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Investigation of the Suspending Properties of Dicerocaryum Zanguebarium and Adansonia Digitata Mucilage as Structured Vehicles

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Abstract: ***The suspending properties of Dicerocaryum zanguebarium and Adansonia digitata gum were evaluated at concentrations of (2.5, 5.0 and7.5%w/v) and (1.25 and 5.0%w/v) in calamine lotion suspension respectively. The physicochemical properties of the gums evaluated were sedimentation volume (F), viscosity, flow rate and compared with those of the suspension that had no suspending agent as a negative control. At all concentrations formulated, Dicerocaryum zanguebarium gum had the strongest suspending ability relative to the Adansonia digitata in calamine lotion. The viscosity of the suspension formulations ranged from 7.18-26.4 centipoise, which was a function of the concentration and type of suspending agent as well as the duration of storage of the suspension. Sedimentation volume, ease of redispersion and the flow rate of the formulations were characteristic of the suspending agent used and were influenced by the concentration of the agent. The profiles of calamine lotion suspension formulations containing Dicerocaryum zanguebarium were better than those of Adansonia digitata irrespective of the concentration of the suspending agent. Dicerocaryum zanguebarium gum could be a potential suspending agent in formulation of pharmaceutical suspensions and help prevent caking in the formulation.***

Keywords: Dicerocaryum zanguebarium, viscosity, flow rate, redispersion, sedimentation volume**.**

1. Introduction

A pharmaceutical suspension is a thermodynamically unstable system that can be stabilized by adding a suitable suspending agent.A number of plant gums have been used assuspending agent in suspension formulations [1].Suspending agents acts as stabilizers that reduces the rate of settling and permits easy redispersion of particulate matter in the suspension after settling. Physical stability of pharmaceutical suspensions is important to develop a product with consistent and reproducible dosage, predictable shelf life and batch to batch consistency [2]. It is important to evaluate the suspending properties of natural gums as they form good suspending agents used in pharmaceutical products like calamine lotion. The preferred rheological behaviour for pharmaceutical suspension is that of pseudo plastic along with thixotropic. The product thus becomes thick on standing. This prevents or reduces the settling of the particles and improves the product's elegancy and this is achieved by using a structured vehicle [3]. They are classified as inorganic materials, synthetic compounds and polysaccharides. Polysaccharide suspending agents include natural gums such as acacia.

The ideal suspending agent for should be readily and uniformly incorporated in the formulation , readily dissolved / dispersed in water , ensure the formation of a loosely packed system which does not cake ,be inert, non-toxic and free from incompatibilities[4]. Suspending properties for natural gums can be evaluated for sedimentation volume (%) (with and without electrolyte), rheology, redispersibility[5].

Natural gums are polymers that reduce the rate of settling and permits easy dispersion of particulate matter in the suspension after settling .They reduce interparticle attraction by forming films around the suspended particles. The use of natural gums in calamine lotion based formulations can improve their overall physical stability [6]. In this way they form structured vehicles useful for formulating deflocculated suspensions and are also useful as emulsifying agents, tablet binders, film-formers and thickeners in the pharmaceutical industry.

Two sources of natural gum in Zimbabwe are the leaves of *Dicerocaryum zanguebarium* (*ruredzo*) and *Adansonia digitata* (*muuyu*) which grow abundantly. This study investigated the suspending properties of the mucilage extract from both plants using their different concentrations and measuring their effect on rheological behavior and physical stability of calamine lotion based suspension.

2. Literature Survey

Ruredzo (Dicerocaryum zanguebarium) is well distributed throughout Zimbabwe. It is a prostrate perennial with annual creeping stems. The stems are almost hairless or somewhat pubescent. Leaves opposite, usually narrowly ovate in outline, up to 2.7 cm long, often more or less deeply pinnately lobed; margin coarsely crenate-serrate. Flowers solitary, axillary, very pale to deep pink or mauve, usually with darker spots on the lower lip and in the throat. Fruit broadly elliptic in outline, 16-27 mm long, hairless or slightly pubescent, with 2 erect spines on a distinctly raised upper surface. In Zimbabwe the leaves are cooked as a relish which

is called derere which is usually used as a side dish. The infusions of the leaves and roots in water will give a slimy material which was used in the past to bath children suffering from measles and also as soap. Plant form is inserted into the vagina to dilate the birth canal and help in the delivery of human and cows.

The purified mucilage extract from ruredzo has a molecular weight of 500,000 daltons and, after reduction of carboxyl groups, has been found to consist of galactose, xylose, arabinose, and mannose in the ration of 21:19:12:1the mucilage contains 8.1% uronic acids, 2% protein, and 7.6% ash [7].

