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Full Length Research Paper

Formulation and evaluation of *Cymbopogon citratus* dried leaf-powder tablets

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The objective of this study was to formulate *Cymbopogon citratus* leaves powder into tablets using both acacia and gelatin as binders at concentrations of 2, 4, 6 and 8% w/w, respectively. The tablets were evaluated using the necessary official and unofficial tests. The results showed that all the batches of tablets passed the uniformity of weight test. The hardness of the tablets was significantly affected by the type of binder and concentration used during formulation ($P < 0.05$). Gelatin had higher crushing strength values than acacia. Friability values for all the tablet formulations were below 1%. The disintegration time of tablets formulated with acacia ranged from 29.10 ± 0.13 to 208.00 ± 0.13 min for tablets formulated with 2 % and 8 % acacia respectively and 2.31 ± 0.27 min to 8.20 ± 0.24 min for tablets formulated with 2 and 8% gelatin. Phytochemical analysis of the powder from the plant leaves was carried out. The results obtained from micromeritic studies showed that the granules had good flowability. Phytochemical analysis showed that alkaloids, carbohydrates, saponins, reducing sugars, steroids, tannins, glycosides, proteins, flavonoids, resins, oils and terpenoids were present at different concentrations, while acid compounds were absent. Therefore, *C. citratus* leaves tablets could be formulated by wet granulation using acacia or gelatin as binder.

Key words: *Cymbopogon citratus*, lemon grass, tablets, phytochemical analysis, micromeritic.

INTRODUCTION

The primary benefit of using plant-derived medicine is that they are relatively safer than synthetic alternatives, offering profound therapeutic benefits and more affordable treatments (Ajali and Okoye, 2009). In recent times, focus on plant research has increased all over the world and a lot of evidence has been collected to show immense potential of medicinal plants used in various traditional systems (Dahanukar et al., 2000). Plants may become the bases for the development of a new medicine or they may be used as phytomedicine for the treatment of disease (Iwu et al., 1999). It is estimated that today, plant materials are present in, or have provided the models for 50% Western drugs (Robbers et al., 1996).

Cymbopogon citratus (DC.) Stapf (Poaceae) (lemon grass) is an aromatic perennial tall grass with rhizomes and densely tufted fibrous root. The plant is a native herb from India and is cultivated in other tropical and subtropical countries (Omotade, 2009; Gore et al., 2010; Dama et al., 2011). It is used as traditional folk medicine in the treatment of nervous condition, gastrointestinal disturbances, fever and hypertension. Lemon grass is also a folk remedy for coughs, elephantiasis, flu, gingivitis, headache, leprosy, malaria, ophthalmia, pneumonia and vascular disorders. It is principally taken in the form of tea as a remedy for digestive problems, diarrhoea and stomach ache. As a medicinal plant, lemon grass has

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been considered a carminative and insect repellent (Omotade, 2009; Gore et al., 2010; Dama et al., 2011). Studies on extracts from *C. citratus* leaves have demonstrated anti-inflammatory, vasorelaxing, diuretic and valuable remedy in treating ringworm as local application (Kokate and Varma, 1971; Gore et al., 2010). Lemongrass oil was claimed to have antihelmintic activity (Gore et al., 2010). In traditional medicine, lemon grass is usually prepared from the fresh herbs in the form of infusions and decoctions also, the dried leaves of lemon grass could be given in form of tea (Darren et al., 2011).

Lemon grass contains mainly citral (Schaneberg and Khan, 2002) and 1 to 2% essential oil on a dry basis (Carlson et al., 2001; Tajidin et al., 2012). Essential oil and citral of lemongrass were detected to gather at parenchyma tissue cells, specifically in the adaxial surface of leaf mesophyll (Lewinsohn et al., 1998). Citral of lemon grass is a natural combination of two isomeric aldehydes, namely isomers geranial (α-citral) and neral (β-citral) (Pengelly, 2004). Other unusual active components are limonene, citronellal, ß-myrcene and geraniol (Schaneberg and Khan, 2002; Tajidin et al., 2012).

