EVALUATION OF *CHRYSOPHYLLUM ABIDUM* GUM EXTRACT AS A SUSPENDING AGENT IN THE FORMULATION OF MIST MAGNESIUM TRISILICATE MIXTURE

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A PROJECT SUBMITTED TO THE DEPARTMENT OF PHARMACEUTICS AND PHARMACEUTICAL TECHNOLOGY IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF DOCTOR OF PHARMACY (PHARM.D) DEGREE OF FACULTY OF PHARMACY, UNIVERSITY OF BENIN, BENIN CITY, NIGERIA.

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CERTIFICATION

This is to certify that this project work "Evaluation of *Chrysophyllum albidum* gum extract as a suspending agent in the formulation of mist magnesium trisilicate mixture" was carried out by **ELOGHOSA NANCY IGBINEDION** with matriculation number **PHA1707050**, in the Department of Pharmaceutics and Pharmaceutical Technology, University of Benin, Benin City, Edo state, Nigeria.

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CERTIFICATION OF THESIS ON PLAGIARISM

We the undersigned attest and declare that the thesis of **ELOGHOSA NANCY IGBINEDION** Titled: **"EVALUATION OF *CHRYSOPHYLLUM ABIDUM* GUM EXTRACT AS A SUSPENDING AGENT IN THE FORMULATION OF MIST MAGNESIUM TRISILICATE MIXTURE"** has successfully passed the anti-plagiarism test and does not violate any copy right regulations.

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DEDICATION

I dedicate this project to God Almighty, to my father Mr. Igbinedion Godwin and also to myself for taking this path in this pharmacy journey.

ACKNOWLEDGEMENT

My sincerest and utmost gratitude goes to God almighty for his unfailing and unending love and faithfulness towards me and to my loving parents Mr Godwin and Mrs Rachael Igbinedion who have been there since the very beginning to this very day. I love you both.

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ABSTRACT

PURPOSE: A dispersion containing indispersible solids undergo rapid sedimentation and this makes it difficult to withdraw uniform and consistent dosing.

Aim: Hence the aim of this study is to evaluate the gum extracted from *Chrysophyllum albidum* fruit as a suspending agent in the formulation of magnesium trisilicate and light magnesium carbonate suspension in comparison with acacia gum as a standard.

Methods: The gum was extracted from the pulp of *Chrysophyllum albidum* fruit by precipitation with methanol and dried into powder form at room temperature for 3 days. The resulting powdered gum was subjected to physiochemical characterization and its organoleptic properties. Varying concentration (5-20%w/v) of the gum were employed in the formulation of mist magnesium trisilicate and carbonate suspension respectively and the resulting suspension were evaluated for sedimentation rates, flow rate and redispersibility index over seven days of storage respectively.

Results: The viscosity indices obtained for gums were 9.38-50.33 (*C.albidum*) and 6.12-39.50 (*A.senegal*) at varying concentration 5-20%w/v respectively. Viscosity of the suspension were concentration dependent; an increase in concentration lead to corresponding increase in viscosity. The suspension displayed a decrease in sedimentation rate with increase in concentration of the gum and this is in tandem with stokes law. The results of the flow rate of freshly made suspension showed a corresponding decrease in flow rate as gum concentration increased 1.25-0.08ml/s (*C.albidum*) and 1.67-0.10ml/s, (*A.senegal*) and this affect was more marked with *C.albidum.* Both gums displayed similar redispersibility indices and again this was concentration dependent.

Conclusion: The study showed that the gum obtained from *Chrysophyllum albidum* compares favourably with *Acacia* gum as a suspending agents in the formulation of pharmaceutical dispersion and hence they can be substituted as suspending agents in pharmaceutical suspension. From the study, research should be carried out on improved and a better method for the extraction of gum from *Chrysophyllum albidum* fruits.

CHAPTER ONE

INTRODUCTION

1.1 Preamble

Drugs which are preparations used to treat or prevent illnesses, are rarely given on their own. Instead, they are given as a component of a formulation along with one or more non-medical agents that perform a variety of specialized pharmaceutical functions. These non-medical agents, also known as pharmaceutical excipients, are used selectively to produce a range of dosage forms. Excipients are being used in unique dosage forms to perform specialized functions, thanks to advancements in drug delivery technology. To satisfy the demands of these drug delivery systems, new and improved excipients are constantly being created. (Raymond C.R, Paul J.S, Sian CO., 2006). Pharmaceutical excipients create an effective and aesthetically pleasing dosage form for therapeutic substances by solubilizing, suspending, thickening, diluting, emulsifying, stabilizing, preserving color, and flavoring it. (Allen L.V, Popovich N.G, Ansel H.C , 2011).

1.2 PHARMACEUTICAL EXCIPIENTS

A variety of definitions exist for excipients, such as inert materials utilized as medication diluents and carriers. The excipients in a medicine can vary between brands, particularly in terms of colorants and preservatives. Pharmaceutical excipients are materials added to pharmaceutical dosage forms for reasons other than their direct therapeutic activity, such as to facilitate manufacture, preserve, support, or improve stability, or increase bioavailability or patient acceptability. Additionally, they could improve the product's general safety or functionality while it's being used or stored, as well as help with product identification. (Martindale, 2011). According to international pharmacopoeias, excipients are utilized for a very broad range of

reasons. Many excipients have multiple uses, which can be advantageous since it minimizes the chance of excipient interactions and lowers the amount of excipients required. The most commonly utilized dose form is a tablet. Their production can be a complicated procedure that calls for a great deal of creativity and formulation knowledge to create a product that will hold up well in handling, storage, and transportation while releasing its active pharmacological ingredient as needed after consumption (Armstrong NA, J Boylan JC,2006).This is accomplished by using a variety of excipients. (Table 1), (Martindale, 2011).

1.3 CLASSIFICATION OF EXCIPIENTS

Excipients can be categorized as follows: Based on their place of origin, how they are used in dosage forms, and the roles they play:

(A) **Excipient based on their origin**

Animal source: - Lactose, Gelatin, Stearic acid, Bees wax, Honey, Musk, Lanolin etc.

Vegetable source: - Starch, Peppermint, Turmeric, Guar gum, Arginates, Acacia etc.

Mineral source: - Calcium phosphate, Silica, Talc, Calamine, Asbestos, Kaolin, Paraffin, etc.

Synthetic: - Boric acid, Saccharin, Lactic acid, Polyethylene glycols, Polysorbates, Povidone etc. (Giorgio Pifferi, Patrizia Restani, 2003).

(B) **Classification of excipients based on their functions**:

Excipients are categorized according to the functions they carry out, such as: - Different excipients used in solid dosage forms carry out different functions, such as: - Binders, diluents, lubricants, disintegrating agents, plasticizers, etc. For example, 5% starch acts as a binder for tablet formulations when used in dry form, but it can also act as a disintegrant when used in dry form.

Solvents, co-solvents, buffers, anti-microbial agents, emulsifying agents, sweetening agents, flavors, etc. are examples of excipients used in liquid dosage forms. Certain excipients are categorized as having the following medicinal values: Anesthetics: chloroform, etc. Laxatives: guar gum, xanthan gum, bentonite, psyllium, etc. Modifiers of pH: - citric acid. Astringent: zinc sulfate, cinnamon, and alum. Cinnamon, dill water, and anise water are carminatives. Sources of nutrients: agar, lactose, etc.

TABLE 1.1 COMMON EXCIPIENTS USED IN TABLETS (Martindale, 2011).

Excipient	Functions	Examples
Diluents	Provide bulk and enable accurate dosing of potent ingredients	Sugar compounds e.g. lactose, dextrin, glucose, sucrose, sorbitol Inorganic compounds e.g. silicates, calcium and magnesium salts, sodium or potassium chloride
Binders, compression aids, granulating agents	Bind the tablet ingredients together giving form and mechanical strength	Mainly natural or synthetic polymers e.g. starches, sugars, sugar alcohols and cellulose derivatives
Disintegrants	Aid dispersion of the tablet in the gastrointestinal tract, releasing the active ingredient and increasing the surface area for dissolution	Compounds which swell or dissolve in water e.g. starch, cellulose derivatives and alginates, crospovidone
Glidants	Improve the flow of powders during tablet manufacturing by reducing friction and adhesion between particles. Also used as anti-caking agents	Colloidal anhydrous silicon and other silica compounds
Lubricants	Similar action to glidants, however, they may slow disintegration and dissolution. The properties of glidants and lubricants differ, although some compounds, such as starch and talc, have both actions	Stearic acid and its salts (e.g. magnesium stearate)
Tablet coatings and films	Protect tablet from the environment (air, light and moisture), increase the mechanical strength, mask taste and smell, aid swallowing, assist in product identification. Can be used to	Sugar (sucrose) has now been replaced by film coating using natural or synthetic polymers. Polymers that are insoluble in acid, e.g. cellulose acetate phthalate, are used for enteric coatings

	modify release of the active ingredient. May contain flavours and colourings.	to delay release of the active ingredient.
Colouring agents	Improve acceptability to patients, aid identification and prevent counterfeiting. Increase stability of light sensitive drugs.	Mainly synthetic dyes and natural colours. Compounds that are themselves natural pigments of food may also be used.

