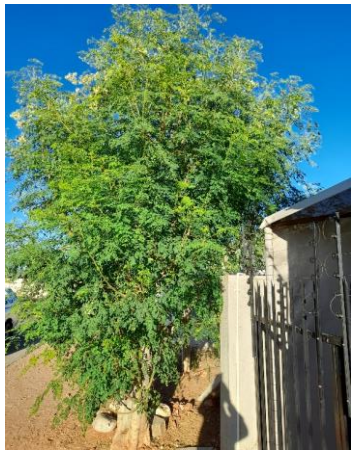
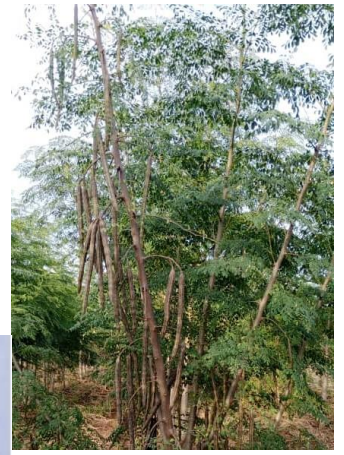
Moringa-Based Green Circular Economy: A Contribution of Curiosity-Driven and Applied Research of the Miracle Tree





By

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PROFESSORIAL INAUGURAL LECTURE
10 November 2022

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Outline of Presentation

- Introduction – Why Moringa-based circular economy?
- Basic and Applied Research
- Moringa Seeds Circular Economy
- Moringa Leaves Circular Economy
- Conclusion
- Acknowledgements

Moringa Species

- M. oleifera
- M. arborea
- M. borziana
- M. concanensis
- M. drouhardii
- M. hildebrandtii
- M. longituba
- M. ovalifolia
- M. peregrina
- M. pygmaea
- M. rivae
- M. ruspoliana
- M. stenopetala

M. peregrina

M. oleifera from Iran

M. oleifera from Botswana

M. stenopetala,
Cimbebasia, Windhoek

M. ovalifolia, Namibia

M. stenopetala

M. oleifera

M. ovalifolia

Why Moringa?

Seedlings




Cuttings

1. Easy to Grow

2. Fast Growing

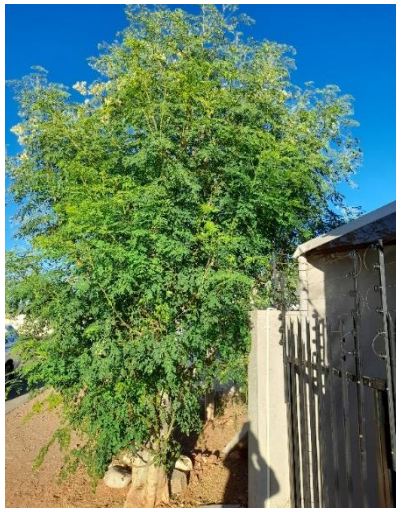
Why Moringa?

