephala* is also known as Ule in Yoruba. The chemical constituents of *C
heamatocephala include Betulinic acid, lupeocaffic acid, astilbin, catechin-3-O-rhamnoside and P-hydroxybenzoic acid (Nia et al., 1999). The leaf contains pipecolic acid derivatives. Pipecolic acid is a non protein amino acid, and its derivatives have been isolated from the leaves of C haematocephala. Three acylated quercetin rhamnosides were reported from the leaves and stem of C. haematocephala and their structures were established as quercitrin 2''-O-caffeate quercitrin 3''-O-gallate and quercitrin 2", 3''-di-O-gallate (Moharram et al., 2006). Also, 17 known compounds were reported for the first time from the genus Calliandra they are gallic acid. Leaves of Calliandra heamatocephala Hask (Mimosaceae) were used against various microbial infections and active against bacteria thereby justifying their use against skin infections (Nia et al., 1999). The betulinic acid acts as an anti-inflammatory agent (Potier, 1991). Antitumoral and anti-HIV activity of betulinic acid has also been reported (Yoshiki et al., 1996). Tyramine is reported present in the leaves at 118 mg / kg fresh weight basis. Six compounds exhibited moderate to strong radical scavenging properties (Moharram et al., 2006). However, the plant is yet to be authenticated for its antisickling activity hence this study. Therefore, the possible antisickling properties of the Calliandra species and the relative antisickling activities of the leaves and roots of the two Calliandra species were investigated and assessed respectively.

2. MATERIALS AND METHODS

2.1 Chemicals and reagents

The chemicals used were ethanol (Fluka), methanol (Fluka), distilled water, Sodium metabisulphite (Hopkins and Williams), Phosphate buffered saline pellets pH 7.0, formalin, liquid paraffin, Tween-80 (BDH) and Para-hydroxybenzoic acid (PHBA) BDH.
2.2 Plant Samples

Two Calliandra species: C. portoricensis and C. haematocephala fresh roots and leaves were collected around Mozambique Hall of Obafemi Awolowo University, Ile-Ife in July 2009, and beside antenatal ward of the Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife respectively in July 2009. The plants were identified and authenticated at the Herbarium Units of Faculty of Pharmacy and the Department of Botany of Obafemi Awolowo University simultaneously.

2.3 Blood sample

Ethical clearance was obtained from the Ethical Committee of the Obafemi Awolowo University Teaching Hospital Complex (OAUTHC), Ile-Ife. Fresh blood samples (5ml) each were collected from confirmed sickle cell anaemia patients who were in a steady state and attending the routine clinic. The blood samples were collected into an EDTA anticoagulant containing bottles and mixed gently to prevent lysing of the red blood cells.

2.4 Preparation of plants materials:

Fresh leaves of C. portoricensis and C. haematocephala were air dried for 24 hours and oven dried at 40°C for 4 hours to bring about complete dryness. The roots of both plants were washed, cut into small pieces, air dried and finally at 50°C for 4 hours. All the dried plants were separately milled into powdered form using grinding machine (Christy) and stored in well sealed amber coloured bottles.

2.5 Preparation of aqueous and ethanolic extracts

Powdered plant materials (200 g) each were separately extracted with (2 L) water or 70 % (v/v) ethanol (2 L). The suspension were allowed to simmer for 3 hour under reflux and finally allowed to cool. The suspension were filtered under vacuum and concentrated to
dryness at 50°C. Any residual water in the dried extracts were removed using activated silica gel desiccators. Final drying was done by freeze-drying. They were finally stored separately into sample bottles until needed for the experiments. The percentage yields of the extracts of the two Calliandra species were determined. A small portion of each of the dried extracts (0.02 g) was reconstituted in distilled water (5ml) to obtain the 4 mg/ml concentration. Serial dilutions were made further to obtain dilutions of 2 mg/ml, 1 mg/ml, 0.5 mg/ml, 0.25 mg/ml and 0.125 mg/ml concentrations, which were used for the antisickling assay.