1.4 QUALITIES OF AN EXCIPIENTS

The following are an excipient's ideal qualities: An excipient must be:

- Chemically stable
- Non-reactive
- Low equipment and process sensitive
- Inert to human body
- Non toxic
- Acceptable with regards to organoleptic characteristics
- Economical
- Having efficiency in regards with the intended use.

Excipients have a tendency to react with medication components, other excipients, and the packaging system, despite being thought of as innocuous substances. Excipients may also contain a variety of contaminants that could cause the formulation's active medicinal components to break down, affecting the formulation's shelf life.

The numerous interactions that an excipient may experience are referred as

- Drug-Excipient interactions
- Excipient-Excipient interactions
- Package-Excipient interactions

Below is a detailed discussion of these interactions.

1.5 DRUG – EXCIPIENT INTERACTION

The excipients, which are present in higher quantities, come into close contact with the active medicinal components in pharmaceutical dosage forms. Drug-excipient interactions can result from specific incompatibility between excipients and medicines. Excipients modify the physicochemical properties of the active medicinal substance, which could accelerate chemical breakdown or result in the creation of molecular complexes (Md Zaki Ahmad, *et al*.,2010). Interactions between drug excipients are further divided into:

- Physical interactions
- Chemical interactions
- Biopharmaceutical interactions

Physical interactions: Physical interactions change dose uniformity, rate of disintegration, etc. Because physical interactions do not result in chemical alterations, the formulation's constituent parts are able to maintain their molecular structure. It's challenging to identify physical interactions. Depending on how the product is used, physical contact might either improve or worsen its performance. (Md Zaki Ahmad, *et al*., 2010).

Chemical interactions: Stable compounds are created when excipients and active medicinal components react. Numerous drug–excipient interactions involving chemicals have been documented. Chemical interactions should generally be avoided since they generally have a negative impact on the formulation. (Md Zaki Ahmad, *et al*., 2010).

Biopharmaceutical interactions: These are the interactions that are seen following drug administration. Medicine and bodily fluids interact inside the body to affect the rate of absorption. When excipients are given with active medicinal components, they all interact physiologically. The following are a few instances of biopharmaceutical interactions. (Md Zaki Ahmad, *et al*., 2010).

(a) **Premature breakdown of enteric coat**: Enteric coating polymers, such as cellulose acetate phthalate and hydroxyl propyl cellulose acetate phthalate, are more soluble at basic pH levels. However, antacids raise stomach pH levels, which causes the enteric coat to break down and the active pharmaceutical ingredient to be released into the stomach, which in turn causes drug degradation in the stomach. Gastric bleeding is one of the negative effects of NSAIDs, which can promote early disintegration of the enteric coat.

(b) **Interactions due to adjunct therapy**: In many formulations, tetracycline antibiotics generate complexes with calcium and magnesium ions, which are frequently used as excipients. These complexes are not absorbed from the gastrointestinal tract when used in conjunction with tetracycline as adjunct therapy. (D.D Wireth *et.al.,*1998).

(c) **Increase in gastrointestinal motility**: A number of excipients, such as sorbital and xylitol, have the propensity to stimulate gastrointestinal motility, which shortens the time that medications like metoprolol can be absorbed. Polyethylene glycol 400 also affects the absorption of ranitidine.

1.6 EXCIPIENT –EXCIPIENT INTERACTION

Excipient-to-excipient interactions are crucial in establishing the stability of dosage forms, even though they are extremely uncommon. While certain interactions are employed in formulations to achieve the desired product qualities, other interactions between excipients may not be acceptable. Such interactions take place between different excipients. To achieve the intended result in the product, certain excipients are prepared as mixtures; for example, the interaction between the excipient and the other excipient helps to improve the formulation's functional capabilities. These excipients fall under the category of coprocessed excipients. (Raymond C Rowe, Paul J Sheskey and Paul J Weller,2003).

Co-processed excipients: Due to its precise dosing and improved patient compliance, tablets are typically thought of as the dosage form of choice when the oral route is desired. In the process of making tablets, excipients like binders, disintegrants, diluents, glidants, lubricants, etc. are added to the active pharmaceutical ingredient. These excipients help the active pharmaceutical ingredient in the tablet dissolve more easily and absorb more readily. Since certain excipients don't produce the intended results, modified excipients with improved qualities are created. (Soujanya, B., Priya, G.P. and Murthy, T.E.G.K., 2015). The introduction of high speed tablet machines and direct compression techniques pose several challenges to the tablet manufacturing process. One novel concept that has been introduced is co-processing, which modifies the functionality of excipients by retaining advantageous attributes and supplementing with newer ones by processing parent excipient with another excipient. The high functionality excipients so formed help improve process ability such as flow properties, compressibility, and improved disintegration and dissolution profiles (M.C Gohel, 2005). Because of their multifunctional

qualities, co-processed excipients help to solve issues. Coprocessing hides the unfavorable characteristics of particular excipients while simultaneously improving functioning. The goal of co-processing is to enhance flow characteristics, compressibility, disintegration potential, and filler-binder combination development.

1.7 PACKAGE –EXCIPIENTS INTERACTIONS

Pharmaceutical packaging is an integral part of the formulation process, so in the pharmaceutical industry, it is crucial that the package chosen appropriately maintains the integrity of the products. Choosing the right package, therefore, starts with identifying the product's physical and chemical characteristics, its needs for protection, and its marketing requirements. (Dennis Jenke, 2007). The chosen package ought to possess inert qualities and shield the product from external environmental factors, among other considerations. Glass is typically used for packaging; however, plastic, metal, rubber closures, and other materials can react negatively with both the drug product and the excipient, changing the stability of the product. Product quality is typically lost as a result of these interactions. (Gonyon.T. *et.al*.,2008).

1.8 PHARMACEUTICAL APPLICATIONS OF GUMS

Gums have significant cohesive and adhesive qualities, which are utilized in the manufacture of pharmaceuticals, due to their complex, branching polymeric structure. Therefore, gums are used in pharmacy in a variety of ways. They are components of bulk laxatives, dental adhesives, and other adhesives. These polymers can be used as a stabilizer, sustain agent in tablets, disintegrating agent, emulsifier, gelling agent, protective colloids in suspension, and binder for tablets. They serve as an adjuvant in certain drug preparations. (Jani GK, Shah DP,*et al*., 2009).

(i) Application of gums in tablets formulation

Due to their sticky nature, gums are used as a binder in tablet formation. They turn the powder mass into granules and give it cohesiveness. They can also be utilized as tablet disintegrates. The gums' tendency to dissolve because they absorb water and swell. They have the capacity to inflate up to five times their initial volume. This swelling causes the tablets to split up into tiny pieces, which accelerates the rate of breakdown.

(ii) Gums as emulsifying and suspending agent

Gums serve as suspending and emulsifying agents. Through interfacial absorption and the consequent formation of a condensed layer with a high tensile strength that resists droplet coalescence, they successfully stabilize the emulsion. By building a robust multimolecular film around each oil globule, they stabilize the oil/water emulsion and slow down the process of coalescence by creating a hydrophilic barrier between the oil and water phases. By hydrogen bonding and molecular interaction, natural gums make the hydration layer surrounding the suspended particle more hydrated. The interfacial tension and surface tension are optimal when the wetting agent is present because this agent does not lessen them. They serve as protective and thickening colloids as well. Hydrophilic colloids found in natural gums create a dispersion with water and raise the viscosity of the continuous phase, so that solid particle suspended in it sufficient for long time to measure the uniform dose e.g. Cordia gharaf Gum. (Doharey.V, Sharma N.*et al*.,2010).

(iii) Gums as sustaining materials in dosage form

Gums can be used to prolong the release of the medication. They have been incorporated into tablets, suspensions, and matrix systems to maintain drug release. When this polymer comes into contact with water, it hydrates and forms a gel. The drug release from this gel is often controlled

by diffusion, meaning that the release is sustained over an extended length of time. Examples of this include guar gums, xanthenes gums, and karaya gums. (Jian S, Yadav SK,*et al*., 2008).

(iv) Gums as coating agent.

Numerous gums function as coating agents, which can maintain drug release or shield the medication from deteriorating in the stomach. As the number of coatings increases, drug release decreases, for example. Grewia Gum. (Ogaji IJ, Okafor IS,*et al.,* 2013).

