UNIVERSITY OF ILORIN

THE TWO HUNDRED AND FIFTY-SECOND (252ND)
INAUGURAL LECTURE

"DRUG FORMULATION AS ESSENTIAL CONSTRUCT FOR SAFE DELIVERY"

By

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The Vice-Chancellor

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My Lords Spiritual and Temporal,
Great Students of the University of Ilorin,
Distinguished Invited Guests,
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Ladies and Gentlemen.

Preamble

To God be the glory for granting me the opportunity to stand here today to share this momentous occasion of 252nd inaugural lecture. It is indeed a rare privilege for me to deliver the first inaugural lecture from the Department of Pharmaceutics and Industrial Pharmacy, but second to that of Prof. M.T. Bakare-Odunola from the Faculty, titled *Pharmacokinetics: Essential Tool In Drug Therapy*, delivered in 2013. Remarkably, today's lecture is the first to be delivered by a **Pharmacist** from the Faculty and more importantly, the first Home-bred Professor. This milestone fills me with great joy and delight. Today's lecture holds a special significance, marking a historic moment for the Department of Pharmaceutics and Industrial Pharmacy and Faculty of Pharmaceutical Sciences of this great University.

Vice-Chancellor, sir, permit me to go down memory lane. In my childhood days at Ilesa in Osun State, I was exposed to two professions. The first was law and the lawyers, I grew up to know in our environment were wealthy and highly esteemed. They drove the best of the cars, had beautiful mansions, spoke special English Language, and commanded great respect. Many times, I joined my peers to catch a glimpse of the lawyers in their distinctive wigs and gowns in a nearby court in our neighborhood in Isokun, Ilesa. I was extremely fascinated and hoped to be like one of them. This ambition motivated me to be more studious during my primary school days. It was a strong force that drove my performance throughout my stay at Salvation Army Primary School, Isokun, Ilesa, and my position in class never went beyond 3rd position throughout, in a population of about 100 students. Much later, in my secondary school days, through hospital visitation, under the guidance of my mother, whenever I was ill, I got exposed to the people, always in sparkling white coats, who mix chemicals in the name of medicine at Wesley Guild Hospital, Ilesa. They were popularly referred to as ***Apoogun Oyinbo***. You will be given the medicine to drink and thereafter recover from the ailment. It appeared magical to me and I felt it may also be okay to become ***Apoogun Oyinbo***. I doubled up my efforts and burnt many candles at night in the company of two friends and classmates, by the name Gbenga Taylor and Gbenga Odeyemi, to engage in a war-like study. The sole aim was to be comfortable in life, having experienced hardship as a result of poor parental background, to the extent that, I had to engage in street hawking of Kerosene, Newspapers, etc, all to augment whatever my parents could afford towards my educational development. The urge and the drive paid off and my performance throughout my secondary school days was always within the top 7th position in a population of about 120 students. Today, by the special grace of God, I am a successful Pharmacist, without any regret, having reached the peak both in academia and practice.

Introduction

Medicines are essential components of health delivery care systems that are sourced from plants, minerals, animals, and chemical materials. The consumption of medicine in Nigeria has been increasing over the past few years, and this trend is expected to continue. This growth is being driven by several factors, including the country's rapidly growing population, the increasing prevalence of chronic diseases, and the rising cost of healthcare. The pharmaceutical industries in Nigeria heavily rely on imported raw materials, with estimates suggesting that over 70% of the raw materials used in the production of medicines are imported. More worrisome recently, is the exit of some pharmaceutical giants like GSK, Sanofi, Procter and Gamble, etc from the country. Cost of some essential medicines like antibiotics, life life-saving anti-asthmatic drugs have gone up astronomically beyond the reach of ordinary Nigerians. This poses a great danger to the health sector. Nigeria as a country has no guarantee of medicine security with over-dependence on imported raw materials. The time to ensure the development of medicines locally is now.

Mr. Vice-Chancellor, permit me to shed more light on the title of today's lecture; **Drug Formulation As Essential Construct For Safe Delivery**. In the course of this lecture, I will interchangeably use the words 'Drug' and 'Medicine'. The difference between being a thin line. Drugs sometimes may be more toxic and could also, on some occasions, lead to the problem of addiction. By way of definition, **drug formulation** is the act of putting together appropriate ingredients in the right proportions and in a non-reactive manner. The **'construct'** in the context of this lecture is the end point of formulation processing leading into whole medicine or drug which must be delivered safely.

Drug formulation rests squarely on two pillars which are the excipients and active pharmaceutical ingredients (API). Pharmaceutical excipients are defined in the United States Pharmacopoeia (USP) as "substances other than the Active

Pharmaceutical Ingredient, that have been appropriately evaluated for safety and are intentionally included in a drug delivery system". They are inert substances used in all drug dosage forms to ensure proper product performance. On the other hand, an active ingredient is any ingredient that provides biologically active or other direct effect in the diagnosis, cure, mitigation, treatment, or prevention of disease or affects the structure or any function of the body of humans or animals. API can be derived directly or indirectly from plants, animals, and mineral sources. Indirectly through the synthesis of some pharmaceutical raw materials using petrochemicals. On the other hand, natural ingredients including herbs and minerals in their crude form or isolated stages can be converted into standardised dosage forms. Historically, Apothecaries were individuals who prepared and dispensed medications, typically from natural ingredients like herbs and minerals. They played a crucial role in healthcare during the medieval and early modern periods, often serving as the primary source of medical care for communities. Apothecaries would compound medications based on prescriptions from physicians and also provide advice on their uses.

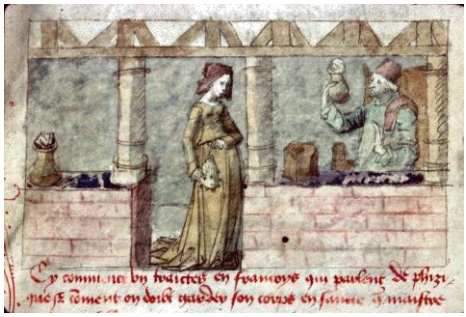


Figure 1: A 15th-century French Apothecarie at the far right
Source: (Allen, 2011).

The ancient apothecaries have evolved into contemporary pharmacists or better still, formulation scientists.

In this inaugural lecture, Vice-Chancellor, sir, I will give an account of my research findings in the last 26 years having collaborated with other scientists and through the supervision of both undergraduate and postgraduate students. I will highlight first, the herbal medicinal products from our forest that I have formulated into useful **constructs** in various dosage forms. In the other part of this lecture, I will give an account of my research activities in the area of excipient development and little drug formulation engineering embarked upon by me that produced useful **constructs for safe delivery.**

Azadirachta indica

Malaria has significant economic and health consequences (WHO, 2023), costing Nigeria over US$1.1 billion annually and accounting for 60% of all hospital visits (htpps://guardian.ng/news). Mr. Vice-Chancellor, as far back as 2006-2011, as part of my contribution towards the control of malaria burden, I carried out various studies on Neem seed oil formulations during my Ph.D research work under the supervision of, Prof. M.N. Femi-Oyewo, FPCPharm, FNAPharm, FPSN, MFR. In this lecture, I will detail, our various findings on the role of the **construct** in the form of dermatological preparations to prevent the malaria disease burden. Neem seed oil is from the seeds of the plant *Azadirachta indica.* The plant is freely grown in most parts of Nigeria. It is either found by the roadsides or fields and even sometimes in the backyards of most residential houses. Neem starts bearing fruits after 5 years and comes to full bearing at the age of 10-12 years. Fruit yield is 5-20 kg per tree per year in the initial years. A mature tree produces 35-50 kg fruit/year (**Aremu** and Femi-Oyewo, 2009a). The Neem Plant with its numerous seeds is shown in Figure 2.

Figure 2: Neem Plant with the seeds (**Aremu a**nd Femi-Oyewo, 2009a).

Neem Plants contain several thousands of chemicals. The most important of them are the terpenoids. More than a hundred terpenoids are known from different parts of the Neem Plant of its biological constituents, the most active and well-studied compound is azadirachtin. Others are nimbin, salanin, epoxyazadiradione, and 12 deacetyl salanin among others.