Plants with antimalarial, antihelmintic and anti-inflammatory properties have been of immense ethnomedicinal use to mankind. In view of the widespread use of herbal products, important technical aspects such as standardization and quality control will be of immense benefit in order to enhance their efficacy and improve patients' compliance (Bonati, 1991; Elisabetsky et al., 1995; Patwardhan, 2005). Therefore the objective of this work was to formulate *C. citratus* dried powder *into* tablets and to study the effect of different binders on the *in vitro* properties of the tablets.

MATERIALS AND METHODS

Lactose (Merck, Germany), maize starch, gelatin, acacia (BDH, England), magnesium stearate (May and Baker, England), and distilled water (Lion water, Nsukka, Nigeria). *C. citratus* leaves powder was obtained from a batch processed in our laboratory. All other reagents and solvents were analytical grade and were used as supplied.

Collection and authentication of plant

C. citratus leaves were collected from the Army Barrack's field along Edem road in Nsukka, Enugu State, Nigeria in the month of April, 2011. The plant had earlier been authenticated by Mr. A. O. Ozioko, a consultant taxonomist with the International Center for Ethnomedicine and Drug Development (InterCEDD), Nsukka.

The voucher specimen of the plant studied is deposited in the herbarium of the Department of Pharmacognosy and Environmental Medicines, University of Nigeria, Nsukka (voucher no 171).

Processing of *C. citratus* leaves powder

The leaves were washed thoroughly in water, chopped and air-dried at 35 to 40°C. The dried leaves were milled severally in an electric grinder.

Phytochemical screening

Phytochemical tests were carried out on the powdered extract for the presence of alkaloids, tannins, saponins, flavonoids, resins, oils, steroids, glycosides, terpenoids, acid compounds, carbohydrates, reducing sugars and proteins. The tests were carried out using standard procedures of analysis (Harborne, 1993; Sofowora, 1993; Trease and Evans, 2002).

Preparation of granules

Granules were prepared by wet granulation method using three different binders at concentrations 2, 4, 6 and 8% w/w. Details of granulation are given in Table 1. The bulking agent, lactose (8% w/w) and maize starch which was used at 10% w/w as the disintegrant were dried and mixed for 10 min in a tumbler mixer with the powdered leaves of *C. citratus*. The binder solution was prepared using adequate amount of distilled water. The powder mixtures were moistened with the appropriate amount of binder solution. The homogeneous wet mass was then screened through a 1.7 mm sieve and the wet granules were dried in a hot air oven at 55°C for 1 h. Thereafter, the dried granules were screened through a 1.0 mm sieve (Lachman et al., 1990; Shendge et al., 2010).

Characterization of granules

Bulk and tapped densities

About 30 g of the sample of the granules were placed in a 100 ml measuring cylinder. The volume occupied by the sample was noted as the bulk volume. The bulk density (ℓ_B) was obtained by dividing the mass of the sample weighed out by the bulk volume, as shown in Equation 1 (Aulton, 2007):

$$\text{Bulk density} = \frac{\text{Mass of powder (M)}}{\text{Bulk volume of powder } (V_B)} \quad (1)$$

The cylinder was tapped on a wooden platform by dropping the cylinder from a height of one inch at 2 s interval until there was no change in volume reduction. The volume occupied by the sample was then recorded as the tapped volume. The tapped density (ℓ_T) was calculated using the formula:

$$\text{Tapped density} = \frac{\text{Mass of powder (M)}}{\text{Tapped volume of powder } (V_T)} \quad (2)$$

Flow rate and angle of repose

A funnel was properly clamped onto retort stand. The funnel orifice diameter, base diameter and efflux tube length were appropriately measured. A 30 g quantity of the granule was weighed out and gradually placed into the funnel with the funnel orifice closed with a shutter. The time taken for the entire sample in the funnel to flow through the orifice was noted. The flow rate was obtained by dividing the mass of the sample by the time of flow in seconds.