20/01/2021

15/04/2021

01/06/2021

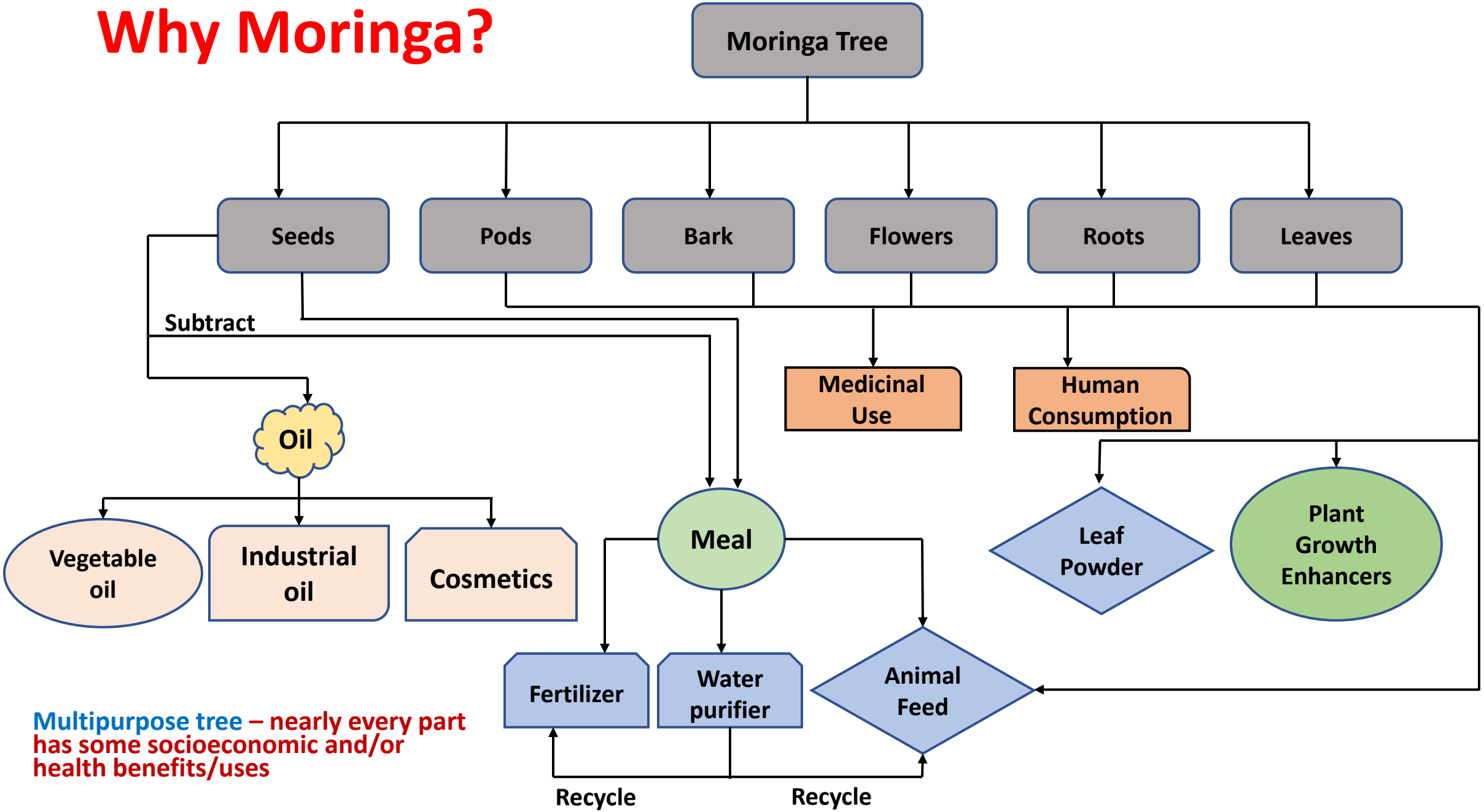
24/10/2021



10/11/2021

Easily blossoms!!

Why Moringa?



Multipurpose tree – nearly every part has some socioeconomic and/or health benefits/uses

Maze of Moringa Uses

Malaria

Cosmetics

Disease Prevention, e.g. Covid-19

Water Purification

Nutrition • **Disease Prevention** • Ointment • Alley Cropping • Fertilizer Erosion Control • **Water Purification** • **Cosmetics** • Textile Printing • Insecticide • Fungicide • Lubricants • Tanning Leather • Dye • Fiber Products • Fences • Ornamentation & Shade • Wind Barrier • Cane Juice Clarifier • **Honey Production** • Clarifier • Condiment • **Cooking Oil** • **Food** • Traditional medicine: Anemia • Anxiety • Asthma • Blackheads • Blood impurities • Blood pressure • Bronchitis • Catarrh • Chest congestion • Cholera • Colitis • Conjunctivitis • Cough • **Diabetes** • Diarrhea • Dropsy • Dysentery • Eye and ear infections • **Flu** • Fever • Glandular swelling • Gonorrhea • Headaches • Hysteria • Intestinal worms • Jaundice • Lactation • **Malaria** • Pain in joints • Pimples • Pregnancy • Psoriasis • Respiratory disorders • Scurvy • Semen deficiency • Skin infections • Sore throat • Sores • Sprain • Stomach ulcers • Tuberculosis • Tumor • Urinary disorders • **Wounds** • **Biodiesel** • **Plant Growth Enhancer** • **Arthritis**