(v) Application of gums in microencapsulation

Due to their capacity to coat, gums are used in the microencapsulation of drug particles to prolong the release of the drug. Gums from Acacia nilotica delile, *Acaica senegal* wild, and amizo gum have had their microcapsulating qualities investigated through the use of spray drying. Gum Kondagogu, Guar Guar, and Gum Xanthan are three examples of the microcapsulating agents that A. nilotica is said to be superior than. (Mankala SK, Nagamalli NK,*et al.,* 2011)

(vi) Application of gums as gelling agent

Gums can combine with other substances or create a gel on their own. The process of gelling involves multiple intra- and intermolecular associations that create a three-dimensional network that traps water molecules. These associations can be caused by chemical treatments (adding the appropriate reagent) or physical treatments (changing temperature and pH). The mechanism of gelatin in acidic polysaccharides, like pectin, is different. As a result of the macromolecular chain's widespread hydrogen bonding, junction zones have developed between the chain's

hydrogen-bonded segments. The interaction of alginic acid with calcium ions results in the creation of gel. Galactomannan and carrageenan work together harmoniously to generate an elastic gel, such as locust bean gum. (Dionísio M and Grenha A,*et al*., 2012)**.**

1.9 SUSPENSION

A suspension is a dispersion or dispersed system in which insoluble solid particles (the internal or suspended phase) is dispersed uniformly throughout the other known as the external phase (or called the suspending medium or the vehicle). For oral preparations, external phase vehicles are typically aqueous in nature; for non-oral preparations, organic and oily liquids are utilized. Due to stability concerns, many suspensions are now sold as powders that are suspended into a predetermined volume of vehicle just prior to use. (Howard CA *et al.,* 1981). Ideal suspensions must have insoluble particles evenly distributed throughout. In a standing condition, the solid particles separate as sediments from the liquid. Typically, while shaking the system, the volume of sediment should be equally re-dispersed. Agents that improve viscosity can help to reduce the settling rate. Smaller suspended particles are better for creating a smooth and beautiful finished product so avoid using rough textures. (Martin A*,* 2001). Particle sizes in suspensions used for ophthalmic purposes must not be larger than 10 μm; if they are, the patient would experience pain and discomfort during administration. The suspension utilized in the parenteral method needs to have tiny particles that are easily able to pass through the syringe needle. (Shamlou P.A, 2016).

1.9.1 TYPES OF SUSPENSION

(i) According to route of suspension

Oral suspension: Since these suspensions are administered orally, they include flavors and sweeteners to cover up the harsh taste of the medication. (Aulton ME, Taylor K.*et al*., 2013).

Topical suspensions: Since they are applied to the body's exterior, they must be devoid of any kind of grit to prevent skin irritation. (Krishna R, Yu L*, et al.,* 2007).

Parenteral suspensions: Since these solutions are to be given intravenously or intramuscularly via parenteral routes, they must be sterile and devoid of extraneous particles. (Habib MJ, Mesue .R *et al.,* 1995).

Ophthalmic suspension: Because ophthalmic solutions are used to treat eye disorders, they should also be devoid of foreign particles and sterile. (Tykhonov OI, Yarnykh TH.*et al*.,2016)

(ii) On proportion of solid particles

Dilute suspension: Solid particle concentrations in diluted suspensions range from 2% to 10% w/v.

Concentrated suspensions: In concentrated suspension the number of solid particles are in concentration about 50% w/v. (Liquid Medicinal Forms. On the materials of the foreign press. Pharm Branch. 2017; 3:26-37).

(iii) On the basis of particles size of solid

Colloidal suspension: size of particle < 1 micron.

Coarse suspension: size of particle >1 micron

Nano suspension: particle size is 10 ng.

(iv) According to the nature of dispersed phase and method of preparation

• Suspension containing diffusible solids

• Suspensions containing in diffusible solid

• Pooling wettable solids

• Precipitate forming liquids

(v) According to the nature of sedimentation rate

Flocculated suspensions. The dispersed phase in a flocculated solution created clusters and a network-like structure of solid particles in the medium. There is no firm cake formed by these clusters. Their size causes them to settle down quickly, which raises the pace of sedimentation. Sediment is readily re-dispersible and loosely bonded in flocculated suspension. It must be carefully considered that the flocculation must be formulated in a regulated manner in order to achieve a balance between the pace of sedimentation and the type of sediment created. (Georgievskii VP, Konev FA.*et al.,* 1996). The formation of flocs, or loose aggregates, in flocculated suspension can accelerate sedimentation because the size of the sedimenting particles will grow. Consequently, flocculated suspensions settle more quickly. In this case, the porosity of the flocs as well as their size affect the sedimentation process. (Manimaran.V, 2022).

Non-flocculated suspension. The solid particles are dispersed differently in the dispersion medium of non-flocculating suspensions. These parts are baked as a solid cake. Because the sedimentation rate is low and the solid particles settle slowly, a hard cake forms that is difficult to re-disperse. (Kulshreshtha AK, Singh ON, *et al.,* 2009). The slow sedimentation rate hinders the entrapment of liquid medium, making agitation-induced re-dispersal challenging. This is known as "claying" or "caking." Larger particles settle quickly in a deflocculated suspension, whereas smaller particles stay in the liquid supernatant, giving the supernatant its hazy appearance. (Manimaran.V, 2022).

Advantages of Suspension

• Duration of drug and onset of drug can be controlled.

• It masks the bitter taste of drugs example chloramphenicol.

• In the comparison of other doses form suspension have higher rate of bioavailability. Order of bioavailability is as follow: solution >suspension >capsule >compressed tablets >coated tablet.

• Chemical stability of some drugs can improve by making suspension E.g., penicillin G.

• Efficient in intramuscular depot therapy.

• Use of co-solvents can be avoided.

• Easy to swallow for elder patients. (Dash A, Singh S, editors. Pharmaceutics: basic principles and application to pharmacy practice. Academic Press; 2013)

Disadvantages of suspension

• Difficulties in formulating the formulation.

• During handling and transportation sufficient care is required.

• Sedimentation and stability can cause problems.

• Chances of non-uniformity and non-accuracy of dose

1.9.2 APPLICATIONS OF SUSPENSION

• People who have difficulty in swallowing of solid dosage forms like tablets can be takes oral suspensions easily.

• The absorption rate of drug from gastrointestinal tract is quicker in suspension because drug is delivered in finely divided form.

• Drugs which have low solubility can be formulated in suspension.

• Some drugs which are unstable in aqueous vehicle for long period are marketed in the form of powder, so that suspension can be prepare at the time of administration.

• Contrast media use for the diagnosis purpose is also given in the form of suspension. E.g., barium sulphate for examination of alimentary canal. (Dalal PS, Narurkar MM.*et al.,* 1991).

1.9.3 FEATURES DESIRED IN A PHARMACEUTICAL SUSPENSION

A considerable degree of shaking is required to easily resuspend the sediment that is created and prevent the suspended particles from settling too quickly.

It should be smooth and easy to pour without being too watery or gritty.

It ought to possess a pleasant taste, color, and aroma.

Excellent syringe ability. ·

Stable in terms of chemistry, physics, and microbiology.

Sterilization should be possible for parenteral/ophthalmic suspension.

1.9.4 SOME THEORETIC CONSIDERATIONS OF SUSPENSION:

- Particle size control.
- Wetting
- Sedimentation

- Brownian movement
- Electro kinetic
- Aggregation
- Thixotropic suspension

Particle size control:

Any suspension's particle size is crucial and needs to be kept within a certain range. Particles that are excessively big or tiny have to be avoided. Larger particles will settle more quickly at the bottom of the container particles larger than 5 um give the product a grainy texture and irritate the eye if injected or implanted and particles larger than 25 um may obstruct the needle. A hard cake at the bottom of the container can quickly form from too fine particles (Manimaran.V, 2022).

Wetting of particles

Water readily wets hydrophilic materials (talc, ZnO, Mg 2CO3) but hydrophobic materials (charcoal, sulfur) are not easily wetted because of the layer of adsorbed air on their surface. As a result, until the air layer is entirely displaced, the particles even those with a high density float on the liquid's surface. By using a wetting agent, the air on the surface can be removed and the vehicle can enter the pores more easily. Non-polar liquids, however, can readily moisten hydrophobic surfaces**.** (Manimaran.V, 2022).

1.9.5 SEDIMENTATION

Sedimentation is the process by which particles or floccules settle in liquid dosage forms due to gravity. Sedimentation Parameters include

Sedimentation volume (F) or height (H) for flocculated suspensions: Sedimentation volume is a ratio of the ultimate volume of sediment (Vu) to the original volume of sediment (VO) before settling. (Manimaran.V, 2022).

F = V u / VO

Where,

Vu = final or ultimate volume of sediment

VO = original volume of suspension before settling

The values of F vary from less than one to more than one.

When F < 1 Vu < Vo

When Vu=Vo and F=1

There is no discernible supernatant when the system is in flocculated equilibrium.

F > 1, Vu > Vu

The network of flocs created in the suspension and the resulting loose, fluffy particles cause the sediment volume to exceed its initial volume.

Degree of flocculation (β): This refers to the proportion of the flocculated suspension's sedimentation volume (F) to the deflocculated suspension's sedimentation volume, F ∞

ß = F / F ∞

$$ß = \frac{\left(\frac{Vu}{Vo}\right) flocculated}{\left(\frac{Vu}{Vo}\right) deflocculated}$$

When the sedimentation volume of the flocculated suspension is equal to the sedimentation volume of the deflocculated suspension, the minimal value of ß is 1. (Manimaran.V, 2022).

Brownian Movement

By allowing the scattered material to flow randomly, Brownian motion of particles prevents sedimentation. Brownian motion is dependent on the dispersed phase's density as well as the dispersion medium's density and viscosity. Particles that are smaller than the critical radius (r) will remain suspended due to the kinetic bombardment of the particles by the suspending medium's molecules When the particle size is between 2 and 5 mm, or when the particle density and medium viscosity are both suitable, Brownian movement can be seen,(Manimaran.V, 2022).