The dynamic angle of repose was determined by measuring the height of heap of powder formed using a cathetometer; the radius was gotten by dividing the diameter by two. Angle of repose (θ) for each granule sample was obtained using the Equation (3) (Aulton, 2007; Ngwuluka et al., 2010):

Table 1. Composition of *C. citratus* tablets.

Tablet (mg)	Quantity (mg)			
Binder*	6.0	12.0	18.0	24.0
C. citratus leaves powder	50.0	50.0	50.0	50.0
Maize starch	15.0	15.0	15.0	15.0
Magnesium stearate	3.0	3.0	3.0	3.0
Lactose qs	300.0	300.0	300.0	300.0

*Acacia and gelatin

$$\theta = \tan^{-1} \frac{h}{r} \quad (3)$$

Compressibility index and Hausner's quotient

Carr's compressibility index (%) of the granules was obtained using the Equation 4 (Aulton, 2007; Ngwuluka et al., 2010):

$$\text{Carr's index (\%)} = \frac{\text{Tapped density} - \text{Bulk density}}{\text{Tapped density}} \times 100 \quad (4)$$

While Hausner's ratio was obtained using Equation 5:

$$\text{Hausner's ratio} = \frac{\text{Tapped density}}{\text{Bulk density}} \quad (5)$$

Preparation of tablets

Initially granules were treated with lubricant, that is, magnesium stearate. Tablets were prepared by compressing the lubricated granules at 46 to 48 kgf using a 9.0 mm punch and die set fitted into an automated F3 Manesty Single Punch tabletting machine (Okorie et al., 2011).

Evaluation of tablets

Disintegration time test

Disintegration time test was conducted using an Erweka ZT 120 basket and rack assembly and 0.1 N HCl maintained at 37.0 ± 1.0°C as the disintegration medium. Ten tablets from each batch were used for the test and the procedure being as stipulated in the British Pharmacopoeia (BP), 2009 for normal release tablets.

Uniformity of weight

Twenty tablets were randomly selected from each batch. The tablets were weighed individually using an electronic balance (Ohaus Adventurer, China) and the individual weights recorded. The mean weight, standard deviation and percentage deviation were calculated (BP, 2009).

Tablet friability test

Twenty tablets were randomly selected from each batch of the tablet. The tablets were dedusted and weighed. The tablets were placed into the drum of the friabilator (Erweka GmbH, Germany) and rotated at 25 rpm for 4 min. The tablets were removed from the friabilator, dedusted and reweighed. The friability result was expressed as loss of mass expressed as a percentage of the initial mass (BP, 2009). The percentage friability was calculated from Equation 6:

$$Friability\,(\%) = 100 \left[\frac{W_o - W}{W_o} \right] \quad (6)$$

where W_o and W are the initial weight and final weight of the tablets, respectively.

Hardness/Crushing strength test

This test was carried out using a Monsanto-stokes hardness tester. Ten tablets from each batch were randomly selected. Each tablet was placed between the jaws of the hardness tester and force was applied by adjusting the knob of tester until the tablet integrity failed. The results were recorded in kgf.

Statistical analysis

Statistical analysis was carried out using Statistical Package for Social Sciences (SPSS) version 14.0 (SPSS Inc. Chicago, IL.USA). All values are expressed as mean ± standard deviation (SD). Data were analysed by one-way analysis of variance (ANOVA). Differences between means were assessed by a two-tailed student's T-test. $P < 0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