2.6 Inhibitory assay:

The evaluation of both aqueous and ethanolic extracts for antisickling activities were carried out using modified methods of Sofowora et al. (1979) and Egunyomi et al. (2009). Vein punctured blood samples from sickle cell anaemia patients not in crises were used. Blood sample (0.2 ml), 0.2 ml of phosphate buffered saline and 0.2 ml of the test extract were mixed together in a test tube. The mixture was overlaid with 1 ml of liquid paraffin to prevent aeration or oxygenation. The mixture was then incubated in a thermostated water bath at 37°C for 4 hr. Freshly prepared 2% (w/v) sodium metabisulphite solution (0.6 ml) was carefully added to the mixture under the paraffin, which was then mixed gently by rolling the test tube between the two palms. The mixture was incubated for additional ninety minutes at 37°C in the water bath. The liquid paraffin was carefully removed using a Pasteur pipette and the cell was fixed with 3 ml of 5% w/v buffered formalin solution. The positive control was as described above except Parahydroxybenzoic acid (PHBA) was added instead of extract while the negative control lacked extract but equivalent volume of 5% (w/v) Tween 80 (dissolution solvent of extracts). Each test was performed in triplicate. A drop of each reaction mixture was smeared on a microscope slide and viewed under high powered magnification (x 100) under the oil immersion. Cells were counted on five fields on each slide; the numbers of sickled and unsickled cells were counted to determine the total number
of cells. The percentage mean sickling as well as the percentage inhibition activity for each extract were estimated.

2.7 Reversal assay

Mixture of the blood sample (0.2 ml) and 0.2 ml phosphate buffered saline in a test tube was carefully overlaid with 1ml liquid paraffin and 0.6 ml of 2% (w/v) sodium metabisulphite was carefully introduced under the liquid paraffin. The mixture was then incubated at 37°C for ninety minutes. At the end of the incubation period, 0.2 ml of the extract was carefully added under the liquid paraffin and was further incubated at 37°C for additional 6 hr. The liquid paraffin layer was removed with a Pasteur pipette and the cells were fixed with 3 ml of 5% (w/v) buffered formalin solution, which was carefully mixed by rolling the test tube between the two palms. The positive control also involved all the procedure described above except that PHBA was added instead of extract while the negative control lacked extract but equivalent volume of 5% Tween 80. A drop of each reaction mixture was smeared on a microscope slide and viewed under high powered magnification (x 100) under the oil immersion. Cells were counted on five fields on each slide, the number of sickled and unsickled cell were counted to determine the total number of cells. The percentage mean sickling as well as the percentage reversal activity for each extract was estimated using the expression below:

\[
\% \text{ Mean Sickling} = \frac{\text{Mean sickled cells}}{\text{Mean total cells}} \times 100
\]

\[
\% \text{ Inhibition activity} = \frac{\text{Control} - \% \text{ Mean sickled}}{\text{Control}} \times 100
\]

\[
\% \text{ Reversal activity} = \frac{\text{Control} - \% \text{ Mean sickled}}{\text{Control}} \times 100
\]

Total number of cells counted = No of sickled + No of unsickled cells
Values are expressed as mean ± SEM of 3 consistent readings. The statistical significance differences were analyzed using Student- Newman- Keuls Multiple Comparison test and analysis of variance. Values of P < 0.0001 were considered to be extremely significant.