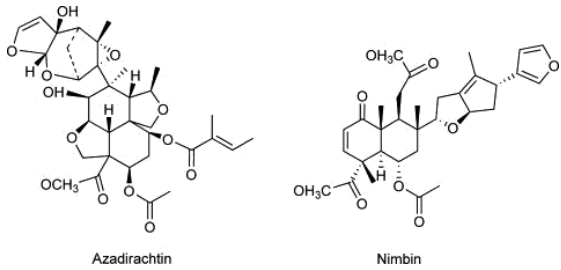


Figure 3: Some of the Terpenoid compounds in Neem seed oil (Mabberly, 1997).

Vice-Chancellor, sir, for the first time, we reported on the stability, safety, and repellent action of Neem seed oil cream as a **construct** against *Anopheles gambiae* mosquitoes, one of the vectors of malaria diseases. Neem seed oil was hauled out

from the ripe seeds of *Azadirachta indica* (A. juss) plant. The oil after characterisation, having satisfied standard specifications of biologically active oil was formulated using a vanishing cream base because of its cosmetic advantage at concentrations (0%w/w– 10.0% w/w) with 0% w/w serving as control formulation.

The formulations at storage temperatures 25^{o}C -30^{o}C were observed for physical changes using basic parameters over 12 months representing a long-term stability studies approach. Chemically, the formulations were investigated for changes in pH, viscosity, and specific gravity during the period of study
It was found out that neem seed oil in a vanishing cream base formulation was stable (**Aremu** and Femi-Oyewo, 2009a). The formulations also showed satisfactory microbial quality and integrity during storage (**Aremu** and Femi-Oyewo, 2009b**;** **Aremu** *et al*, 2009a).

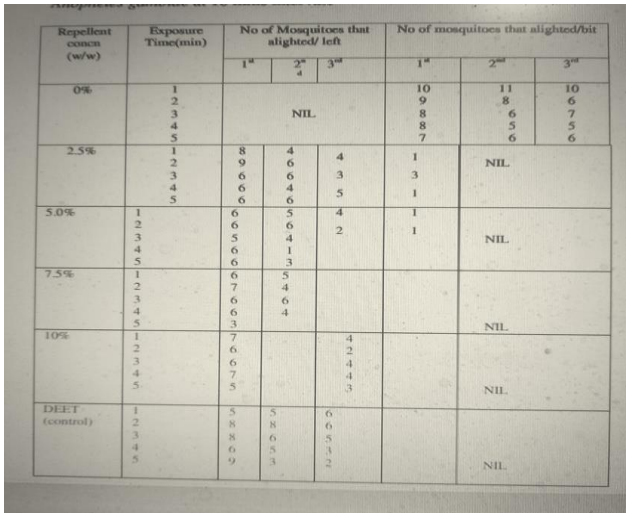
The safety of the dermal application of Neem seed oil cream was investigated. For any drug formulation, safety especially to the major organs is of utmost importance. Acute toxicity study was carried out with the application of neem seed oil cream to the dorsal part of both female and male albino rats for 14 days to observe any adverse effects and whether such is sex-related or not. Histopathologically, there was no breakdown in the architecture of the organs such as the liver and kidney. However minor irritations of the skin were observed, which eventually disappeared (**Aremu** *et al*, 2008).

In subsequent study, insect-repellent action against *Anopheles gambiae* mosquitoes was carried out. Prevention of mosquito bites is one of the main strategies to control or minimise the incidence of malaria disease. The use of insect repellents can provide practical and economical means of preventing mosquito-borne diseases (**Aremu** *et al*, 2009b).

The formulated creams were evaluated against disease-free Laboratory-reared *Anopheles gambiae* mosquitoes using human bait techniques (Tawatsin *et al*, 2006). A commercially available repellent Deet was used as control. Six volunteers (Age

23 – 50 years) participated in the laboratory tests. From this investigation (**Aremu** *et al*,2009b), we established that, the duration of protection of various concentrations of Neem seed oil cream and control (Deet) was of the order 10.0% > Deet> 7.5%> 5.0% >2.5% w/w. It is interesting to note that 10.0%w /w Neem seed oil cream was able to protect against mosquito bites longer than control (DEET) as shown in Table 1**.** It follows, therefore, that, Neem seed oil cream may present great potential against mosquito bites **(Aremu** *et al*, 2009b). It is worth noting that, Neem seed oil cream production can be supported by continuous sourcing of oil from natural sources without going through the rigour of synthesis. Table 1 below clearly shows the duration of protection of different concentrations of Neem seed oil and DEET (reference standard).

Table 1: Repellency Determination of various Concentrations against Anopheles gambiae at 10mins intervals



Repellent concn (w/w)	Exposure Time(min)	No of Mosquitoes that alighted/ left			No of mosquitoes that alighted/bit		
		1st	2nd 4	3rd	1st	2nd	3rd
0%	1 2 3 4 5	NIL			10 9 8 8 7	11 8 6 5 6	10 6 7 5 6
2.5%	1 2 3 4 5	8 9 6 6 6	4 6 6 4 6	4 3 5	1 3 1	NIL	
5.0%	1 2 3 4 5	6 6 5 6 6	5 6 4 1 3	4 2	1 1	NIL	
7.5%	1 2 3 4 5	6 7 6 6 3	5 4 6 4			NIL	
10%	1 2 3 4 5	7 6 6 7 5		4 2 4 4 3		NIL	
DEET (control)	1 2 3 4 5	5 8 8 6 9	5 8 6 5 3	6 6 5 3 2		NIL	

Source: (**Aremu** *et al*, 2009b)

Aremu and Ikuyajesin (2016) evaluated the antifungal activity (folklore claim) of Neem seed oil ointment, another **construct** against *Tinea capitis*. The fungus *Tinea capitis* has been a serious public health concern because of its easy transmissibility. It is usually caused by the species of *Microsporum, Trichophyton, and Epidermophyton* that invade the hair shaft, endemic in many countries afflicting primarily pre-pubertal children between 6 and 10 years. It is more common in males than females.

For safe delivery, there must be a release of the medicament from the vehicle. The drug release from the different concentrations of ointment prepared using oil extract from n-hexane solvent is shown in Table 2

Table 2: Mean *in-vitro* drug release of Neem seed oil ointment.

Sample	Time(hours) at 25ºC					Time(hours) at 37ºC				
	1 (cm)	2 (cm)	3 (cm)	12 (cm)	24 (cm)	1 (cm)	2 (cm	3 (cm)	12 (cm)	24 (cm)
NSO1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NSO2	0.30	0.50	0.80	1.10	1.10	0.30	0.90	1.20	1.35	1.35
NSO3	0.30	0.70	1.00	1.60	1.60	0.30	0.90	1.50	2.00	2.00
NSO4	0.40	1.00	2.00	2.70	2.70	0.40	1.00	2.00	3.0	3.00
NSO5	0.50	1.50	2.50	3.25	3.25	0.40	1.30	2.50	3.8	3.80

Source: (**Aremu** and Ikuyajesin, 2016).

The rate of release of Neem seed oil is greatly influenced by the diffusion coefficient, concentration, and solubility of the oil in the ointment base. It may be possible to predict the *in-vitro* availability of medicament from the vehicle base. Temperature

also affected the rate of release of Neem oil at various concentrations, higher at 37^{o}C than 25^{o} C as can be seen in Table 2. This is possibly so because the temperature can alter the diffusive tendency of drugs in ointment base at elevated temperatures due to an increase in the fluidity of the base (**Aremu** and Ikuyajesin, 2016).

Neem seed oil ointment formulations had higher zones of inhibition at 7.5% w/w, 10.0% w/w against *Trichophyton violaceum*, and at 5.0% w/w, 7.5% w/w, 10.0% w/w against *Epidermophyton flocussum* than the reference standard (Whitfield's Ointment). This suggests that Neem seed oil ointment could be useful as an alternative in the treatment of *Tinea capitis.*

Mr. Vice-Chancellor, we went further in carrying out a pre - clinical evaluation of Neem seed oil (NSO) cream as an antifungal agent dermatologically, by recruiting human volunteers after necessary protocols had been established. The *Pityriasis versicolour* infection of the skin of one of the patients is shown in Plate 1, the patient responded positively to Neem seed oil cream as shown in Plate 2.At concentrations 7.5% w/w and 10.0% w/w, the formulations showed excellent improvement in the clinical conditions of the patients as shown in Plate 2. They compared favourably with the commercial sample. This points to the fact that this herbal formulation will be a useful product commercially (**Aremu** and Femi-Oyewo, 2008). Plate 1 below shows the side face of one the patients before application of different concentrations of neem seed oil cream and the reference sample (Whitfield ointment).