The growth of the baobab tree (*Adansonia digitata*) is restricted to hot, dry woodland on stoney, well drained soils, in frost-free areas that receive low rainfall. Main stem of larger Baobab trees may reach up to 28 m in girth, although baobab trees seldom exceed a height of 25 m. The massive, usually squat cylindrical trunk gives rise to thick tapering branches resembling a root-system, which is why it has often been referred to as the upside-down tree looking like it has been picked out of the ground and stuffed back in upside-down. The stem is covered with a bark layer, which may be 50-100 mm thick. The bark is greyish brown and normally smooth but can often be variously folded and seamed from years of growth. The baobab is leafless for nine months of the year. The leaves are hand-sized and divided into 5-7 finger-like leaflets. Being deciduous, the leaves are dropped during the winter months and appear again in late spring or early summer. The large, pendulous flowers (up to 200 mm in diameter) are white and sweetly scented. They emerge in the late afternoon from large round buds on long drooping stalks from October to December. The flowers fall within 24 hours, turning brown and smelling quite unpleasant. The fruit is a large, egg-shaped capsule, covered with yellowish brown hairs. The fruit consists of a hard, woody outer shell with a dry, powdery substance inside that covers the hard, black, kidney-shaped seeds. This tree is slow growing, mainly due to the low rainfall it receives [8], [9].

The tree is named the small pharmacy. This is because every part of the tree has medicinal value.The tree has functions like it is an antimicrobial, analgesic, antipyretic, antioxidant and antiviral properties. The gum has been proved to be a good suspending agent in paracetamol in comparison to sodium carboxymethyl cellulose and tragacanth gum [10], [11].

The drink made from the white powdery substance soaked in water is also used to treat fevers and other complaints .The fruit pulp is used to treat fevers and diarrhea. In West Africa leaves and bark are used to treat diarrhea and have anti-inflammatory and are used to treat urinary disorders .Leaves are also used to treat fever ,reduce perspiration and as and astringent.

Calamine lotion is a topical suspension that contains zinc oxide and iron oxide as active ingredients. It is used as an antipruritic to treat sunburn, rashes, eczema, chicken pox and insect bites and stings. The problem of the calamine lotion is that when it cracks it cannot be redispersed.

3. Methods

Matured *ruredzo* and *muuyu* leaves were harvested from Bocha, Mutare end of January and sun dried for about 4-5 days. After drying the leaves, they were pounded using a mortar and pestle until they were in the powdered form separately.

Extraction of gum mucilage from Dicerocaryum zanguebarium (DZ) gum

The powdered form was weighed to 136 grams and soaked in 2.3 litres of hot boiling water. The dispersion was allowed to stand for 24 hours for the gum to be extracted. The mucilage was filtered through a muslin cloth and the mucilage was then precipitated with 96% ethanol using a volume ratio of 1:1 and filtered. Then the gum was ovendried at a temperature of 40oC until dry and the dried gum was pulverized using a mortar and pestle until it was in powdered form.The gum was then stored in airtight containers for use when required.

Extraction of Adansonia digitata (AD) gum

A mass of 80 grams of the powder was soaked in 1.4 litres of hot boiling water. The dispersion was allowed to stand for 24 hours for the gum to be extracted.The mucilage was filtered through a muslin cloth and the mucilage was then precipitated with absolute alcohol using a volume ratio of 1:1. The precipitate was then filtered and oven dried at 40oC until dry and the gum was pulverized using a mortar and pestle until a powder of the gum was formed and stored in airtight container.

Preparation of calamine lotion

Calamine 8gm
Zinc oxide 8 gm.
Methyl and propyl paraben 0.5 gm.
Glycerol 6 ml
Lime water quantity sufficient 100 ml

1) Calamine, zinc oxide,methyl and propyl paraben are mixed together till a homogenous powder was obtained using mortar and pestle.
2) the gum was added. Formulations with *Adansonia digitata* gum concentration of 1.25% and 5% w/v were done and 2.5%, 5% and 7.5% w/v *Dicerocaryum zanguebarium* gum were also made. A negative control was made without any gum.

For each formulation glycerol was poured little at a time using a 10mL measuring cylinder to the powder and triturated to form a smooth paste.

3) A small volume of lime water was added using a 150mL beaker till a smooth levigate was obtained.
4) The small levigate was diluted with small portions of lime water and then a larger volume of lime water added up to the volume.
5) The resulting suspension was then packed into a 100mL HDPE plastic bottle which was then labelled.