Electro kinetic Properties

Zeta Potential: The difference in potential between the solution's electro-neutral area and the surface of the firmly bonded layer (shear plane) is known as the zeta potential. As the distance from the surface increases, the potential first decreases quickly before becoming less steep. This occurs as a result of the counter ions near the surface acting as a screen to lessen the electrostatic attraction between the charged surface and the counter ions farther away. The stability of systems with distributed particles can benefit from the practical application of zeta potential. Since this potential controls the strength of repulsion between the nearby, similarly charged, widely distributed particles rather than the Nernst potential. When the zeta potential falls below a particular threshold, the particles gather together because the attractive forces outweigh the repulsive forces. This is referred to as flocculation,(Manimaran.V, 2022).

Thixotropic suspension

A thixotropic suspension is one that, when shaken, becomes fluid instead of viscous during storage. A properly prepared thixotropic suspension would hold its fluidity for a considerable amount of time, allowing for convenient dosage administration, but it would quickly return to its former viscosity.

1.10 SOLUBILITY PROFILE

A comprehensive description of the various conditions that affect a material's (solute's) ability to dissolve in a given solvent, typically including concentration, temperature, pressure, pH, and the presence of other solutes. (Atkins and Paula, 2006; Chang, 2010). Key elements of a solubility profile include:

Solute and Solvent:

The top duo of the show! Solute refers to the substance that is being dissolved, and solvent refers to the medium that dissolves it. (Atkins and Paula, 2006).

Concentration:

This metric, which is frequently expressed in moles per liter (mol/L) or grams per liter (g/L), measures the amount of solute dissolved in a given volume of solvent. (Chang, 2010).

1.10.1 FACTORS AFFECTING SOLUBILITY

The degree of solute dissolution is determined by several factors, including:

Temperature:

Because solvent molecules travel more quickly and have more energy to disrupt solute-solute interactions, solubility often increases with temperature. You'll notice that the sugar dissolves more quickly in hot coffee when compared to cold coffee when you shake sugar into it. (Atkins and Paula, 2006).

Pressure:

Higher pressure often forces gas molecules into the solvent, increasing the solubility of the gas. When you open a sealed bottle of carbonated beverage, the pressure drops and the fizz (CO2) gas leaks out. This is because the gas is more soluble at high pressure. (Atkins and Paula, 2006)

pH:

pH can have a significant effect on the solubility of ionizable solutes because of changes in their charge state that alter interactions with the solvent One acidic drug that dissolves more easily in basic drinks is aspirin. (Chang, 2010).

Presence of Other Solutes:

Sometimes the presence of other dissolved compounds alters the target solute's solubility. This could be due to competition for solvent molecules or changes in the solvent's properties. Salt can sometimes make sugar dissolve in water more quickly. (Paula and Atkins, 2006).

Solubility Profiles in Action:

Drug Development:

The right solubility profile is essential for a medication to be effective. Poor solubility pharmaceuticals could limit their therapeutic efficacy by making it harder for the body to absorb them. Formulating drugs with the right solubility is essential for a successful course of therapy. (Shang and Zhu, 2010).

Chemical Separations:

A technique based on differences in solubility, fractional crystallization can be used to purify a wide range of compounds. Scientists can add specific solvents or change the temperature to selectively crystallize out desired components. (Atkins and Paula, 2006).

Environmental Science:

Knowing how soluble contaminants are in soil and water facilitates the evaluation of their possible effects on the environment and the creation of remediation plans. (Schwarzenbach *et al*., 2003).

1.11 EVALUATION OF SUSPENSION

SWELLING INDEX

A dimensionless indicator of the degree of volumetric expansion a material undergoes when coming into contact with a liquid is the swelling index (SI), often known as the swelling ratio. The usual way to represent it is as the ratio of the swelled material's final volume (Vf) to its original volume (Vi). SI = Vf / Vi . (Whistler and BeMiller, 2009; Eliasson and Larsson, 2006).

Importance of Swelling Index:

The swelling index is an important measure used in many different domains, such as:

- Soil Mechanics: Assessing the risk of damage and ground movement caused by the high swelling capacity of expansive soils (Mitchell, 1993).
- Food Science: Knowing how water is absorbed by starches, flours, and other carbohydrates and how this impacts the texture and usefulness of food items (Eliasson and Larsson, 2006).
- Pharmaceutics: Assessing the disintegration properties of tablets and capsules to ensure efficient drug release (Shang and Zhu, 2010).
- Textile Industry: Controlling a fabric's finishing and structural stability based on its swellability (Textile Research Institute, 2006).

- Biomaterials: Developing materials with specific swelling characteristics for use in tissue engineering, drug delivery, and other applications. (Peppas and Langer, 1994)

1.11.1 FACTORS AFFECTING SWELLING INDEX:

Numerous factors impact a material's swelling index:

- Material properties: Its chemical composition, structure, and porosity all have a significant impact on its capacity to absorb water and expand. (Whistler and BeMiller, 2009).
- Liquid properties: The amount of swelling can depend on the type of liquid, its pH, temperature, and solute content. (Atkins and Paula, 2006).
- External conditions: Furthermore, the amount of swelling can also be influenced by temperature, pressure, and mechanical force. (Eliasson and Larsson, 2006).

Academics and industry professionals can use knowledge of a material's swelling index to:

- Identify and control its functions in a range of contexts (Whistler and BeMiller, 2009).
- Develop new materials with unique qualities in accordance with the required swelling properties. (Peppas and Langer, 1994).
- Modify processing settings to impart desired properties to materials. (Eliasson and Larsson, 2006).

1.12 COLOUR,ODOUR, TASTE:

These qualities are particularly crucial for suspensions that are taken orally. Color variation frequently denotes uneven dispersion and/or variations in particle size. Variations in particle size,

crystal habit, and subsequent particle dissolution are sometimes blamed for flavor variations, particularly with regard to active ingredients. Chemical instability can also be indicated by changes in taste, smell, and color.

1.13 REDISPERSIBILTY

Another crucial step is to evaluate redispersibility. Utilizing a mechanical shaking apparatus could help quantify this characteristic to some extent. Used in controlled conditions, it can produce repeatable results by simulating the motion of a human arm throughout the shaking process. (Rudra Narayan Sahoo, 2020).

1.14 RHEOLOGIC METHODS:

In order to establish the settling behavior and the configuration of the vehicle and particle structural properties for comparison, rheologic behavior can also be utilized. Over the course of storage, the suspension's structure changes. The rheologic approach is a useful tool for evaluating structural changes. Using a Brookfield viscometer set up on a helipath platform is a useful rheologic technique. The dial reading on the viscometer then indicates the amount of resistance the T-bar spindle encounters at different levels in the sediment when it is made to descend gradually into the suspension. This method measures undisturbed samples as the T-bar moves down in the suspension and changes positions continuously. As the T-bar drops as it rotates and continuously enters new, relatively undisturbed material, this approach also indicates which level of the suspension the structure is greater due to particle agglomeration. Consequently, the dial reading can be plotted versus the spindle's number of revolutions using the T-bar spindle and the helipath. The outcome shows the way the particles are settling over time. Better suspensions in a screening study have a slower rate of increase in dial reading with spindle revolutions, meaning that the curve remains horizontal for an extended length of time. (Rudra Narayan Sahoo, 2020).

RHEOLOGIC CONSIDERATIONS

As rheology influences the settling of particles, it is significant when determining a suspension's viscosity. The pace at which particles settle out decreases with increasing viscosity. The suspension flows differently when the bottle is shaken or product is poured out, and how the lotion spreads when it is applied to the affected area more while the suspensions were being manufactured. (Rudra Narayan Sahoo, 2020).

1.15 VISCOSITY OF THE MEDIUM

According to Stoke's law: Stoke's law states that the rate of sedimentation is equal to 1/(viscosity of the medium). Suction viscosity ought to be at its ideal level. Thickening or suspending substances can be added to increase viscosity. There are benefits and drawbacks to choosing a high viscosity.

Advantages

- Sedimentation rate is retarded, hence enhances the physical stability of the suspension
- Inhibits crystal growth, because movement of particles is diminished
- Prevents the transformation of metastable crystals to stable crystal

Disadvantages

- Redispersibility of the suspension on shaking is difficult
- Pouring out of the suspension from the container may be difficult
- Creates problems in the handling of materials during manufacture
- May retard absorption of drugs from the suspension.

VISCOSITY:

- Factors affecting viscosity: The viscosity of a suspending substance can be affected by concentration, temperature, pH, and interactions with other chemicals. To optimize the formulation and achieve the appropriate suspension qualities, it is imperative to comprehend these aspects. (McClements, 2005).
- Types of viscosity and their effects: Shear-thinning, shear-thickening, or Newtonian behavior can all be exhibited by suspending agents. While shear-thinning (pseudoplastic) viscosity diminishes with increasing shear, enhancing flowability but perhaps jeopardizing stability at rest, Newtonian viscosity remains constant with shear stress. (McClements, 2010). For most applications, shear-thickening (dilatant) viscosity increases with shear, which can be undesirable. (Dickinson, 2009).
- Rheological characterization techniques: Viscosity and rheological qualities are measured and analyzed by rotational viscometers, rheometers, and other equipment. (McClements, 2010).