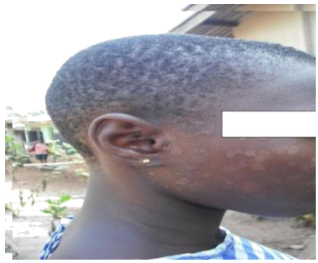


Plate 1: Side face before application of 10%w/w NSO cream (**Aremu** and Femi-Oyewo, 2008).

Plate 2 below shows the face after two weeks post application of 10%w/w NSO cream.

Plate 2: Side face post application of 10%w/w NSO cream (**Aremu** and Femi-Oyewo, 2008)

In another work, we formulated and **constructed** NSO suppository for usage in the hemorrhoidal condition of anorectal region. In this study, oil hauled out from the Neem seed was used as an active ingredient in an anti-inflammatory suppository formulation using macrogol (MG) and dika fat (DF) as bases. Suppositories are solid dosage formulations intended to be inserted into the body orifices where they melt or disperse to deliver medicaments in order to elicit local or systemic effects. Some authors have categorised this dosage form as semi-solid (**Aremu**, 2021). Suppositories are gaining more prominence as alternative dosage forms to other dosages because of the

drawbacks of the latter (**Aremu** *et al*, 2019a). They can be designed to deliver several medicaments such as antibiotics, antimalarials, anti-inflammatories, analgesics, contraceptives, anti-emetics, herbal remedies et cetera.

Neem seed oil was further characterised for fatty acid composition. Gas chromatography of Neem seed oil reveals seven major peaks as shown in Figure 4 and identified from the NIST library to be, octadec-9-enoic acid (47.69 %), palmitic acid (23.07 %), stearic acid (20.22 %), stearic acid ethyl ester (9.88 %), palmitic acid ethyl ester (3.50 %), and eicosanoic acid (0.91 %) and squalene (1.37%).

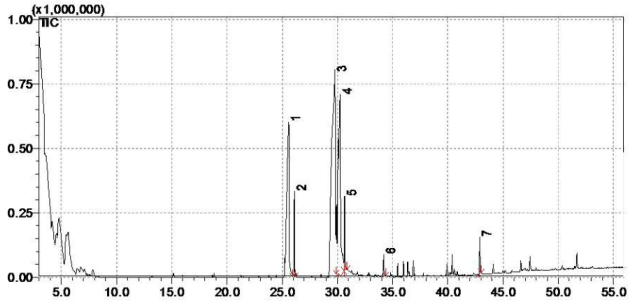


Figure 4: Gas Chromatography Spectrum of Neem Seed Oil (**Aremu** *et al*, 2019a)

Fatty acids are broadly occurring in natural fats and dietary oils and they play an imperative role as nutritious substances and metabolites in living organisms. Many fatty acids are well-known to have antimicrobial, anti-inflammatory properties. Squalene, one of the compounds identified in the GC-MS analysis of NSO is known to play a part in immunomodulation and wound healing. This is as a result of a rise in the generation of anti-inflammatory cytokines such as IL-10, IL-13, and IL-14 and a consequent decrease in pro-inflammatory cytokines like TNF-α. Palmitic acid ethyl which was one of the fatty acid esters identified during the analysis,

also possesses anti-inflammatory activity. Stearic acid (20.22 %) was one of the known compounds existing in substantial amounts. It can diminish cholestasis-induced liver injury which causes inflammation in the liver. The various anti-inflammatory components of NSO justified the formulation as a rectal dosage form.

In this study Neem seed oil suppositories were successfully formulated using both macrogol and dika fat with macrogols exhibiting better physicochemical characteristics. Therefore, it is a promising product for the alleviation of anorectal haemorrhoids (**Aremu** *et al*, 2019a).

Acalypha wilkesiana

The plant *Acalypha wikesiana* Mull Arg (Copper leaf) is a plant from the family Euphorbiaceae. The genus Acalypha comprises about 570 species (Ikewuchi and Ikewuchi, 2009), a large proportion of which are weeds while the others are ornamental plants. The plants are found all over the world, especially in the tropics of Africa, America and Asia. *Acalypha wilkesiana* is an evergreen shrub. It grows 3m high and spreads 2m across. The stem is erect with many branches andthe branches have fine hairs. It has a closely arranged crown. The leaves are coppery green with red splashes of colour. This gives a mottled appearance. The leaves are large and broad with teeth around the edge.

Figure 5: *Acalypha wikesiana* Plant (**Aremu** and Adekoya, 2016a).

Vice- Chancellor, sir, following the appropriate protocols, we formulated the leaf extract into an aqueous cream, another **construct** for antifungal evaluation, specifically against clinical isolates of *Tricophyton tonsurans* and *Epidermophyton floccosum*. *Acalypha wikesiana*. Leaf extract cream formulations, at concentrations of 7.5%w/w and 10.0%w/w, showed inhibition against *Tricophyton tonsurans*. This suggests that the formulation may be explored in the treatment of fungal infection, where specifically, *T. tonsurans* is implicated (**Aremu** and Adekoya, 2016a).

Bridelia ferruginea

The plant *Bridelia ferruginea* is a common medicinal plant in Nigeria and the commonest Bridelia species of the Savanah woodland occurring in other humid Savanah regions of Africa, especially from Guinea to Zaire, Mali and Angola. Its common names in Nigeria include Kirni, Kizni (Hausa), Maren (Fulani), Ora (Igede), Iralodan (Yoruba) and so on.

Figure 6: *Brideliaferruginea* plant (**Aremu** and Adewoyin, 2017).

The extract of the bark, leaves and roots of *Bridelia ferruginea* has been used ethnomedicinally for oral thrush ‘Efu’ in many parts of Nigeria. The bark and the bright red infusion from it are commonly sold in Nigeria markets. Similar use is made of a root decoction in Ivory Coast (Dada-Adegbola *et al.* 2010).

Mr. Vice-Chancellor, for the first time, **Aremu** and Adewoyin (2017), successfully developed a mouthwash formulation in the form of a solution dosage form as a **construct** and this was evaluated against *Candida albicans*, the fungal organism usually implicated in oral thrush. Nystatin suspension was used as a reference standard. We found out that, the mouthwash formulations inhibited the growth of *Candida albicans* in the order of increasing extract concentrations contained in them, with the highest concentration (2.5%w/v) exhibiting the largest zone of inhibition as shown in Table 3 below.

Table 3: Mean inhibition zones of *Brideliaferruginea* stem bark extract mouthwash solutions (mm)

Mouthwash solutions (%w/v)	**Candida albicans**
0.0	0.00
0.5	10.50 ± 0.71
1.0	12.50 ± 0.71
1.5	15.25 ± 1.77
2.0	20.50 ± 2.12
2.5	25.50 ± 0.71
Positive control	28.00 ± 1.41
(Nystatin oral suspension)	

Source: (**Aremu** and Adewoyin, 2017).

All formulated mouthwash solutions showed potential for use in the treatment of oropharyngeal candidiasis. The results of this study indicate that *Bridelia ferruginea* stem bark extract can be formulated into mouthwashes for oral use in treating oral thrush caused by *Candida albicans.*

We investigated and established safety of the liver and kidney through oral usage of *B.ferruginea* plant extract formulations, using balb/c mice (Shittu and **Aremu** *et al*, 2020; Shittu and **Aremu** *et al*, 2021). We found out that, upon histological evaluation of the liver obtained from the mice after exposure to different concentrations of *B. ferruginea* stem bark extract for 28 days revealed that 200,400, and 800mg treated groups had no alterations in the histology of the liver and kidney when compared with control group.