Blood pressure

Diabetes

Food

Why Moringa?

such as sweeping the streets and collecting garbage on a daily basis.

They were paid between N$650 and N$700 per month for their services.

If they worked overtime (on Saturdays and Sundays) some workers could make at least N$900 per month.

The decision to terminate the contracts of the temporary workers comes after an internal investigation into allegations of maladministration and corruption at the town found

comply with the recommendations of the investigation.

He said this is aimed at ensuring that the municipality maintains good corporate governance and best management practices.

Simvula said other recommendations contained in the report of that investigation would also be implemented.

The concerned investigation conducted by the Ministry of Urban and Rural Development in 2019 revealed widespread maladministration,

cated from owners and transferred to municipal workers.

The report further unmasks various schemes through which municipal bosses have been paying themselves irregular housing and vehicle allowances without owning houses and vehicles, among other things.

The targeted workers staged a demonstration last week to express their disappointment with the move to terminate their contracts.

They are claiming they are entitled to be employed on permanent

which is representing the concerned workers, has also expressed disappointment with the municipality's decision.

Nanlo's Evilastus Kaaronda yesterday said the municipality was acting in bad faith, as it failed to provide an opportunity for negotiations with the workers.

Kaaronda said Nanlo has advised the workers to file a case with the Office of the Labour Commissioner.

"Grootfontien is being mismanaged. These people have rightful expectations. That recommendation is in contradiction with the Labour Act," he said.

Zambia: 208 912 cases; 3 647 deaths
204 847 recovered
393 212 full vaccinations
Botswana: 178 050 cases; 2 367 deaths
Zimbabwe: 129 919 cases; 4 607 deaths
Angola: 55 583 cases; 1 513 deaths

Source: Johns Hopkins University; Ministry of Health and Social Services; South Africa Department of Health; Zambia Ministry of Health

Epembe water woes continue

• ANNA SHINANA

THOUSANDS of people in the Ohangwena region are forced to resort to unhygienic methods of accessing water, such as digging wells, to take care of their most basic human needs.

The water crisis at the Epembe constituency affects about 14 837 inhabitants.

"People still have no access to clean water. The situation is bad," says concerned community member Jason Fillipus. "People need water. The Epembe council must make sure that water is given to the inhabitants in their jurisdictions.

"How do these people sleep at night when others have no access to clean water? Yet they promised to fight and bring services to their people," laments Fillipus.

Water from wells is shared by both humans and animals. This precarious situation came about after water provisions were cut due to a accumulated debt owed to the Directorate of Rural Water Supply (DRWS) which has not been settled.

Families that utilise the government-provided water points are required to pay a certain fee each month to keep the taps running, with committees tasked to collect fees. A lack of cooperation amongst villagers has been observed, however, as some pay up while others fail to do so.

Epembe is a constituency in the Ohangwena region, on the Angolan border. Several villages such as Eenheni, Etapa, Onhinda, Omuhongo, Onaame and Onamundidi are located in the consistuency.

"This is unbearable owing to the fact that Namibia is a dry country and people and animals have nowhere to get water," charges concerned community leader Thomas Fillemon.

The community is appealing to the government to show them some mercy.