DENSITY:

- Density matching for particular applications: To completely prevent creaming or sedimentation, it may occasionally be advantageous for the suspending agent and distributed particles to have matching densities. Modifying the formulation composition or combining suspending agents with varying densities can accomplish this. (McClements, 2010).
- The role of the density gradient: A little greater suspending agent density produces a gradient that slows down the sedimentation of scattered particles (Sharma *et*

al., 2020). But an overabundance of density might negatively impact the flowability and presentation of suspension. (McClements, 2005).

Additional Significant Features:

- pH stability: The efficiency of the suspending agent may be impacted by chemical degradation or surface property changes brought on by pH variations. For long-term suspension stability, pH-stable agent selection is essential. (Sharma *et al*., 2020).
- Non-toxicity and non-irritancy: Suspending agents must be used with care, taking into account safety regulations and the likelihood of unfavorable outcomes.
- Solubility: Insufficient solubility may cause the suspending agent to precipitate or aggregate, which would impair its effectiveness. Temperature, pH, and the solvent system are some of the variables that affect solubility. (McClements, 2005).

1.16 AIM AND OBJECTIVE

In Nigeria, most pharmaceutical industries depend on importation of raw materials which are expensive and depletes our foreign reserve. Gums are readily available locally and have found wide applications as thickener's and suspending agents in pharmaceutical formulations. However, a search in literature shows that gum from *Chrysophyllum albidum* have been exploited in tablet formulations. But its suspending properties has not been exploited. Hence the aim of the study was to extract gum from *C.albidum* and evaluate its potential as suspending agent in the formulation of stable suspension. Specific objectives include:

(I) extract the gum of *Chrysophyllum albidum*

(II) evaluate the organoleptic properties and physiochemical characterization of *C.albidum*

(III) evaluate it as a suspending agent in the formulation of suspensions

(IV) compare the suspending properties of the gum with acacia gum as the standard

CHAPTER TWO

MATERIALS AND METHOD

2.0 MATERIALS

2.1 *Chrysophyllum albidum* (African star apple) fruits.

The *Chrysophyllum albidum* fruits were sourced from a local market in Benin City, Edo state, south-south, Nigeria.

The tropical fruit known as African star apple, or *Chrysophyllum albidum* is distributed throughout West, East, and Central Africa. It is a naturally occurring plant that is extensively found in lowland rain forest zones and is a member of the Sapotaceae family (Madubuike and Ogbonnaya, 2003). Due to its varied ethno-medical usefulness and sweet, succulent fruits, it is widely accepted (Amusa *et al.,* 2003, Okoli and Okere, 2010). African star apple fruit is a seasonal fruit that has roughly five seeds inside and might occasionally have an oval or spherical shape. It is accessible from December to April every year, and when it bursts, the pulp releases a sweet, milky fluid that is pale orange in color. In Southern Nigeria, the fruit is commonly consumed and goes by several local names, including "agbalumo". According to (Amusa *et al.,* 2003), the fruit is allowed to fall naturally to the forest floor, where it is collected. According to studies, within five days after harvest, over thirty percent of African star apple fruits are lost due to high tropical temperatures and humidity, improper post-harvest handling procedures, and inadequate processing and preservation methods (Amusa *et al.,* 2003).The plant's nutritional benefits, antibacterial properties, and effectiveness against a range of illnesses have long been recognized. For example, the leaves are used to treat skin irritation, diarrhea, and stomachaches; the bark is used to treat yellow fever and malaria (Adisa, 2000). The fruit has a high calcium and nutrient content. (Gibson Lucky Arueya, Grace Febechi Ugwu, 2017).Fruits and vegetables are

infamously inconsistent, with individual pieces within a lot sometimes having quality significantly different from the lot average. The product gains value when it is sorted and categorized based on the existence of quality attributes or the lack of flaws. Human senses, labor costs, and inspector sensitivity, speed, endurance, and availability are the constraints on human inspection. To increase sorting efficiency, consistency, and accuracy, automation is required. Nondestructive high-speed sensors measuring many quality parameters on each item, a way to combine those measurements into a classification judgment, and a mechanism to physically move the piece into its correct category are necessary for practical commercial sorting. Non-timber forest products, such as fruits, seeds, roots, stems, leaves, and flowers, have kept rural and urban communities' food security, health, and socioeconomic wellbeing intact (FAO, 1989). Fruits are essential components of a healthy diet since they are a natural source of nutrients that both humans and animals need, such as protein, carbohydrates, minerals, and dietary fiber. The edible tropical fruit known by several tribe names in Nigeria as agbalumo (Yoruba), udara (Ibo, Efik, and Ibibio), ehya (Igala), and agwaluma (Hausa) is the African star apple *(Chrysophyllum abidum)*, an indigenous species. It is categorized as a member of the Sapotaceae family and is a wild plant. The genus *Chrysophyllum* comprises approximately 70–80 species of tropical trees that are indigenous to tropical areas across the globe. (Florence Abolaji Bello and Adiehe Abigail Henry, 2015). *Chrysophyllum albidum's* outer skin is often glossy when ripe and can be green, yellow-orange, or deep purple-red, depending on the type. Additionally, the color of the interior flesh can change from white to creamy yellow. The interior flesh has a soft feel and is juicy and luscious, while the exterior skin is thin and smooth. Many people compare the fruit's texture to that of a lychee or plum. The fruit is renowned for having a high moisture content, which makes it tasty and revitalizing. When bitten into or pressed, the pulp releases a significant

amount of juice. The juicy pulp surrounding the seed is the part of *Chrysophyllum albidum* that can be eaten. Because of its delicious flavor and appealing texture, the pulp is the most sought-after portion of the fruit.

Taxonomical classification

Kingdom: plantae

Phylum: Spermatophyta

Class: Magnoliopsida

Order: Sapotales

Family: Sapotaceae

Genus: *Chrysophyllum*

Species: *Chrysophyllum albidum*

Fig 2.1:A selection of fruits from *Chrysophyllum albidum* displaying the pulp and seed.

Fig 2.2: A grouping of fruits of *Chrysophyllum albidum*

2.2 *Acacia senegal* powder

The *Acacia senegal* powder was sourced from Pyrex pharmaceuticals in Benin City, Edo state , south-south, Nigeria.

Gum arabic, sometimes referred to as acacia gum or *Acacia senegal*, is a naturally occurring gum that is extracted from the sap of several acacia tree species. For ages, it has been utilized in a wide range of products, such as food, medicine, fabrics, and cosmetics. Gum arabic usually takes the form of flakes, granules, or powder that ranges in color from white to pale yellow. The processing and contaminants used might change the color of the material. Gum arabic dissolves easily in water to produce a transparent, thick solution. It is used in various industries, including food and beverage as a stabilizer and emulsifier, as it dissolves in water to form a stable colloidal dispersion. Because gum arabic possesses hygroscopic qualities, it can take in and hold onto moisture from its surroundings. Gum arabic is stable throughout a wide range of pH levels, from acidic to alkaline settings, which adds to its adaptability in diverse applications. This feature helps maintain the stability of products and keeps them from drying out. Gum arabic keeps its qualities well at a variety of temperatures and demonstrates strong thermal stability.

Source and Harvesting:

- Acacia gum is obtained by making small incisions in the bark of Acacia trees, allowing the sap to ooze out.
- The sap hardens into nodules or tears, which are then collected and processed.
- Chemical Composition:
- Acacia gum is a complex mixture of polysaccharides and glycoproteins.
- It is soluble in water, forming a sticky, viscous solution.

Traditional Uses:

- Traditional medicine: Acacia gum has been used in various cultures for its potential health benefits. It has been employed to soothe sore throats, as a demulcent for gastrointestinal issues, and for its purported anti-inflammatory properties.

Culinary Uses:

- Food industry: Acacia gum is widely used as a food additive, particularly in the production of confectionery, beverages, and baked goods.
- It serves as a stabilizer, thickener, and emulsifier in food products.
- Acacia gum is often used in the creation of edible glazes and coatings.

Industrial Applications:

- Pharmaceutical industry: Acacia gum is utilized in the formulation of medications as a binder or encapsulating agent.
- Printing industry: It is used in the preparation of inks and as a binder for watercolor paints.
- Textile industry: Acacia gum is employed in textile printing as a thickening agent for dyes.
- Health and Wellness:
- Prebiotic properties: Acacia gum has been studied for its prebiotic effects, promoting the growth of beneficial gut bacteria.
- Dietary fiber: It is rich in soluble fiber, contributing to digestive health.
- Sustainability:
- Acacia trees are generally hardy and well-suited to arid environments, contributing to the sustainability of acacia gum production.

- Sustainable harvesting practices are important to ensure the long-term viability of Acacia tree populations.

Fig 2.3: *A.senegal* gum powder

2.3 MAGNESIUM TRISILICATE

Acid reflux, dyspepsia, and heartburn are the main conditions for which magnesium trisilicate is used as an antacid. Mg2Si3O8 is the chemical formula for this inorganic compound, which is made up of magnesium, silicon, and oxygen." By reducing too much stomach acid, magnesium trisilicate acts as an antacid. In the stomach, it combines with hydrochloric acid to produce magnesium chloride, silicon dioxide, and water. This process lowers acidity and relieves symptoms such as acid reflux and heartburn. It is usual to find magnesium trisilicate in a number of forms, such as tablets, chewable tablets, and suspensions. The onset and duration of effect of these formulations might vary, and they provide a variety of delivery choices. Magnesium trisilicate powder obtained as gift sample from the pharmaceutical technology laboratory, uniben.