In another study, **Aremu** *et al* (2016) developed dermatological formulations of *B.ferruginea* stem bark extract and evaluated its antimicrobial properties against common organisms usually implicated in skin infections. All the cream formulations with extracts incorporated showed release. The rate of release of phytochemicals from the cream base was observed to be time-dependent. The nature of the cream and temperature could also affect diffusion, rate of release, and absorption of active constituents (**Aremu** *et al*, 2016; **Aremu** and Aremu, 2016; **Aremu** and Olawoyin, 2018).

All test concentrations had an inhibitory effect against organisms used. This inhibition was concentration-dependent. In this investigation, we established that *B. ferruginea* stem bark extract can be formulated into dermatological preparations for topical application in treating infections caused by *Staphylococcus aureus*, *Pseudomonas aeruginosa, Aspergillus niger*, *Trichophyton rubrum* and *Candida albicans*

Ceiba petandra and *Lanneakerstingii*

The plant *Ceiba petandra* belongs *to the* family *Malvaceae* and sub-family *Bombacoideae*. Its synonyms are *Bombax pentandrum*, *Ceiba caribaea*, *Eriodendronanfractuosum*, *Bombax ceiba*. It is commonly called Kapok tree or white silk cotton (English), Rimi, Riimaayee (Hausa, Nigeria), Vamber (Tiv, Nigeria), Kïng (Yandang, Nigeria), Ogungun, Araba (Yoruba, Nigeria), Akpu-ota (Igbo, Nigeria) (Doughari and Ioryue,2009). In the Nigeria folk medicine, *Ceiba petandra* is

used for the treatment of diabetes and infections. The leaves are used as laxative, similar to that of *Cassia podocarpa* (**Aremu** and Adefemi, 2003) and as infusion for colic in man and livestock. The leaves are used as curative dressings on sores. Decoction of boiled roots is used to treat oedema.

Lannea kerstingii belongs to the family Anacardiaceae. It is synonymous with *Lannea barteri*. *Lannea kerstingii* is locally called kondro (Bale, Ivory Coast), tudi (Hausa, Nigeria), kanchimbelli (Sisaala, Ghana), nimbiligh (Tiv, Nigeria). It is utilised in traditional medicine by various cultures worldwide, although its application varies by region.

Aremu *et al* (2017) developed various dermatological formulations of these plants and discovered that cream formulations of the stem bark extracts of *Ceiba petandra* and *Lannea kerstingii*, but not their combinations using modified Aqueous Cream (BP) possess satisfactory physicochemical characteristics to support further development. The antifungal properties of the cream formulations were evaluated (Kola-Mustapha and **Aremu** *et al*, 2014). Cream formulations containing extracts from only one of these plants are more promising rather than the combinations. In general, this study showed that *Lannea kerstingii* or *Ceiba petandra* extracts can be formulated into creams for potential use in treating infections caused by *Trichophyton rubrum* and *Trichophyton mentagrophytes*.

Acacia nilotica

Vice-Chancellor, sir, I am delighted to report that, through my supervision of the M.Sc work of Abu-Saheed Kamaldeen, the first candidate to graduate from the Faculty with a postgraduate degree, we were able to develop an oral antibiotic capsule from the *Acacia nilotica* seed extract. It was the first of its kind in the country.

After the granulation technology, to which the crystalline extract of *Acacia nilotica* seed extract (ANSE) was subjected to, alongside with essential adjuvants, encapsulation

into hard gelatin shells followed thereafter. The content of the capsule with regard to the extract was assayed. From the capsule formulation, each capsule is expected to have an average of 350mg of the extract. The official acceptance criteria with respect to the percentage content of capsules states that, the amount of drug content should be within the range of 85.0% to 115.0% of nine dosage units assayed with no unit of the range of 75.0% to 125.0% (BP, 2020). All the ten randomly selected capsules fell within the acceptance criteria which indicates that the capsules contained the desired quantity of extract ranging from 96.84 to 100.55%. A dosage form must contain an adequate quantity of the active ingredient, for it to elicit a fully desirable therapeutic response. A more than enough quantity may lead to overdose and elicit toxic effects, while less than required quantity may not give the desired therapeutic response. Similarly, conducting an *in-vitro* dissolution test is equally important. A dosage form that does not dissolve within the body system does not get absorbed and therefore, cannot elicit the desired therapeutic response. Thus, conducting the release profile of a newly formulated dosage form of a drug goes a long way to determining the bioavailability of the drug when eventually used. It also tells us to a large extent, the suitability or otherwise of the proposed dosage form. The official acceptance criteria state that there should be 80% dissolution of extract within 45 minutes for hard gelatin capsules (BP, 2020). From the result obtained in this study as shown in Figure7**,** more than 80% dissolution of the formulated capsule occurred within 30 minutes. At the 45-minute peak time, the *Acacia nilotica* seed extract capsules had dissolved about 85.93% of the extract. Figure 7 below clearly explains the dissolution profile of ANSE capsules, depicting what is likely to happen when ingested into gastrointestinal tract (GIT).

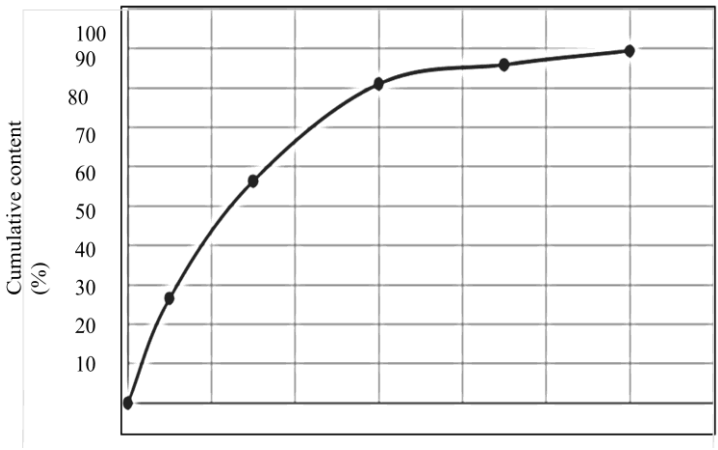


Figure 7: *In-vitro* Dissolution test of ANSE capsules **(**Abu-Saheed and **Aremu,** 2023).

` This shows that dissolution of the active medicament is within the official limit and it also shows the tendency of the formulation to act fast, after ingestion to elicit the desired therapeutic response within the physiological solution (Abu-Saheed and **Aremu**, 2023). Thereafter, ANSE capsules were tested against selected organisms following appropriate protocols. The inhibitory activity against the organisms is shown in Table 4. In this work, ANSE capsules were successfully formulated, and they demonstrated promising antimicrobial activities and therefore, could be explored as antibiotics, especially in gastroenteritis where one or more of the interrogated organisms could be implicated (Abu-Saheed and **Aremu**, 2023).

Table 4: Antimicrobial properties of ANSE and formulated capsules

Organisms	Extract (20mg/ml)	Extract (40mg/ml)	Capsule (20mg/ml)	Capsule (40mg/ml)	Control 1 (Lactose cap)	Control 2 (DMSO)
E.coli	17.50±0.58	18.25±0.50	18.50±0.58	19.00±0.00	0	0
S. aureus	19.75±0.50	19.50±0.58	19.00±0.00	19.25±0.50	0	0
Ps. Aeruginosa	18.75±0.50	19.00±0.82	17.50±0.58	18.50±0.58	0	0
C. albicans	18.00±0.00	18.75±0.50	18.00±0.82	18.75±0.96	0	0

Source: (Abu-Saheed and **Aremu**, 2023).