"Government parastatal NamWater must write off the debt incurred by our people. We need long-term solutions for the water scarcity experienced in the region. Most people are poor and unemployed, and can't afford to pay for water. Government should also rehabilitate all boreholes left after road construction from Oshikunde up to the Ohangwena and Kavango border so that people in the surrounding villages can benefit from them," pleads community member Alufeusa Eliud.

Ohangwena region governor Walde Ndevashiya confirms that the region is in dire need of financial resources to address the ongoing problem of water shortages.

"Most constituencies in the region do not have reliable sources of potable water and many people depend on salty and contaminated water from ageing boreholes," Ndevashiya says.

"The community should be patient, their concerns have been noted by the government. We know that there is a crisis where water is concerned. We just need them to be a bit more patient," he adds.

File photo

UNHYGIENIC ... People at the Epembe constituency of the Ohangwena region draw water from a well at Onhinda village.

24/10/2013

29/10/2013

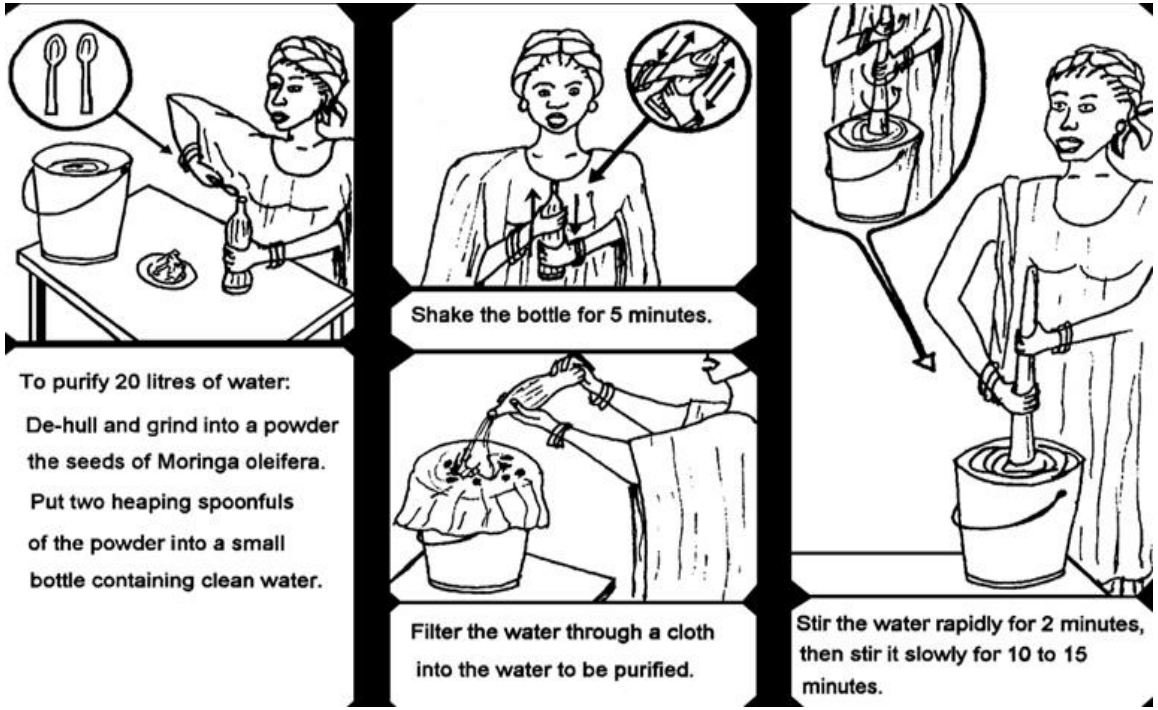
Why should Namibia have such headlines when it has the environmental conditions for the miracle tree?