Determination of Suspending Properties

Sedimentation volume

Sedimentation volume was measured after two weeks .Samples from different concentration each of volume 50 mls were transferred into 50 mls measuring cylinder and were allowed to stand. The volume occupied by the solute in the cylinder below the supernatant was recorded every 30 minutes until no further change in the volume was noted in the samples within a period of two hours.

Viscosity measurement of suspension [12], [13]

The viscosity of suspension samples was determined using the A&D Vibro viscometer. The sample whose viscosity was to be determined was placed in the viscosity sample holder with a volume within the range of 35-45 mls and the results were recorded.

Flow rate of the suspensions

The flow rate was determined by measuring the time taken for each suspension sample to flow through a 20ml pipette and the results obtained were recorded. The procedure was done three times and average time calculated. The apparent flow rate was calculated using the formula below:

Flow rate = volume of pipette in mls/flow time in seconds

4. Results

Extraction results

In the first extraction 18 grams of *Dicerocaryum zanguebarium* produced 0.21 grams of the gum and 10 grams of *Adansonia digitata* produced 0.12 grams of the gum. Three extractions were then performed on the remaining 135.76 grams of *Dicerocaryumzanguebarium* leaves which produced 23.66 grams of the wet mass of the gum which yielded 4.92 grams dried mass. Three extractions were then performed on the remaining 74.39 grams of *Adansonia digitata* leaves which produced 17.62 grams of the wet mass of the gum which yielded 2.97 grams dried mass.

Table 1: Percentage yield for *Dicerocaryum zanguebarium* and *Adansonia digitata*

Gum	*Percentage yield wet mass*	*Percentage yield dry mass*
Dicerocaryum zanguebarium(DZ)	17.4	3.62
Adansonia digitata(AD)	23.7	3.99

Table 2: Calamine lotion formulation with different concentrations of Adansonia digitata (AD) gum

Excipient	Control	AD 2.5%w/v	AD 5%w/v
Calamine powder B.P.	8g	8g	8g
Zinc Oxide	8g	8g	8g
DZ gum	-	-	-
AD gum	-	3g	3g
Methyl paraben	0.25g	0.25g	0.25g
Propyl paraben	0.25g	0.25g	0.25g
Glycerol	6mL	6mL	6mL
Lime water QS	100mL	100mL	100mL

Table 3: Calamine lotion formulation with different concentrations of *Dicerocaryum zanguebarium (DZ)* gum

Excipient	DZ 2.5%w/v	DZ 5%w/v	DZ 7.5%w/v
Calamine powder B.P.	8g	8g	8g
Zinc Oxide	8g	8g	8g
DZ gum	-	-	-
AD gum	-	3g	3g
Methyl paraben	0.25g	0.25g	0.25g
Propyl paraben	0.25g	0.25g	0.25g
Glycerol	6mL	6mL	6mL
Lime water QS	100mL	100mL	100mL

Sedimentation volume results

Sedimentation volume is the ratio of the final or ultimate volume of sediment to the original volume of suspension before settling .It is calculated using the formula below:

$F = V_u / V_O$

Where,

V_u = final or ultimate volume of sediment.

V_O = original volume of suspension before settling.

Table 4: Sedimentation volume of the suspension after every thirty minutes for 2 hours

Formulation type	V_u at 30 minutes	$V_u$at60 minutes	$V_u$at90 minutes	V_u at 120 minutes
control	35	33	30	30
DZ 7.5%w/v	50	50	50	50
DZ 5%w/v	50	50	50	50
DZ 2.5%w/v	50	49	47	47
AD 1.25% w/v	34	32	32	32
AD 5%w/v	39	36	33	33

V_O= 50mL

Table 5: Sedimentation volume (F) values

Formulation type	**F value**
control	0.6
DZ 7.5%w/v	1
DZ 5%w/v	1
DZ 2.5%w/v	0.94
AD 1.25% w/v	0.64
AD 5%w/v	0.66

Viscosity of suspension

Table 6: Viscosity measurement of suspension

sample	**Viscosity (cp)**	**Temperature ^oC**
control	6.82	21.5
DC 7.5%	26.4	21.3
DC 5%	26.3	21.2
DC 2.5%	22.3	21.5
AD 1.25%	7.15	21.4
AD 5%	7.02	21.6