The Antimicrobial properties of the formulated ANSE capsules are stated in Table 4. At 20mg/ml, both the extract and the capsule exhibited the highest zone of inhibition against *S. aureus* when compared to other organisms used. Similar results were obtained for the 40mg/ml extract and capsules. The 20mg/ml extract had the lowest zone of inhibition against *E. coli* while the 20mg/ml capsule had the lowest inhibition against *Ps. Aeruginosa.*

Acacia nilotica seed extract was further developed into an ointment formulation, characterised and evaluated for its antibacterial activities. The effectiveness of the application of this ointment dermatologically was assessed by observing the effect of shear rate on the viscosity of the ointment formulations as presented in Figure 8. As the shear rate increased, the viscosity of the formulations decreased, indicating a shear thinning behaviour which implies that when the ointment is applied to the skin by applying rubbing force, flow will be enhanced, depending on the rate of shear. In addition, Figure 9, shows the rheological pattern of the ointment formulations with

a plot of shear stress against shear rate and it depicts pseudo plastic rheological flow. Ointments generally cling as films until stress is applied before they begin to flow. In terms of viscosity, the ointment formulations are acceptable (**Aremu** *et al*, 2020a)

Figure 8 below clearly illustrates the effect of the shear rate on the viscosity of the ointment, while Figure 9 shows the interplay between shear stress and shear rate as it affects the rheological behaviour of the ointment.

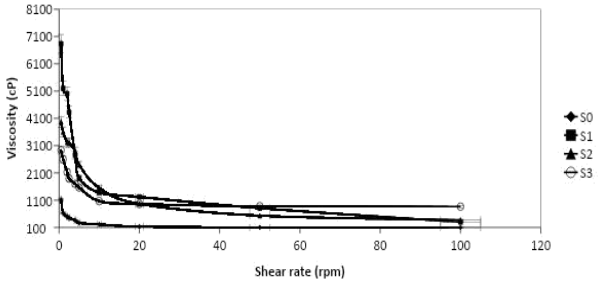


Figure 8: The effect of shear rate on the viscosity of the ointment formulations (**Aremu** *et al*, 2020a).S0 = formulation containing Shea butter alone. S1, S2 and S3 = formulations containing ANSE at concentrations of 5.0, 7.5 and 10.0 %w/w respectively.

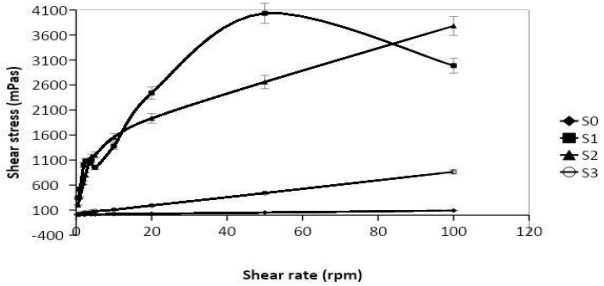


Figure 9: Shear stress versus shear rate plots for the ointment formulation (**Aremu** *et al*, 2020a).

Ointment formulation (10%w/w) of all the preparations demonstrated inhibitory activity against the six pathogenic organisms commonly responsible for human infections. This formulation also exhibited an impressive Minimum Inhibitory Concentration (MIC) of 0.5 mg/ml, wider zones of inhibition, with the highest value being 20.0±0.5 mm and broad spectrum of activity as it inhibited both Gram-positive and negative organisms. The ointment formulation at 10 %w/w concentration showed potential for use in the treatment of wound and skin infections. It could, therefore, be developed for commercial use (**Aremu** *et al*, 2020a).

Hyptis suaveolens

The plant, *Hyptis suaveolens* (L.) is also known as pignut, bush mint, horehound, wild spikenard and a variety of names in French, Portuguese, Spanish and Hindi (Witayapan *et al*, 2007). It is a plant which is usually known as a weed with a variety of medicinal and food uses cultivated in India and Mexico. It is a small erect plant usually about 2.5 m in height with a woody, hairy stem (Witayapan *et al*, 2007). It is a plant belonging to the family, Lamiaceae. It is basically considered an obnoxious weed and widely distributed throughout the tropics and subtropics. Almost every part of the plant has been reported to have medicinal properties. This plant is known for its strong smell which confers on it its insecticidal properties. It produces flowers and seeds in abundance annually which makes it a good candidate for pollination (Abagli and Alavo, 2011). It contains alkaloids, phenols, saponins and most importantly essential oils
The dermatological formulations of *Hyptis suaveolens* aerial extract were successfully **constructed**, they were oil-in-water emulsions, washable and cosmetically acceptable hence can find application as vanishing cream in addition to therapeutic importance. In addition, the pH of the formulated creams after exposure to different storage conditions had no significant change showing the stability of the active ingredient in the base. The creams had high viscosity values indicating the adherent

property to the skin surface after application. The fair to very high occlusion values showed that in addition to the therapeutic activity of these cream formulations, they will also help in preventing skin dryness, maintaining skin smoothness and elasticity. The globule size distribution as shown in Figure10, for all the formulations implied that the activity of the dermatological formulations will cut across the hair follicles, stratum corneum, follicular ducts and skin surface. However, the activity of the formulations against bacterial clinical isolates was not as encouraging as that of the standard strains. The cream formulations especially at higher concentrations of 5.0 and 7.5 %w/w exhibited significant antifungal activity against the tested microorganisms. The overall assessment indicates that the formulations have potential for development as a standardised dosage form for the treatment. of skin infections where the interrogated organisms are implicated. It could, therefore, be developed for commercial use (**Aremu** *et al*, 2020b). For brevity of the outcome, see Figure 10 below:

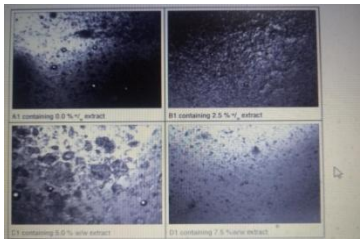


Figure 10: Photomicrographs of *Hyptissuaveolens* dermatological formulations showing dispersed globules (**Aremu** *et al*, 2020b).

Vernonia amygdalina

The plant *Vernonia amygdalina*, commonly called bitter leaf, is a perennial shrub of 2-5m in height that grows throughout tropical Africa. It belongs to the family, Asteraceae, and has a rough bark with dense black straits, and elliptic leaves that are about 6 mm in length. The leaves are green and have a characteristic odour and bitter taste (Sayed *et al*, 1982).We

investigated the folklore claim of the antifungal activity by extracting the leaves and then formulated them into an ointment. The medicated ointment was evaluated against common fungal organisms that are usually implicated in skin infections. The **construct** was successfully developed with satisfactory physicochemical characteristics and release patterns. We found out that, the herbal formulation of the leaf extract will be useful in the treatment of certain skin infections where *Tricophyton tonsurans* and *Tricophyton rubrum* have been suspected to be the causative organisms (**Aremu** *et al*, 2018).

Moringa olifera

The plant Moringa oleifera Lam. is a species of the family, Moringaceae.It is native to South Asia (India, Pakistan, Bangladesh and Afghanistan) but has been cultivated in the Philippines and the Sudan, Latin America and Africa. In Nigeria, *Moringa oleifera* has become naturalized and is popularly known as "Okwe-beke" by the Igbos, "Zogale" by the Hausas, and "Ewe igbale" by the Yorubas) (Evbuomwan*et al*, 2017).

Oil hauled out from the seeds of Moringa, was characterised and used in the development of suppositories aimed at alleviating haemorrhoids in the anorectal region. We found out that, in the GC-MS analysis (Figure 11**),** Moringa seed oil showed the presence of various compounds with 9-Octadecenoic acid (56.98 %) being more abundant compared to other compounds (Isimi and **Aremu** *et al*,2021). 9-Octadecenoic acid has been found to inhibit production of inflammatory agents in RAW 264.7 cells. Another fatty acid found in the GC-MS analysis of seed oil is n-Hexadecanoic acid which through enzyme kinetics study is known to inhibit Phospholipase A (2) which is involved in initiating inflammation. Figure 11 below further shows the distribution of fatty acids in Moringa oil.

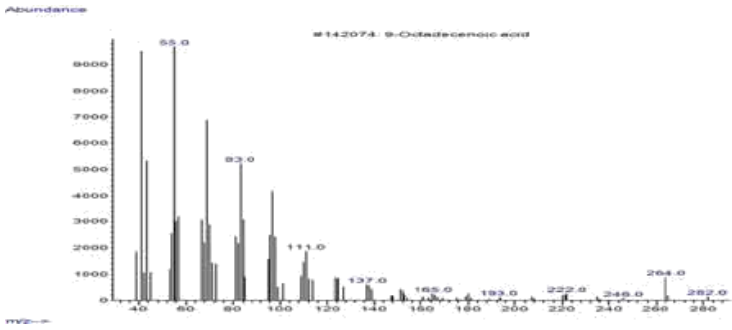


Figure 11: Gas chromatography spectrum of Moringa seed oil (Isimi and **Aremu** *et al*, 2021).