2.4 METHANOL

Methanol, which has the molecular formula CH3OH, is a colorless, volatile, and flammable liquid that is sometimes referred to as methyl alcohol, wood alcohol, or wood spirit. With a methyl group (CH3) connected to a hydroxyl group (OH), it is the most basic type of alcohol. Methanol is frequently utilized as a fuel, antifreeze, industrial solvent, and precursor to other compound.The methanol used was obtained from a local market in Benin City and used as a extracting solvent to precipitate the gum.

2.5 METHODOLOGY

2.5.1 EXTRACTION OF GUM (*CHRYSOPHYLLUM ALBIDUM*)

Clean water was used to wash the fresh fruits. Using a knife, the fruit pulps were extracted and the seeds were removed. The juice from the pulp was manually strained using a nylon towel with tiny pores to precipitate the gum, methanol was added. The 13200 ml juice obtained was treated with 26400ml of methanol (i.e 1:2 ratio). The resulting precipitate was cleaned with distilled water, sieved through a muslin bag, and allowed to air dry for seven (7) days. The resulting dried mass was ground into a 350–500µm-sized fine powder. Before being characterized, the resultant powdered mass was kept in an airtight chamber containing activated silica gel. (Florence. E.Eichie, Florence I.Iweka *et al.,* 2015).

Fig 2.4.Showing the precipitated gum extract from (*Chrysophyllum albidum*) juice

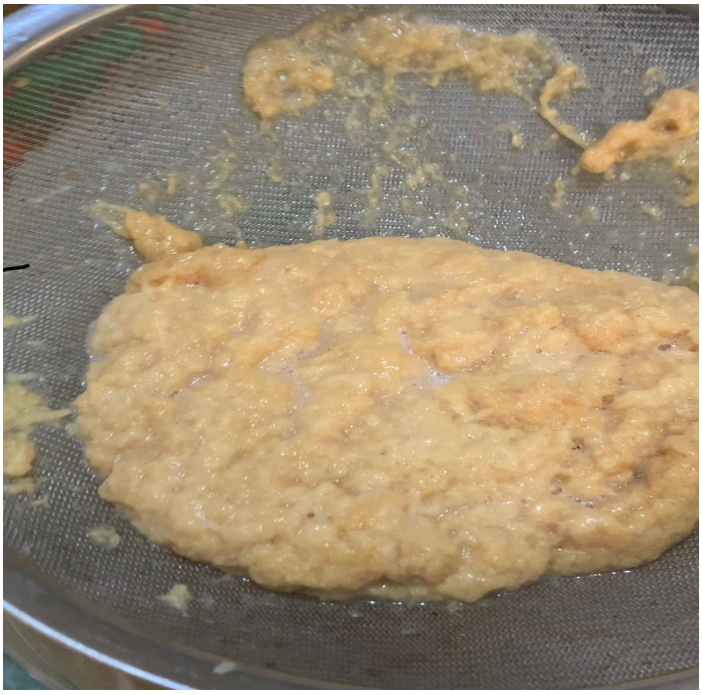

Fig 2.5 Showing the extracted gum extract from (*Chrysophyllum albidum*) juice.

2.6 PHYSIOCHEMICAL CHARACTERIZATION OF THE GUMS

Organoleptic properties: The gum extract and *Acacia senegal* were tested for look, taste, odor, and color, by five different people. Each person received a score sheet to record their observations.

Determination of solubility profile in various solvents

C.albidum gum's solubility was assessed in a range of solvents, including distilled water, 0.1N HCl, 0.1N NaOH, acetone, chloroform, methanol, ethanol, and phosphate buffer (pH = 6.5). One sample (0.50 g) of the gums from either *A. Senegal* or *C.albidum* was diluted in 50 milliliters of each of the different solvents. As a potential indicator of disintegration, the resulting dispersions were seen for homogenous dispersions. (Florence.E.Eichie,Florence I.Iweka *et al.,*2015).

Determination of viscosity profile of mucilage's

Different concentrations of the gums (*A. Senegal* and *C. albidum*) were prepared in water at room temperature (1%, 2.5%, 5%, and 7%$^{w}/_{v}$ respectively). Using a size 1A suspended level viscometer, the viscosities of the resultant mucilage at different gum concentrations were measured at room temperature (28±20C) in accordance with the British Pharmacopoeia 2012. (Richards JH. Rheology, In:Cooper and Gunns, 1972). After making determinations in triplicate, the mean ± SD was reported. Since the test was of comparative value, the time of flow (s) was taken as the index of viscosity.

Determination of swelling index

A 100 ml measuring cylinder was filled with a sample of each powdered gum (2 g), and the cylinder was tapped to remove any air or voids. The volume was recorded and marked as (Vt). After adding 40 milliliters of distilled water and letting it stand for 24 hours during the night, the

volume occupied (Vv) by the gum sediment was measured. The ratio of the end volume to the initial volume was used to calculate the swelling index (θ). (Bowen and Vadino, 1984).

Determination of specific densities

The fluid displacement method, which has been used by other researchers in the past, was used. (Irwin R, Roger LS, *et al.,* 2002) A pycnometer was filled with liquid paraffin, covered, and weighed. A sample (0.5 g) of each gum was placed into the empty pycnometer, and the weight was recorded. The pycnometer containing the gum extract was then filled with liquid paraffin, the stopper was replaced, the excess liquid was wiped off, and the final weight was recorded. Representative measurements were made, and the mean values were utilized to calculate the gum's density, as shown using equation (1) below.

Weight of pycnometer +liquid paraffin = 40.407g

Weight of pycnometer + gum extract = 20.639g

Weight of pycnometer + liquid paraffin + gum extract = 40.896g

Specific gravity of liquid paraffin = 0.8425

Weight of gum extract = 1.0g

Using the formula;

$$Pg = \frac{w}{[(a+w)-b]SG} \quad \text{.....(1)}$$

$$Pg = \frac{1.0}{[(40.407+1.0)-40.896]0.8425}$$

Pg = 2.323g/ml

Gum particle weight (W), liquid paraffin's specific gravity (SG), pycnometer + liquid paraffin weight (a), and gum particle weight (b) are all given.

2.7 PREPARATION OF THE SUSPENSION

5g of sodium bicarbonate was dissolved in 20ml of water. The solution was used to triturate 5g of magnesium trisilicate and 5g of light magnesium carbonate to form a smooth paste and then triturated with varying concentrations (5%, 10%,15%,20%) of the gum extract *Chrysophyllum albidum* and *Acacia senegal* respectively. The resulting mixture was mixed with more distilled water to make up to the required 100ml.Prescription table shown below.

Tables 2.1 Representing a prescription table used in the preparation of varying concentration (5-20%w/v) of *C.albidum* and *A.senegal*, respectively as a suspending agent in mist magnesium trisilicate mixture.

Prescription	**Amount given(mg)**	**Amount used(g)**
Magnesium Triscilate	500	5
Light Magnesium carbonate	500	5
Sodium Bicarbonate	500	5
Water	10ml	100ml

2.7.1 Determination of flow rate of freshly prepared suspension

The time taken for each sample of the suspension to flow through a 10ml pipette was determined by using the formula below:

Flow rate (Fr) = $\frac{v}{t}$ ……. (2)

Where V, is the volume of the pipette in (ml) and t is the time of flow in seconds. Triplicate determinations were made and the mean ±SD was reported.

2.7.2 Determination of viscosity of freshly prepared suspension

5%, 10%, 15%, and 20% concentration of fresh *Chrysophyllum albidum* suspension and *Acacia senegal* suspension were prepared. The suspension was poured into the viscometer through the falling tube and sucked through the capillary tube until the suspension flows past the upper reservoir while the ventilation tube was closed to avoid air bubbles. The time of flow of each concentration through the capillary of a suspended level viscometer (size 4A) was determined. The viscosity of the fluid is directly proportional to the time of flow. Triplicate determination was made and mean±SD was reported.

2.7.3 Determination of redispersibility index

The redispersibilty index as determined by the number of cycles required to effect uniform dispersions after a prolonged storage for seven(7) days was carried out by standing the stored suspension straight in upright position followed by uniform 180° movement and back. The pair of successive upward and downward movement of each of approximate force constituted one complete cycle of shaking, the number of shakings required for complete elimination of the sediment from the bottom of the tubes was recorded. (Jerald E, Dosi S and Raji A, 2007).