Micromeritic properties

Results obtained from the micromeritic studies are presented in Table 2. The results showed that *C. citratus* granules exhibited good flowability and the values obtained fell within the acceptable range for good powder flow. Values of angle of repose were significantly ($P < 0.05$) below 35°, which showed that the granules had low interparticle cohesion and hence good flowability. Hausner's ratio less than or equal to 1.25 indicates good flow, while Hausner's ration greater than 1.25 indicates poor flow. Therefore, the granules were within the specified limits for good flow, except batch A3 which had Hausner's ratio (HR) of 1.31. Also, Carr's index of 5 to 16 indicates good flow, while 18 to 23 shows fair flow (Aulton, 2007; Yüksel et al., 2007; Onyechi, 2008). Therefore, the granules exhibited good flowability; however, batch A3 also had Carr's compressibility index (CI) of 23.53% and therefore, exhibited a fair flow. The results of compressibility index indicate that the prepared granules had good flowability and consolidation properties. When the CI and HR are adequate, the powder flows at minimum bulk density. A high bulk density, that is, a low porosity, will result in a low deformation potential, a lack of space for deformation during compression will cause less intimate contact between the

Table 2. Micromeritic properties of *C. citratus* granules formulated with different binders and varying binder concentrations.

Batch	ℓ_B (g/ml)*	ℓ_T (g/ml)*	AR (°)*	HR	CI (%)	FR (g/s)
A1(2% acacia)	0.53 ± 0.03	0.53 ± 0.07	26.17 ± 0.01	1.10	8.62	8.39 ± 0.06
A2 (4% acacia)	0. 56 ± 0.01	0.64 ± 0.03	29.28 ± 0.01	1.14	12.58	5.90 ± 0.03
A3 (6% acacia)	0.52 ± 0.07	0.68 ± 0.05	31.43 ± 0.03	1.31	23.53	6.93 ± 0.07
A4 (8% acacia)	0.49 ± 0.01	0.60 ± 0.01	30.68 ± 0.07	1.22	18.33	7.08 ± 0.01
B1 (2% gelatin)	0.45 ± 0.10	0.51 ± 0.06	29.65 ± 0.11	1.13	11.80	10.04 ± 0.05
B2(4% gelatin)	0.46 ± 0.12	0.54 ± 0.11	29.33 ± 0.05	1.17	14.80	9.31 ± 0.03
B3 (6% gelatin)	0.50 ± 0.10	0.61 ± 0.01	27.87 ± 0.07	1.22	18.00	8.77 ± 0.07
B4 (8% gelatin)	0.54 ± 0.07	0.65 ± 0.07	28.42 ± 0.03	1.20	16.9	9.12 ± 0.03

Values shown are mean ± SD (*n = 3); A - B: *C. citratus* granules prepared with different binders; ℓ_B and ℓ_T = Bulk and tapped densities, AR = Angle of repose, HR = Hausner's ratio, CI = Carr's compressibility index, FR = Flow rate.

Table 3. Properties of *C. citratus* tablets.

Batch	Tablet weight (mg ± CV)*	Disintegration time (min ± SD)[a]	Friability (%)*
A1(2% acacia)	303.70 ± 1.99	29.10 ± 0.13	0.64
A2 (4% acacia)	304.10 ± 1.33	102.00 ± 0.24	0.43
A3 (6% acacia)	302.70 ± 1.39	162.00 ± 0.11	0.56
A1(8% acacia)	303.80 ± 1.69	208.00 ± 0.13	0.52
B1 (2% gelatin)	302.00 ± 1.32	2.31 ± 0.27	0.89
B2(4% gelatin)	303.40 ± 1.66	3.10 ± 0.17	0.87
B3 (6% gelatin)	305.30 ± 1.90	7.50 ± 0.11	0.85
B4 (8% gelatin)	302.40 ± 2.12	8.20 ± 0.24	0.60

*Mean for 20 tablets, [a]Mean for 10 tablets ± SD, CV: coefficient of variation, SD: standard deviation, A - B: *C. citratus* tablets, $P < 0.05$ was considered significant.

particles within the tablets, resulting in weaker tablets (Yüksel et al., 2007). The results showed that the granules had low bulk and tapped densities and hence, exhibited good properties required for the production of good quality tablets. The values of flow rate of granules ranged from 5.90 ± 0.03 to 8.39 ± 0.06 (g/s) for granules prepared with acacia (A1 to A4), and 8.77 ± 0.07 to 10.04 ± 0.05 (g/s) for granules formulated with gelatin as binder (B1 to B4). The results indicated that granules formulated with acacia exhibited a faster flow than those formulated with gelatin.