Croton oil is widely used to induce experimental haemorrhoids in laboratory animals. Treatment with suppositories prepared with Moringa seed oil caused a reduction of the RAC which is an indication of the reduction of inflammation as can be seen in Figure 12.

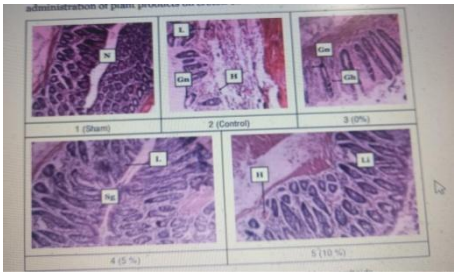


Figure 12: Effects of Moringa oil suppository on croton oil-induced haemorrhoids in Wistar rats. Li - lymphocyte infiltration, N - normal, H - haemorrhage, SG - normal gland, Gn - Glandular necrosis, GH - glandular hardening (Isimi and **Aremu** *et al*, 2021).

From various outcomes in this study, we were able to establish that**,** Moringa seed oil suppositories will be invaluable

in the treatment of anorectal inflammatory conditions and should be explored commercially (Isimi and **Aremu** *et al*, 2021).

Carica papaya

Carica papaya Linn (Caricacae) with common names Ibepe (Yoruba), Gwandau (Hausa), Paw (Australia), and Mamao (Braxil), exists in America, parts of Asia, India, and Africa as a tree-like herb with an extensive rooting system, 2 – 10m tall, usually unbranched, although sometimes branched due to injury, containing white latex in all parts (Fatope *et al*,1993) Carica species particularly the fruits, seeds and roots are known to contain papain among many biologically active compounds, papain is a proteolytic enzyme with a wide pH range has been used variously medicinally in combating dyspepsia and other digestive disorders, as dewormer in traditional veterinary medicine, antibacterial and antifungal.

The extracts of the root of both male and female species of plant were screened against selected gram-positive and gram-negative organisms. We were able to establish the antimicrobial activity of both extracts, requiring further development into viable **constructs** (**Aremu** and Adekoya, 2016b).

Mr. Vice-Chancellor, drugs are rarely administered alone to patients, but in form of dosage forms. A dosage form generally consists of a drug (drugs) together with a varying number of other substances (called excipients), that have been added to the formulation in order to facilitate the preparation, patient acceptability, and functioning of the dosage form as a drug delivery system.

In this lecture, I will report my modest contributions towards the development of locally available excipients, including those that I explored, while serving as a visiting consultant at National Institute For Pharmaceutical Research and Development (NIPRD), Abuja.

Gums and mucilages

Natural gums are long chains of sugars (polysaccharides) within native plants that are either water-soluble or capable of absorbing water. Mucilages are generally normal products of metabolism (physiological products) formed within the cell (intracellular formation). Gums readily dissolve in water, whereas mucilage forms slimy masses. Both gums and mucilages are plant hydrocolloids yielding a mixture of sugars and uronic acid on hydrolysis.

Beilschmiedia gum.

Natural and synthetic gums are used widely as binders in the formulation of tablets (**Aremu** and Itiola, 2002). Beilschmiedia gum known as 'gbokonisa' in Yoruba was investigated. *Beilschmiedia manii* is a plant that thrives well in Nigeria, especially in the Southern parts of the Country in Ogun and Cross River States. It grows very well in marshy areas and usually reaches up to 30-40 ft high and 3 ft in diameter with a spreading crown and straight pole.

We reported (Femi-Oyewo and **Aremu** *et al*,2009), the binding properties of Beilschmedia seed gum (BMSG) in paracetamol tablet formulations in comparison with gelatin BP. We found out that Paracetamol formulations containing Beilschmeidia gum had shorter disintegration and dissolution times than those produced with gelatin gum. The hardness, disintegration time and dissolution rate increased with an increase in the concentration of Beilschmiedia gum. The outcome suggests that Beilschmiedia gum possess potential as a commercial binding agent, especially in the production of antacid tablets which require fast disintegration (Femi-Oyewo and **Aremu** *et al*, 2009).

In another investigation, **Aremu** and Ogungbemi (2014) evaluated the binding properties of Beilshmeidia gum in comparison with official gelatin in the formulation of chloroquine phosphate tablets. Chloroquine is still the drug of

choice in treating malaria, where *Plasmodium vivax* is endemic (WHO, 2010).

In our work, we found out that The BMSG formulations were observed to have lower disintegration time than those prepared with gelatin as shown in Figure 13 and BMSG formulations were also observed to release a higher amount of the drug and at a faster rate than the gelatin formulations. This rapid dissolution rate shows that BMSG could be suitable for use as a binder in conventional tablets where the fast release of the drug is desired (**Aremu** and Ogungbemi, 2014).

Figure 13 below further explains the disintegration behaviour of the two binders interrogated.

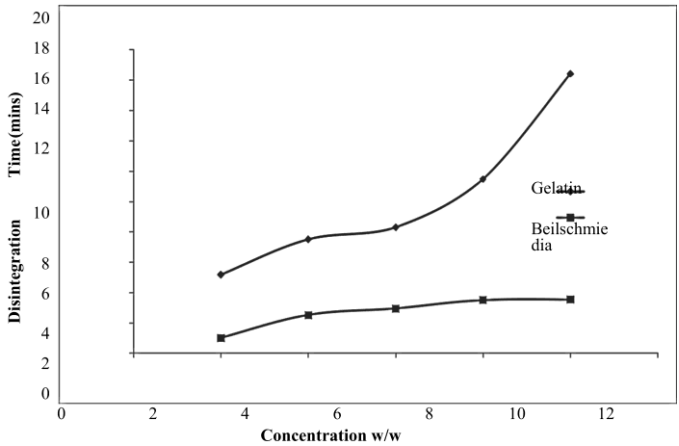


Figure 13: Effect of binder type and concentration on tablet disintegration time (**Aremu** and Ogungbemi, 2014).

***Abelmoschus esculentus* (okra) mucilage/Trona**

Aremu and Oduyela (2015) reported on the development of okra in combination with trona as a suspending agent. Gum of the *Abelmoschus esculentus* (Family Malvaceae) is a natural polymer consisting of D-galactose, L-rhamnose and L- galacturonic acid (Agarwal *et al*, 2001). Trona (Kaun in

Yoruba) is an evaporite mineral also known as Sodium sesquicarbonate. A white crystalline hydrated double salt, Na2CO3.NaHCO3.2H2O is soluble in water but less alkaline than sodium carbonate and decomposes on heating.

In our investigation (**Aremu** and Oduyela, 2015), we formulated metronidazole suspension commonly associated with caking problems during storage due to agglomeration of the particles overtime. We aimed to solve this problem and at the same time, develop the two natural agents as viable substitutes to the commonly used compound tragacanth BP as suspending agents. We assessed different formulations containing purified okra powder, a combination of okra and trona (4:1) and those containing conventional Compound Tracaganth BP.

We found out that, the sedimentation volume and viscosity were directly proportional to the concentration of the suspending agents (Table 5). The reverse case was observed with the flow rate. This observation is similar to our earlier work (**Aremu** *et al*, 2010). The study revealed that metronidazole suspensions formulated with the combination of okra and trona and those containing okra alone as suspending agents have better suspending properties when compared to the conventional Compound Tragacanth BP. On the other hand, metronidazole suspension formulated with the combination of okra and trona showed an observable improvement in its suspending properties when compared with those containing okra alone especially at higher concentrations, inferring that the addition of trona improves the suspending property of okra gum. It can, therefore, be concluded that the addition of trona in a concentration ratio of 1:4 to okra gum as a suspending agent, influences and have better physicochemical properties of the metronidazole suspension, especially at higher concentration. Therefore, the combination of locally sourced okra and trona has the potential to be used as a suspending agent, especially in suspensions experiencing caking problem as a result of sedimentation such as metronidazole suspension.