2.7.4 Determination of sedimentation rate of suspension

The prepared suspension of *C.albidum* and *A.senegal* with varying concentration (5%, 10%,15%,and 20%$^{w}/_{v}$) respectively was shaken vigorously and 50ml was poured at same time into a 50ml graduated measuring cylinder after which it was allowed to stand on a flat table surface and kept at room temperature. The sedimentation rate of the formulations were noted every day for the following seven (7) days after preparation. The readings of the sedimented volumes were taken when the particles settled down and the cloudy supernatant started to clear up on descending from the top surface of the suspension. The results were then recorded appropriately. (Brhane ,2020)

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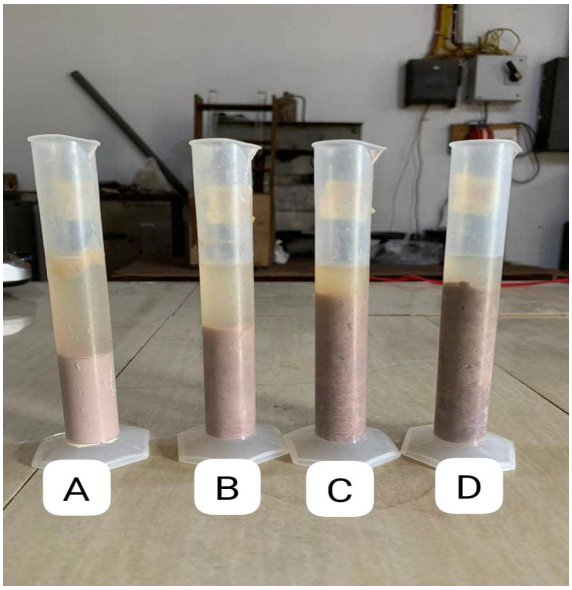

Figure2.6: Showing the sedimented volumes of mist magnesium trisilicate mixture and the supernatant in a suspension containing varying concentration of *C.albidum* as suspending agent.

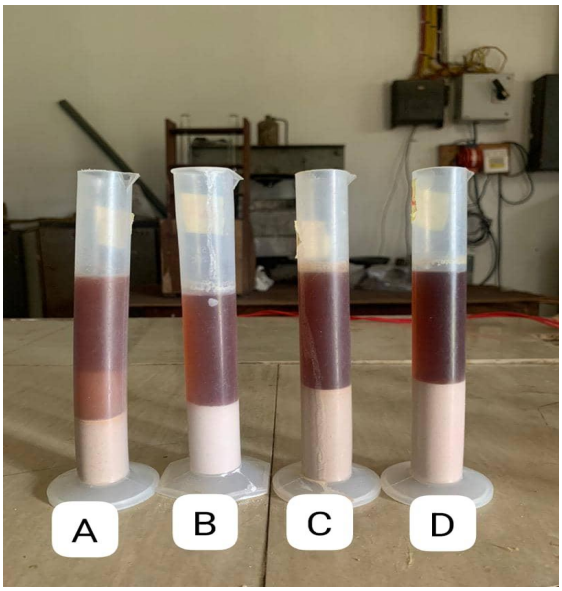

Figure2.7: Showing the sedimented volumes of mist magnesium trisilicate mixture and the supernatant in a suspension containing varying concentration of *A.senegal* as suspending agent.

Where,

A=5%, B=10%, C=15%, D=20%.

CHAPTER THREE

RESULTS AND DISCUSSION

3.1 ORGANOLEPTIC PROPERTIES OF *Chrysophyllum albidum* and *Acacia senegal* shown in Table 3.1 below.

Table 3.1 Result showing the organoleptic properties of *Chrysophyllum Albidum* and *Acacia Senegal*.

PARAMETERS	***C.albidum***	***A.senegal***
Colour	Dark brown	Light brown
Odour	Fruity	Odourless
Texture	Coarse	Coarse
Taste	Sour	Characteristic

The air dried *C.albidum* gum powder has a pleasant fruity odour, coarse in texture and dark brown brown in colour while *A.senegal* has a light brown colour, coarse in texture and odourless as shown in Table 3.1 above.

The coarse powder gum of *C.albidum* and *A.senegal* is shown in fig.3.1 and fig.3.2 below respectively.

3.2 PHYSIOCHEMICAL CHARACTERIZATION OF *Chrysophyllum albidum* and *Acacia senegal*.

Table 3.2 Result showing the solubility of *Chrysophyllum Albidum* and *Acacia Senegal* in different solvents.

SOLVENTS	*C.ALBIDUM*	*A.SENEGAL*
Cold distilled water	Soluble	Soluble
Hot distilled water	Soluble	Soluble
Acetone	Insoluble	Insoluble
Chloroform	Soluble	Soluble
O.1N Hcl	Insoluble	Insoluble
0.1N NaOH	Insoluble	Insoluble
Methanol	Insoluble	Insoluble
Ethanol	Insoluble	Insoluble
Phosphate buffer pH 6.5	Soluble	Soluble

Both gums displayed the same solubility characteristics, they were soluble in water, and phosphate buffer with a pH (6.5), insoluble in acid, bases and organic solvents except chloroform. The various gums are highly hydrophilic in nature.

Figure 3.1:*C.albidum* gum extract powder

Figure 3.2: *A.senegal* gum powder

Table 3.3 Result showing the swelling index and particle density of both gums.

PARAMETERS	***C.albidum***	***A.senegal***
Particle density (g/ml)	2.32 ±0.14	1.05 ±0.02
Swelling index	1.429±0.4	1.286±0.3

From the result shown above, both gums are highly hydrophilic in nature as revealed by similar swelling capacity of 1.429 ±0.4 for *C.albidum* and 1.286 ± 0.3 for *A.senegal* respectively.The particle density of (*C.albidum*) were showed to be 2.32 ±0.14g/ml and (*A.senegal*) to be 1.05 ±0.02g/ml respectively. Particle density measurements are essential for understanding the physical characteristics of materials because they reveal details about porosity and how particles behave throughout different processes like compaction, mixing, and flow.

Table 3.4 Result showing the viscosity of varying concentration *C.albidum* gum and *A.senegal* gum mucilages.

CONCENTRATION (%w/v)	***CHRYSOPHYLLUM ALBIDUM*(secs)**	***ACACIA SENEGAL*(secs)**
1.0	55.2 ± 0.02	46.63 ± 0.02
2.5	106.3 ± 0.05	76 ± 0.03
5.0	199.7 ± 0.12	190 ± 0.10
7.5	318.67 ± 0.25	248 ± 0.21

Table 3.5 Showing the result of viscosities of *C.albidum* suspension and *A.senegal* suspension with varying concentrations.

CONCENTRATION (%w/v)	***CHRYSOPHYLLUM ALBIDUM*(secs)**	***ACACIA SENEGAL*(secs)**
5.0	9.38 ± 0.07	6.12± 0.05
10	14.43± 0.15	10.40± 0.07
15	21.77± 0.21	16.40 ± 0.15
20	50.33± 0.32	39.50± 0.25

Data presented as MEAN±SD, Where n=3

From the result shown above at Table 3.4 the viscosity of both *C.albidum* gum and *A.senegal* gum mucilages increased with increase in their concentration. There was a marked increase in viscosity of 7.5% (*C.albidum)* gum 318.67 ± 0.25 secs, as compared to 7.5% of (*A.senegal gum)* 248 ± 0.21secs.Also the result shown above at Table 3.5 the viscosity of both *C.albidum* suspension and *A.senegal* suspension increased with increase in their concentration. There was a marked increase in viscosity of 20% *C.albidum* (50.33± 0.32secs) suspension as compared to 20% of *A.senegal* suspension (39.50± 0.25secs). Hence the viscosity of both suspension and mucilages where concentration dependent;an increase in concentration lead to corresponding increase in viscosity.

Table 3.6 Result showing the sedimentation volumes of varying concentrations *C.albidum* and *A.senegal* suspensions.

DAYS	**5%w/v**		**10%w/v**		**15%w/v**		**20%w/v**	
	C.albidum (ml)	*A.senegal* (ml)	*C.albidum* (ml)	*A.senegal* (ml)	*C.albidum* (ml)	*A.senegal* (ml)	*C.albidum* (ml)	*A.senegal* (ml)
1	24	20	36	25	43	27	45	30
2	24	15	33	19	42	22	44	23
3	22	15	32	19	42	22	44	23
4	22	15	32	19	42	22	44	23
5	22	15	32	19	40	22	43	23
6	22	15	32	19	40	22	43	23
7	22	15	32	19	40	22	43	23

The sedimentation rate of *C.albidum* suspension and *A.senegal* suspension from the result shown at Table 3.6 showed that there was a marked difference among the formulations. This result also showed that as the concentration of the suspending agents increased the rate of sedimentation of the various suspension decrease significantly (see figure 2.6 and 2.7 above). As seen in the result shown above at 10%w/v concentration of the suspending agent, *C.albidum* had a lower sedimentation rate giving the volume of sediment measuring 32ml while that of 10%w/v *A.senegal* provided a higher sedimentation rate with the sediment volume measuring 19ml.The suspensions displayed a decrease in sedimentation rate with increase in concentration of the gum and this is in tandem with stokes law. The decrease in sedimentation rate can be said to be attributable to the viscosity of the various gum.

Table 3.7 Effect of gum concentrations on the flow rate of suspension.

CONCENTRATION (%W/V)	FLOW RATE(ml/secs)	
	CHRYSOPHYLLUM ALBIDUM	*ACACIA SENEGAL*
5	1.25±0.17	1.67±0.13
10	0.29±0.11	0.40±0.13
15	0.15±0.06	0.26±0.09
20	0.08±0.02	0.10±0.05

Data presented as MEAN±SD, Where n=3

The outcome of freshly made suspensions flow characteristics, as shown in Table 3.7, it can be seen that the flow rates for *C.albidum* ranged from 0.08±0.02ml/s to 1.25±0.17ml/s, while for *A.senegal* 0.10±0.05ml/s to 1.67±0.13ml/s, this was concentration dependent. Lower concentration of the gum displayed high flow rates while higher concentrations gives lower flow rate. It is a desirable quality for pharmaceutical suspension to exhibit good free flow characteristics as this is an essential quality especially for dispersion intended for parenteral administration and hypodermic needles.