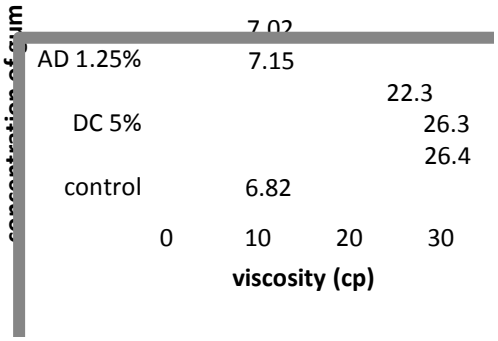

Figure 1: Viscosity of calamine lotion at different gum concentrations

Flow rate of the suspensions

It was calculated using the formula below

Flow rate = volume of pipette in mls/average flow time in seconds

Table 6: Calamine lotion flow rate

Sample	*Time taken 1*	*Time taken 2*	*Time taken 3*	*Average time*	*Flow rate mls/sec*
control	9.10	9.02	9.05	9.05	2.21
DC 7.5%w/v	14.98	14.24	14.33	14.52	1.33
DC 5%w/v	13.31	13.56	12.88	13.25	1.51
DC 2.5%w/v	11.91	12.38	12.10	12.13	1.65
AD 1.25%w/v	10.66	10.86	10.92	10.81	1.85
AD 5%w/v	10.98	10.34	10.44	10.58	1.59

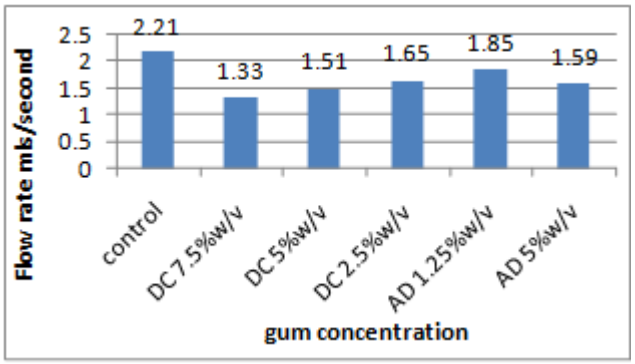

Figure 2: Flow rate of calamine lotion at different gum concentrations

5. Discussion

Dicerocaryum zanguebarium gum can be easily dispersed and dissolved in water which is a common vehicle for liquid dosage forms. It is readily and uniformly incorporated in the formulation and ensures the formation of a loosely packed system which does not cake and inert and not-toxic this makes it advantageous for use as a suspending agent. *Adansonia digitata* gum was less soluble in water and this resulted in green colouring of the calamine lotion as the concentration of gum was increased.

Sedimentation volume (F) can have values ranging from less than 1 to greater than1 in practice it is usually found to be less than 1.When F= 1 it means the product is in flocculation equilibrium and shows no clear supernatant. i.e. it shows great stability and is less likely to cake. Suspensions with F =1 are elegant and pharmaceutically acceptable [12], [13]. This was observed with suspensions that were suspended with *Dicerocaryum zanguebarium* gum.

The F value decreased with number of days of storage for both control and calamine suspended with *Adansonia digitata* while for the calamine lotion suspended with *Dicerocaryum zanguebarium* gum, the F value was constant up to two weeks after manufacturing for the 2.5%w/v which had a slight decrease. As for the other 5.0 and 7.5%w/v the sedimentation volume did not change.

The viscosity of calamine lotion is changed by the addition of structured vehicles which also act as thickening agents. According to Stokes law he increase in viscosity of a suspension results in the rate of sedimentation of the insoluble solid being slower. Viscosity increased with concentration of suspending agent for *Dicerocaryum zanguebarium* gum containing suspending agent. Suspension containing *Dicerocaryum zanguebarium* gum was found to be more viscous than suspension containing *Adansonia digitata* at similar gum concentrations.

Calamine lotion thickened on addition of suspending agent and reduced flow rate out of the pipette as compared to the negative control. This was related to the viscosity of the suspension at different gum concentration, increasing viscosity reduced the flow rate.

6. Conclusion

Calamine lotion was formulated with *Adansonia digitata* gum concentration of 1.25%w/v and 5%w/v, *Dicerocaryum zanguebarium* gum at concentration 2.5%w/v, 5%w/v, 7.5%w/v respectively. The formulations were evaluated for their physicochemical suspending properties which included sedimentation volume, viscosity, flow rate and yield value of the natural gums used. The *Dicerocaryum zanguebarium* gum showed better suspending properties in calamine lotion than *Adansonia digitata* gum at 5%w/v concentration but increasing *Dicerocaryum zanguebarium* gum concentration to 7.5%w/v did not significantly improve the suspending properties or change the viscosity of the suspension. The flow rate decreased with increasing viscosity which is important to optimize the ideal gum concentration for calamine lotion which will allow ease of pouring out and thickening on storage. In view of these properties, gum of *Dicerocaryum zanguebarium* gum can be employed as stabilizer and thickener of choice when high viscosity is desired especially in cosmetic, pharmaceutical and food industries. *Dicerocaryum zanguebarium* gum can be employed as a suspending agent because it can be easily dispersed /dissolved in water .It is readily and uniformly incorporated in the formulation and ensure the formation of a loosely packed system which does not easily cake.