Table 5 below further illuminates, for better understanding, the sedimentation characteristics of all the suspending agents used in this study.

Table 5: Effect of varying concentration of suspending agent on the sedimentation volume of Metronidazole suspension **(Aremu** and Oduyela, 2015).

SUSPENDING AGENTS	CONCENTRATION OF SUSPENDING	SEDIMENTATION VOLUME(cm3) TIME (days)									
	AGENT (%w/v)	0	5	10	15	20	25	30	35	40	45
COMPOUND	1	1.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
TRAGACANTH	2	1.00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.10	0.10
GUM	3	1.00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
	4	1.00	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.12	0.12
	5	1.00	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.12	0.12
OKRA GUM	1	1.00	0.18	0.17	0.17	0.16	0.16	0.16	0.16	0.16	0.16
	2	1.00	0.27	0.27	0.26	0.26	0.25	0.25	0.25	0.25	0.25
	3	1.00	0.36	0.35	0.35	0.35	0.34	0.34	0.33	0.33	0.33
	4	1.00	0.48	0.45	0.45	0.45	0.45	0.43	0.42	0.42	0.41
	5	1.00	0.58	0.53	0.53	0.53	0.53	0.52	0.49	0.48	0.46
OKRA AND	1	1.00	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
TRONA IN	2	1.00	0.29	0.29	0.28	0.28	0.28	0.28	0.28	0.28	0.28
RATIO 4:1	3	1.00	0.43	0.41	0.39	0.38	0.38	0.38	0.38	0.38	0.38
	4	1.00	0.47	0.43	0.43	0.42	0.42	0.42	0.42	0.42	0.42
	5	1.00	0.77	0.68	0.66	0.65	0.65	0.64	0.64	0.62	0.60

FATS

Fats are lipids obtained from different sources such as plants, and animals e.g. pigs, goats and cattle They usually exist as solids of complex mixtures at room temperature, consisting of a high proportion of saturated fatty acids. Fats from different animals have different textures and melting points and in some climes, are consumed as part of a diet (**Aremu** *et al*, 2020c), They are sometimes incorporated as enhancers of food taste, texture and flavouring agent.

Irvingia gabonensis

Wild mango (*Irvingia gabonensis*, Aubry Lecomte ex O'Rork-Baill, family: Simarubaceae) grows naturally in parts of Africa extending from Senegal to the Sudan and to the South of Angola. It is available between July and October. It grows about 40 m in height with a straight bole of up to 100 cm in diameter. It can be found in the tropics, where it is highly-valued for multiple uses, one of which is the edible seeds used in soups (Ogbono- Igbo) and as a food flavour (Ogunsina *et al*, 2008). The fat extracted from the seeds of *Irvingia gabonensis* (Dika fat) was explored as a suppository base (vehicle) in comparison with reference bases such as Cocoa butter, Macrogol and a combination of cocoa butter and beeswax in the formulation of Promethazine Hydrochloride rectal suppositories. Possible interaction between the bases and the medication was assessed using the Fourier transform infrared spectroscopy (FT-IR), in addition to drug content uniformity and evaluation of the release of the medicament from the base, to ensure **safe delivery.**

Our key findings showed that, Dika fat yields 51.3% w/w. The fat obtained was a light yellow-coloured solid with its characteristic odour. The yield can sustain commercial production because of the availability of the seeds all year round.

The FTIR spectra of PMZ, Dika fat, Macrogol as well as suppositories containing PMZ with Dika fat and PMZ with Macrogol revealed that the PMZ spectrum showed principal peaks at 2200-2480 cm-1 for NH+ stretching, at 1453 cm-1 for CH_3 and CH_2 bending and 756 cm-1 for out of plane CH bending of disubstituted aromatic respectively. The prominent bands displayed by the PMZ spectrum are also present in the suppository containing Dika fat at 2344 cm-1 and 723 cm-1 respectively. The presence of these same absorption bands as the pure drug demonstrates the absence of interaction between the drug and suppository base (Dika fat) used. However, there was complete deletion of the disubstituted aromatic band and a considerable shrinkage of the absorption bands representing NH^+stretching for CH_3 and CH_2 bending in the suppository

containing Macrogol, implying some level of interactions between the drug and suppository base (Macrogol) used (**Aremu** *et al*, 2020c).

The mean drug content in the suppositories met the USP requirement for content uniformity. The mean drug content of the four batches fell within 96.7- 99.2% as can be seen in Figure 14.Drug release is an important property of a therapeutic system, constituting a prerequisite to absorption of the therapeutic agent and one that contributes to the rate and extent of active availability to the body when intended for systemic action or easy availability when it is for local action. The *in-vitro* dissolution study revealed that the release rate was higher in oil-soluble bases compared to the water-soluble base. Suppositories produced with macrogol exhibited poor release characteristics with 43.6 % of drug released as against 75% released with suppositories produced with Dika fat in 45 minutes as can be seen in Figure 15. Promethazine hydrochloride is a water-soluble drug, the affinity of macrogol for water-soluble drugs may promote the entrapment of the drug and hinder the drug release as observed. Figures 15 and 16 below further illustrate the content and the release of the promethazine hydrochloride from the suppository base respectively.

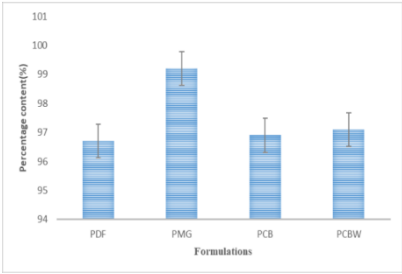


Figure 14: Percentage content of Promethazinesuppositories (**Aremu** *et al*, 2020c).

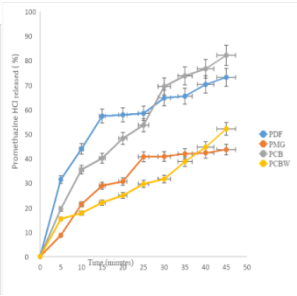


Figure 15: Release profile of Promethazine hydrochloride suppositories (**Aremu** *et al*,2020c).

PDF=Promethazine HCl+Dika fat,
PMG=Promethazine HCl+Macrogol base,
PCB=Promethazine HCl+cocoa butter,
PCBW=Promethazine HCl +cocoa butter+10%w/w beeswax.

Out of the four suppository bases interrogated such as Dika Fat, macrogol, cocoa butter and blend of cocoa butter and beeswax, Dika fat which is obtained from an abundant plant source in the tropics may be a very good substitute to the more expensive bases. It was also established in this work that there is chemical interaction between Promethazine hydrochloride and macrogol as a base (**Aremu** *et al*, 2020c).

Cow fat/Palm kernel oil

Animal fats are largely used in the production of margarine, pastries and food flavours. Technically, animal fats have been employed as adjuvants in food, paint, paper, cosmetic as well as pharmaceutical industries. Recently, they have been found application in renewable biofunctional building blocks for the manufacture of plastics or biopolymers. Acetylsalicylic acid was formulated into suppositories using cow fat admixture either with palm kernel oil or liquid paraffin and compared with cocoa butter blends as bases ultimately to eliminate the untoward effects of a conventional oral delivery form of the drug. For biological activity to be effected, the drug must diffuse out of the

bases. The release pattern of acetylsalicylic acid from the suppositories is shown in Figure16

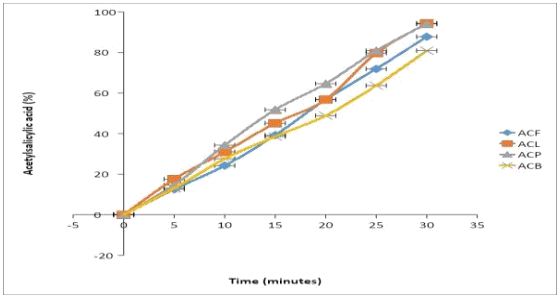


Figure 16: Release profile of Acetylsalicylic acid suppositories (**Aremu** *et al*, 2019b).