3. RESULTS AND DISCUSSION

The percentage yield of powdered leaves and roots and their extracts shown in Table 1 indicated that 70% ethanol appeared to have better extractive capability than water. The percentage yield of the latter extracts of the roots and leaves of the two Calliandra species were higher than the aqueous extracts. The water being inorganic polar solvent present in the 70% Ethanol could have combined with the organic polar nature of the Ethanol thereby demonstrated better extractive capability. As such both the organic and the inorganic salts of the plants which could be putative in a synergistic manner were thus extracted. Water, though an inorganic polar solvent has the capability of extracting organic component of a plant especially the polar component but less of the lipophilic component, but the thermal energy enabled water to extract some of the lipophilic component; but not as much as organic polar solvent under the same thermal condition. The above could explain the relatively higher extractive yields of the 70% ethanol solvent over water. The ethanolic root extract of C. haematocephala had the highest yield. This result corroborates the statement that extracts with ethanol extraction were most effective followed by cold-water and hot water extraction respectively (Okigbo and Ogbonnaya, 2006). Another experiments also reported that ethanol had higher yield of extracts than water (Puttawong et al., 2009). This could also justify the use of alcohol or local gin as extraction solvent in some ethnomedical preparations in West Africa.
The inhibitory activities of the leaf and root extracts of the two *Calliandra* species were compared at various concentration ranges (0.125 mg/ml – 4.0 mg/ml) as shown in Fig 1 (a-d). The inhibitory activities of the extracts were significantly different (P< 0.0001) from each other and appreciable antisickling activities greater than 70% were recorded at concentration greater than (0.5 mg/ml). The inhibitory activities for the aqueous extracts were relatively lower than that of the ethanolic extracts. This could be due to the better extractive capability of 70% ethanol as discussed earlier. However, both the aqueous (Cpraq) and ethanolic (Cpret) root extracts of *C. portoricensis* exhibited higher inhibitory activities than others. The Cpret extract at high concentration (4.0 mg/ml than the control) was the most active extract with inhibitory activity of 90.19% compared to PHBA which gave 84.04%. Plate 1 showed Red blood cells (RBC) of HbSS patient under hypoxial state. The film showed lots of sickle cells with the deformed RBC with sickle shape. However, in the Plate 2 at highest concentration of 4 mg/ml virtually all the RBC maintained the spherical, ovoid shape of normal RBC which was indicative of the capacity of the extract to inhibit the sickling of red blood cells.

The relative reversal activities of the leaf and root extracts of the two *Calliandra* species were compared and presented in fig. 2 (a-d). The result indicated that all the extracts showed a significantly (P<0.0001) increase in antisickling activity as the concentration increases from 0.5 mg/ml – 4 mg/ml. The ethanolic leaf extracts (Cplet and Chlet) of the two species exhibited better reversal of sickling activity at varying concentrations compared to the aqueous leaf extracts (Cplaq, Chlaq and Cplet) possessed the highest reversal of the sickling activities of HbS to normal red blood cells shape (87.59%). However, the activity of the root extracts of *C. portoricensis* was found to be more pronounced than *C. haematocephala* with ethanolic root extract (Cpret) given higher antisickling activity. Both extracts from *C. portoricensis* seemed to have higher reversal activity in comparison with that of *C.
haematocephala. Thus Cpret (ethanolic root extract) was the most active with 92.63% reversal ability compared to the PHBA (positive control) which was 90.86%. Plates 2a and 2b showed the photomicrograph of red blood cells (HbSS). The untreated control showed high percentage of sickled cells under hypoxic condition while plate 2b showed the reversed normal spherical shaped RBC after treatment with the ethanolic root extract of Calliandra portoricensis (Cpret).

This study showed that the putative antisickling compound(s) were hydrophilic in nature. Both extracts still showed very good activities in the inhibitory and reversal tests. The antisickling assays of the leaves and roots of the two Calliandra species indicated that both the inhibitory and reversal activities of ethanolic and aqueous extracts had a linear correlation in activity. Generally, as the concentration increases, the activities also increased significantly (P < 0.0001). It was observed that both the ethanolic and aqueous the leaf extracts of C. portoricensis had a weak reversal of sickling activity as the concentration increases (Fig 2a) unlike the results obtained for reversal activity of both root extracts of C. portoricensis and the extracts of either root or leaf of C. haematocephala.

In this experiment sickling condition was potentiated by low oxygen levels, in the medium due to the addition of Sodium metabisulphite. increased acidity and dehydration of the blood are also implicated in the causation of sickling of HbS.. The constituents of the aqueous and ethanolic extracts of the plant are highly oxygenated due to the presence of poly hydroxyl constituents of the plant such as Gallic acid, methyl gallate, myricitrin, quercitrin, myricetin 3-O-â-D-4C1-glucopyranoside, afzelin, isoquercitrin, myricetin 3-O-(6''-O-galloyl)-â-Dglucopyranoside, myricitrin 2''-O-gallate, quercitrin 2''-O-gallate, afzelin 2''-O-gallate, myricitrin 3''-O-gallate,afzelin 3''-O-gallate (17), 1,2,3,4,6-penta-O-galloyl-â-D- 4C1-glucopyranose, myricitrin 2''-3''-di-O-gallate, quercetin 3- O-methyl ether (Moharram et al., 2006). hence they have the potential of possessing antioxidant properties. Caffeic acid which
is reported to be present in the plant was known to exhibit antioxidant property \textit{in vitro} and \textit{in vivo} and also possess immunomodulatory and anti-inflammatory activities (Olthof \textit{et al.}, 2001). This is similar to p-hydroxybenzoic acid earlier reported to be the active antisickling principles of \textit{Zanthoxylum xanthoxyloides} Waterm (Sofowora and Soyede, 1971).