Table 3.7 Result showing the redispersibility of *C.albidum* suspension and *A.senegal* suspension with varying concentration.

CONCENTRATION (%W/V)	NUMBER OF CYCLES	
	CHRYSOPHYLLUM ALBIDUM	*ACACIA SENEGAL*
5	7	4
10	22	20
15	36	32
20	74	50

The redispersibilty indices of suspension made from *C.albidum* and *A.senegal* were concentration dependent. Suspension made from *Acacia senegal* were easily redispersed after a week storage, A marked redispersibilty index was seen in 20% *Chrysophyllum albidum* suspension and 20% *Acacia senegal* which were redispersed at 74 and 50 cycles respectively .This may as a result of its wide viscosity difference which makes it flow and pourability difficult. However, Redispersibility indices of (5-20%w/v) *A.senegal* suspension was seen to be high.

CHAPTER FOUR

4.0 CONCLUSION AND RECOMMENDATION

The results of the study demonstrated that *Chrysophyllum albidum* gum extract compares favorably to *Acacia senegal* when used as a suspending agent in pharmaceutical dispersion formulation. As a result, it can be utilized to stabilize and suspend pharmaceutical suspensions. This will serve as substitutes to imported materials and excipients used in the formulation of suspension.

RECOMMENDATION

From the study, research should be carried out on:

- improved methods for the extraction of gum from *Chrysophyllum albidum*

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APPENDIX I

RESULT OF THE ORGANOLEPTIC PROPERTIES OF *C.albidum* gum extract and *A.senegal* gum

Result showing the organoleptic properties of *Chrysophyllum Albidum* and *Acacia Senegal*.

PARAMETERS	***C.albidum***	***A.senegal***
Colur	Dark brown	Light brown
Odour	Fruity	Odourless
Texture	Coarse	Coarse
Taste	Sour	Characteristic

APPENDIX II

PHYSIOCHEMICAL CHARACTERIZATION OF *Chrysophyllum albidum* and *Acacia senegal*.

Result showing the solubility of *Chrysophyllum Albidum* and *Acacia Senegal* in different solvents.

SOLVENTS	***C.ALBIDUM***	***A.SENEGAL***
Cold distilled water	Soluble	Soluble
Hot distilled water	Soluble	Soluble
Acetone	Insoluble	Insoluble
Chloroform	Soluble	Soluble
O.1N Hcl	Insoluble	Insoluble
0.1N NaOH	Insoluble	Insoluble
Methanol	Insoluble	Insoluble
Ethanol	Insoluble	Insoluble
Phosphate buffer pH 6.5	Soluble	Soluble

APPENDIX III

RESULT SHOWING THE VISCOSITY OF VARYING CONCENTRATION OF *C.albidum* gum and *A.senegal* gum mucilages.

CONCENTRATION (%w/v)	***CHRYSOPHYLLUM ALBIDUM*(secs)**	***ACACIA SENEGAL*(secs)**
1.0	55.2 ± 0.02	46.63 ± 0.02
2.5	106.3 ± 0.05	76 ± 0.03
5.0	199.7 ± 0.12	190 ± 0.10
7.5	318.67 ± 0.25	248 ± 0.21

APPENDIX IV

RESULT SHOWING THE VISCOSITY OF VARYING CONCENTRATION OF *C.albidum* suspension and *A.senegal* suspension.

CONCENTRATION (%w/v)	***CHRYSOPHYLLUM ALBIDUM*(secs)**	***ACACIA SENEGAL*(secs)**
5.0	9.38 ± 0.07	6.12± 0.05
10	14.43± 0.15	10.40± 0.07
15	21.77± 0.21	16.40 ± 0.15
20	50.33± 0.32	39.50± 0.25

Data presented as MEAN±SD, Where n=3

APPENDIX V

RESULT SHOWING SEDIMENTATION VOLUMES OF VARYING CONCENTRATION *C.albidum* and *A.senegal* SUSPENSION.

DAYS	**5%w/v**		**10%w/v**		**15%w/v**		**20%w/v**	
	C.albidum (ml)	*A.senegal* (ml)	*C.albidum* (ml)	*A.senegal* (ml)	*C.albidum* (ml)	*A.senegal* (ml)	*C.albidum* (ml)	*A.senegal* (ml)
1	24	20	36	25	43	27	45	30
2	24	15	33	19	42	22	44	23
3	22	15	32	19	42	22	44	23
4	22	15	32	19	42	22	44	23
5	22	15	32	19	40	22	43	23
6	22	15	32	19	40	22	43	23
7	22	15	32	19	40	22	43	23

APPENDIX VI

EFFECT OF GUM CONCENTRATIONS ON THE FLOW RATE OF SUSPENSIONS.

CONCENTRATION (%W/V)	FLOW RATE(ml/secs)	
	CHRYSOPHYLLUM ALBIDUM	*ACACIA SENEGAL*
5	1.25±0.17	1.67±0.13
10	0.29±0.11	0.40±0.13
15	0.15±0.06	0.26±0.09
20	0.08±0.02	0.10±0.05

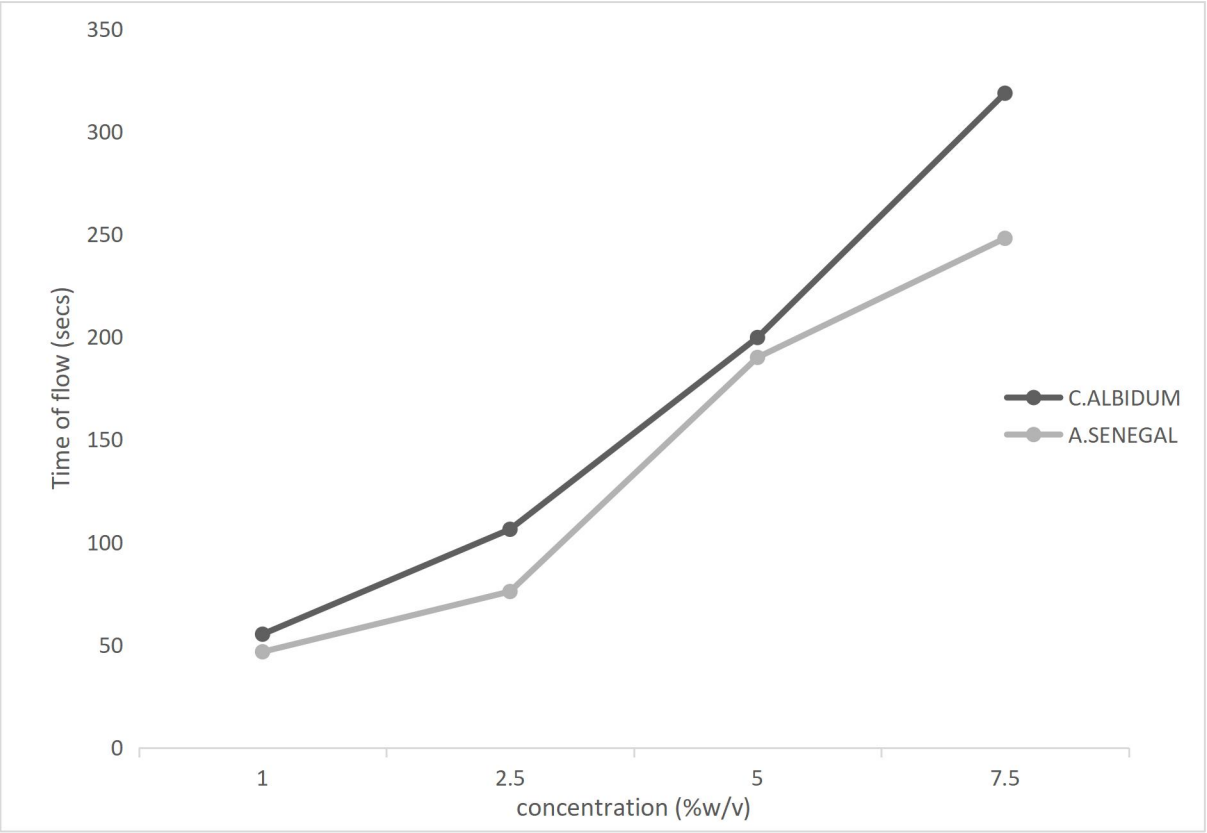
Data presented as MEAN±SD, Where n=3

APPENDIX VII

RESULT SHOWING THE REDISPERSIBILITY OF *C.albidum* and *A.senegal* SUSPENSION WITH VARYING CONCENTRATION.

CONCENTRATION (%W/V)	NUMBER OF CYCLES	
	CHRYSOPHYLLUM ALBIDUM	*ACACIA SENEGAL*
5	7	4
10	22	20
15	36	32
20	74	50

APPENDIX VIII



APPENDIX VIII: Showing varation in concentration of gums with Time of flow(secs) of the mucillages.