References

[1] Senthil, V, and D Sripreethi. “Formulation and Evaluation of Paracetamol Suspension from Trigonella Foenum Graecum Mucilage,” Journal of Advanced

Pharmacy Education & Research, 2011; 5, no. 1: 225–33.
[2] Reichel Charles D. "Rapid Quantitative Physical Stability Development For Pharmaceutical Suspensions". Pfizer Global Research and Development, Groton/New London Laboratories, Pfizer Inc, Groton, CT 06340. Accessed on "18 April 2014. http://www.pfizer.com/stabilitydevelopmentforsuspensions/poster/pdf.
[3] M.E. Aulton. Pharmaceutics the Science of Dosage Form and Design, 2nd Edn, Churchill-Livingstone publisher: 334-336, 2002.
[4] D. Attwood and A.T. Florence. Fast track Physical Pharmacy, Pharmaceutical Press: 63-75, 2008.
[5] Gebresamuel N., Gebre-Mariam T. "Evaluation of the suspending properties of two local Opuntia spp. mucilages on paracetamol suspension," Pak J Pharm Sci, 2013; 26(1):23-9.
[6] Al-Achi A., Greenwood R., Akin-Isijola A., Bullard J. "Calamine Lotion: Experimenting with a New Suspending Agent," Int J Pharm Compd, 1999 Nov-Dec; 3(6):490-492.
[7] Marume M., Benhura M.A.N. "Emulsifying properties of the mucilage extracted from Ruredzo (*Dicerocaryum zanguebarium*)," Biosci. Biotech. Biochem., 1993 57 (12).
[8] Esterhuyse N., Von Breitenbach J. Sohnge H, 2001, Remarkable trees of South Africa.
[9] Orwa C, Mutua A, Kindt R, Jamnadass R, Simons A. 2009. Agroforestree Database:a tree reference and selection guide version 4.0 (http://www.worldagroforestry.org/af/treedb/)
[10] Ogaji I J, Omachi A .J, Iranloye A. T. "Effect of Adansonia digitata Gum on Some Physicochemical Properties of Paracetamol Pediatric Suspension Formulations," IJRPS 2012; 2(2), 75-83.
[11] FAO Corporate Document Repositoroy, Indigenous multipurpose tree of Tanzania, http://www.fao.org/docrep/x5327e/x5327e0g.htm#, 31 October 2013
[12] Femi-Oyewo M N, Adedokun M O, Olusoga T O, ."Evaluation of suspending properties of Albizia zygia gum on sulphadimidine," Trop. J. Res. 2004; (3): 279-284.
[13] Senthil V, Suresh, Kumar, Nagasamy ,Venkatesh D. "Formulation And Evaluation of the Suspending Properties of Natural Suspending Agent on Paracetamol Suspension," Research J. Pharm. and Tech, 2009; 2 (4): 719-722.

Author Profile

Tapiwa Manyarara received the Bachelor of Pharmacy Honours degree in 2009 with the University of Zimbabwe and is currently doing his MPhil in Medicine with the same institution. Mr Manyarara is currently in the final year for the MPhil program and is specializing in the use of nanotechnology and natural polymers to improve pharmaceutical formulations. He is a member of the Pharmaceutical Society of Zimbabwe and Standards Association of Zimbabwe technical committee on cosmetics. Mr. Manyarara lectures at the Harare Institute of Technology in pharmaceutical formulation technology and nanopharmacy disciplines.

Joey Chifamba is a listed Zimbabwean Manufacturing and formulation development expert with unique and extensive combinations of both industrial manufacturing and Academic experience both locally and internationally. Chifamba is a chartered Industrial Chemist and Certified Supply chain and Quality Auditor with various Graduate and Post Graduate qualifications including Applied Chemistry, Quality Auditing, and Supply chain Management, Business administration and is currently studying towards a D.Phil. in Medicine (Nano Pharmaceutics). Chifamba lectures in Pharmaceutics at the Harare Institute of Technology and has been a consultant in cosmeceutics for over 10 years for the University of Zimbabwe, School of Pharmacy. He has carried out wide consultancy work both locally and internationally in formulation development and manufacturing bench marking.

Precious Derera is a final year student doing Bachelor of Pharmacy Honours degree at Harare Institute of Technology. Interests of her research are to encourage the use of natural gums which are found in indigenous plants as suspending agents.