ACF= acetylsalicylic acid + cow fat; ACL= acetylsalicylic acid +cow fat /liquid paraffin (3:1); ACP= acetylsalicylic acid + cow fat/palm kernel oil (3:1); ACB= acetylsalicylic acid + cocoa butter.

Acetylsalicylic acid suppositories using cow fat, cow fat/liquid paraffin (3:1), and cow fat/palm kernel oil (3:1) were successfully formulated and characterised. All the three bases especially, cow fat/liquid paraffin (3:1) have the potential for usage in the formulation of suppositories that could withstand storage in the tropics (**Aremu** *et al*, 2019b).

Goat Fat

In another investigation, we used Goat fat and its binary blends, either with palm kernel oil or liquid paraffin in comparison with blends of cocoa butter and its blends in the formulation of Acety-salicylic acid (ASA) suppositories. We found out that, GC-MS spectra show that goat fat contains mainly long-chain fatty acids and methyl esters; chiefly cis-vaccenic acid (52.29 %), saturated fatty acids such as octadecanoic acid (38.26 %), hexadecanoic acid also known as palmitic acid (8.46 %) and alcohols. Vaccenic acid (VA) is a positional and geometric isomer of oleic acid and is reported as

the predominant trans-isomer in ruminant fats. The chemical and physical stability, non-reactive and widely compatible properties of these fatty acids confer on goat fat the properties of a good suppository base. From the release profile (Figure 17), the release mechanism of acetylsalicylic acid from the suppositories was analysed with the Korsmeyer-Peppas model. The release exponents, n, for all the formulations, range from 0.76 to 0.98. These values of 'n' for all the formulations were greater than 0.5 suggesting non-Fickian diffusion mechanisms of drug release from the suppositories**.** It indicates that the release. of the drug from the bases involves the melting of the base and partitioning of the drug between the molten base and the dissolution medium. The non-Fickian diffusion mechanism can ensure better release of the medicament, faster absorption and timely onset of action.

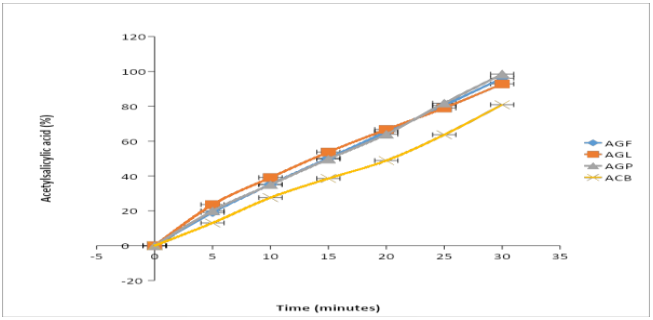


Figure 17: Release profile of Acetylsalicylic acid suppositories (**Aremu** *et al*, 2019c).

AGF= Acetylsalicylic acid + goat fat; AGL= Acetylsalicylic acid + Goat fat/ Liquid Paraffin (3:1); AGP= Acetylsalicylic acid + Goat fat/Palm kernel oil (3:1); ACB= Acetylsalicylic acid + Cocoa butter.

The binary blends of goat fat with palm kernel oil or liquid paraffin may be a very good substitute for the more expensive bases (**Aremu** *et al*, 2019c).

Vice-Chancellor, sir, a formulation scientist can be likened to an automobile engineer, where there is vehicle and there is the passenger. In our **construct,** the excipient is the vehicle and the API is the passenger. Auto vehicles are designed to deliver **safely s**o also our **construct**. Besides, there are elements of science and engineering in all we do. The science is the 'pharmaceutics', the engineering is the 'technology' or 'industrial pharmacy'. Therefore, all that, I have been saying are revolved around science and technology. Further to this is some process engineering we embarked upon.

In our investigation of certain processes, Ajala and **Aremu** *et al* (2011) and Peter and **Aremu** *et al* (2018), we varied compressional pressure, granulation (direct compression and wet granulation methods) and the excipients (directly and non-directly compressible materials) and assessed the mechanical properties (crushing strength, friability and crushing strength-friability ratio) and release properties (disintegration and dissolution time) of paracetamol tablets. The outcome indicated that tablets produced through the wet granulation method had higher values of CSFR/DT ratio than those produced through the direct compression method. The CSFR/DT ratio has been suggested as a better index for measuring tablet quality than the crushing strength-friability ratio because, in addition to measuring tablet strength (crushing) and weakness (friability)**,** it simultaneously evaluates all negative effects of these parameters on disintegration time. In general, higher values of the CSFR/DT ratio indicate a better balance between binding and disintegration properties. The release kinetics of paracetamol tablets were observed to be influenced by the interplay of variables involved such as compressional pressure, formulation excipient and method. The wet granulation method was found to birth optimum release compared to direct compression. This suggests that by employing the wet granulation method, with carefully selected excipients and optimal compressional pressure, a better-quality paracetamol product can be achieved.

Conclusion

Mr. Vice-Chancellor, in this lecture, I have expounded on diverse **formulations** and the development of various **constructs** in the form of dosage forms. I have illustrated, in most cases, the **delivery** patterns leading to eventual therapeutic actions. In addition, I have highlighted the significance of developing herbal medicine dosage forms as viable alternatives to synthetic or imported medicines, particularly in the treatment of common ailments, such as skin infections, mouth infections (candidiasis), gastrointestinal infections (gastroenteritis), and the control of malaria burden through usage of repellents, among others. Furthermore, I also enunciated on the development of some locally sourced excipients. In all, I shed light on insights from 10 medicinal plants and 6 excipients that can be translated, given the will, into actual utilisation. These plants are naturally available in our environment, as ordained by God right from the time of creation '*Then God said, let the land produce vegetation: seed-bearing plants and trees on the land that bear fruit with seed in it, according to their various kinds. And it was so…* (Genesis 1:11). Beyond their availability in the wild, scientists have also established various cultivation methods for these plants. In other words, sustainable sourcing is guaranteed. Challenges such as impurities and variation in the yield and quality of plant materials as a result of geographical location can be overcome through further standardisation. Therefore, the time to look inward for the availability of medicines is **now.** A focus in this direction will eventually lead to a reduction in the demand for foreign currency, medicine security, a boost in agricultural activities, and ultimately a better economy. I urge our industries to take advantage of these budding opportunities.

Recommendations

A. Government

1. The establishment of pharmaceutical **raw materials** manufacturing industries, where synthetic and herbal raw materials can be processed for sale to finished products manufacturing industries cannot be overemphasised. Tax waiver for at least five years should be granted willing investors.
2. There should be a tripartite arrangement whereby, government will be willing to purchase the non-sponsored **patented products** from researchers and invariably collaborate with manufacturing industries for translation into commercial products.
3. Phased banning of importation of raw materials and finished products, commencing with basic products for the treatment of common ailments like malaria, infectious diseases, haemorrhoids, cough and so on.
4. A policy from government on domestication of herbal pharmacy section to run alongside with orthodox pharmacy to enable the patient's choice, in all our hospitals as practiced in China and many other countries of the world should be enacted.

B. Industries

5. Our industries must develop a change of attitude towards embracing locally available raw materials. A deliberate effort to collaborate with researchers by way of grants as it is done in developed countries of the world is strongly advocated.

C. Institutions

6. Introduction of the collegiate system in all Faculties of Pharmacy in the country, to reflect current realities, so as to run programmes such as B.Sc Herbal medicine, B.Pharm, PharmD amongst other degree programmes as practiced in many countries of the world.
7. Setting up of Drug Research and Manufacturing Unit (DRMU) in our home Faculty. This can be achieved through Public Private Partnership (PPP) arrangement. This will be a goldmine venture for the University.
8. The immediate creation of at least Herbal Pharmacy either in the Faculty or in the Health Center of the University of Ilorin is hereby advocated. Faculty of Pharmacy, OAU, Ile-Ife is a model to emulate where they operate "Village Chemist" They sell and dispense herbal medicines to the needy.

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Vice-Chancellor, sir, permit me to end this trajectory with this song.

Mo yin yin logo o, ibi e sinmi de, me mo pe mo le de be o. Mo yin yin logo o

Thank you all for listening.

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