Tablet properties

Table 3 shows the properties of tablets formulated with different binders and varying binder concentrations and the results indicate that all the batches of tablets formulated complied with BP, 2009 standard for tablets weight above 250 mg. The tablets weight had percentage deviation below 5%. Tablets friability results presented in Table 3 showed that the tablets passed the friability test as the friability values were significantly below 1% ($P < 0.05$).

Therefore, the tablets can comfortably withstand handling, packaging and transportation without compromising the properties of the tablets. The results of disintegration time test presented in Table 3 showed that tablets formulated with acacia failed the disintegration time test for normal release tablets and hence could be used in formulating sustained release *C. citratus* tablets; however, tablets formulated with gelatin as binder complied with BP, 2009 specification for the disintegration time of normal release tablets. The results of crushing strength tests presented in Figure 1 showed that the tablets formulated with gelatin significantly exhibited higher crushing strength values than tablets formulated with acacia ($P < 0.05$). However, tablets formulated with 4, 6 and 8% binder complied with BP, 2009 specification for crushing strength of ≥ 5 kgf.

Phytochemical constituents of lemon grass leaves

The results of the phytochemical screening of the plant leaves are shown in Table 4. The results indicate the

Table 4. Results of the phytochemical screening of *C. citratus* leaves.

Phytochemical constituents	Remark
Alkaloid	+
Carbohydrate	+
Saponin	++
Reducing sugar	++
Steroid	+
Tannin	++
Glycoside	+
Protein	++
Flavonoid	+
Resin	+
Oil	++
Acid compound	-
Terpenoid	+++

$^{+++}$High concentration, $^{++}$Moderate concentration, $^{+}$Low concentration, $^{-}$Absent.

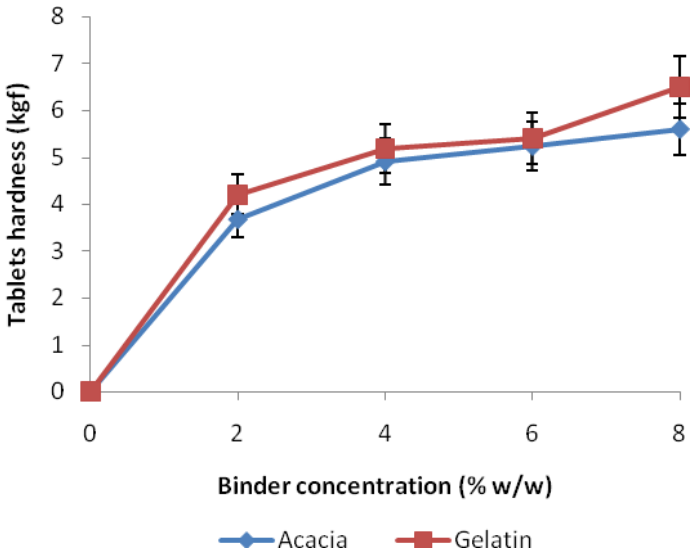

Figure 1. Effect of binder type and concentration on the hardness of tablets containing *C. citratus* leaves powder.

presence of very important phytochemicals at different concentrations in the leaves. Phytochemical screening of the plant leaves showed that the plant leaves contain alkaloids, carbohydrates, saponins, reducing sugars, steroids, tannins, glycosides, proteins, flavonoids, resins, oils and terpenoids. Acid compounds were however, not found in the plant leaves.

Conclusion

C. citratus leaves powder tablets were produced by wet granulation method using both acacia and gelatin, respectively, as binders. The properties of the tablets were affected by the binder type and concentration of the binder used in formulating the tablets. Increase in binder concentration caused an increase in hardness and disintegration time of tablets. The results obtained from the study showed that gelatin showed good properties for formulating *C. citratus* normal release tablets, while acacia (4, 6 and 8%) exhibited good properties for formulating sustained release *C. citratus* tablets.

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