The presence of these compounds in \textit{Calliandra} could be responsible for the observed antisickling activity. Similarly the presence of Gallic acid and methyl 3, 4, 5-Trihydroxy benzoic acid found in the plant could also contribute to the antisickling property of the plant because gallic acid has been reported to protect human cells against oxidative damage. This indicates that the \textit{Calliandra} may indeed have a great potential in the management of sickle cell disorder. This study has confirmed the antisickling properties of the two plants species. However, the more active plant has been identified as \textit{C. portoricensis}.

\textbf{4. CONCLUSION}

\textit{Calliandra} plant especially \textit{C. portoricensis} could be regarded as a potential antisickling plant that can play essential role in the management and treatment of sickle cell disorder.

\textbf{ACKNOWLEDGEMENT}

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Table 1: Percentage yield of powdered leaves and roots and their extracts

<table>
<thead>
<tr>
<th>Plant Species</th>
<th>Extracts</th>
<th>Percentage yield (%)</th>
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<tr>
<td><em>C. haematocephala</em> roots</td>
<td>aqueous</td>
<td>7.60</td>
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<tr>
<td></td>
<td>ethanol</td>
<td>8.20</td>
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<tr>
<td><em>C. haematocephala</em> leaves</td>
<td>aqueous</td>
<td>5.83</td>
</tr>
<tr>
<td></td>
<td>ethanol</td>
<td>6.72</td>
</tr>
<tr>
<td><em>C. portoricensis</em> roots</td>
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<td>4.50</td>
</tr>
<tr>
<td></td>
<td>ethanol</td>
<td>4.95</td>
</tr>
<tr>
<td><em>C. portoricensis</em> leaves</td>
<td>aqueous</td>
<td>4.53</td>
</tr>
<tr>
<td></td>
<td>ethanol</td>
<td>6.02</td>
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</table>

**Fig. 1a:** The inhibitory activities of ethanol (CPLET) and aqueous (CPLAQ) leaf extracts of *C. portoricensis* with *Para-hydroxybenzoic acid* (PHBA) as control.
Fig. 1b: The inhibitory activities of ethanolic (CPRET) and aqueous (CPRAQ) root extracts of *C. portoricensis* with Para-hydroxybenzoic acid (PHBA) as control.
Fig. 1c: The inhibitory activities of ethanolic (CHLET) and aqueous (CHLAQ) leaf extracts of *C. haematocephala* with *Para-hydroxybenzoic* acid (PHBA) as control.
Fig. 1d: The inhibitory activities of ethanolic (CHRET) and aqueous (CHRAQ) root extracts of *C. haematocephala* with Para-hydroxybenzoic acid (PHBA) as control.
Plate 1: Untreated control showing sickled red blood cells

Plate 2: Inhibitory activity (90.19%) after treatment with Cpret at 4mg/ml
Fig. 2a: The reversal activities of the ethanol (CPLET) and aqueous (CPLAQ) leaf extracts of *Calliandra portoricensis* with Para-hydroxybenzoic acid (PHBA) as control
Fig. 2b: The reversal activities of the ethanol (CPRAQ) and aqueous (CPRET) leaf extracts of *Calliandra portoricensis* with Para-hydroxybenzoic acid (PHBA) as control.
Fig. 2c: Reversal activities of ethanolic and aqueous leaf extracts of *C. haematocephala* with Para-hydroxybenzoic acid (PHBA) as control.
Fig. 2d: Reversal activities of ethanolic (CHRET) and aqueous (CHRAQ) root extracts of *C. haematocephala* with Para-hydroxybenzoic acid (PHBA) as control.
Plate 2a: Untreated control showing sickled red blood cells

Plate 2b: The reversed sickled red blood cells on treatment with Cpret with a reversal activity of 92%.