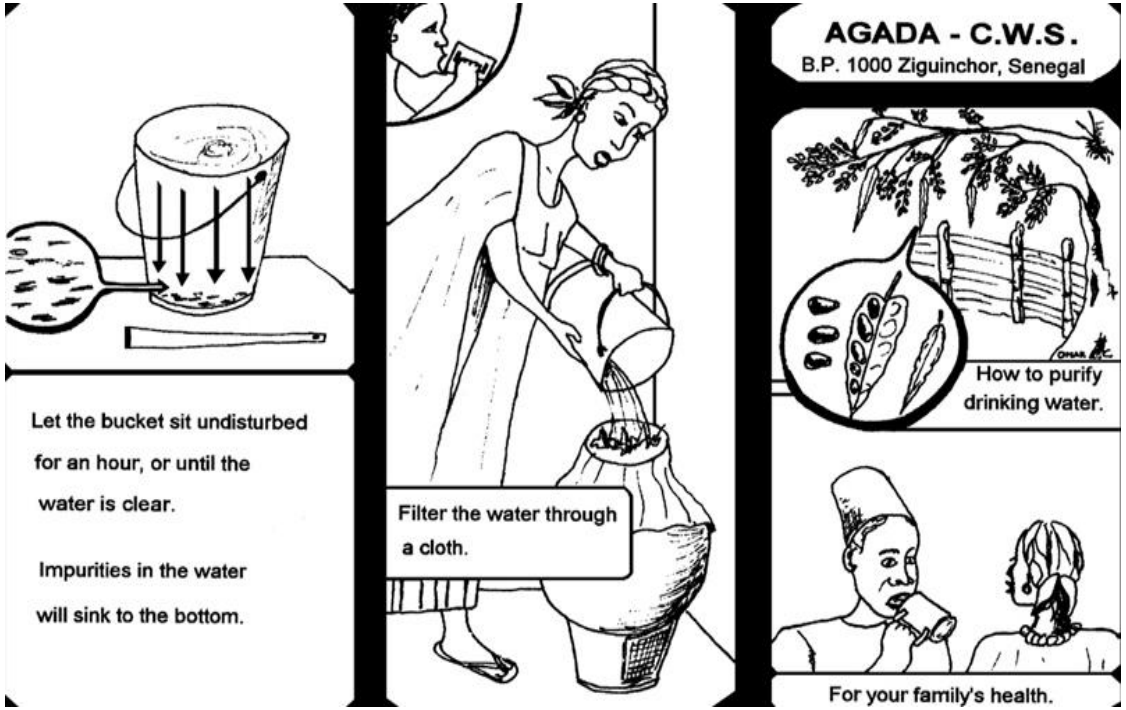
Three Basic EVILS of Water Crisis

- Too Much (= Flooding)
- Too Little (= Drought)
- Too Dirty (= Pollution)

Water is Life, Sanitation is Dignity

Historical water treatment process using Moringa seeds





Why and how does it work?

Water Treatment

Moringa tree

Seed pods

Moringa Seeds

Seed kernels

Grinding and sieving the seed powder

Seed powder

?

?

?

Coca Cola

Tapwater - Windhoek

?

3 Prototypes

BASIC RESEARCH EXPERIMENTAL WORK

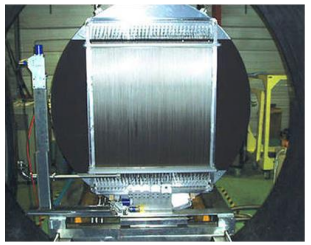
- Extraction and purification of seed proteins
- UV-Vis spectroscopy
- FTIR spectroscopy
- Density measurements
- Capillary viscometry
- Amino acid composition
- Elemental analysis
- Surface tension measurements
- Steady-state fluorescence spectroscopy
- Circular dichroism (CD) spectroscopy
- Zeta potential measurements
- Dynamic light scattering
- Neutron reflection and Neutron Scattering
- etc.

NIST Center for Neutron Research, MD, USA

Institut Laue-Langevin, Grenoble, France

ISIS Rutherford Appleton Laboratory Harwell Oxford, UK

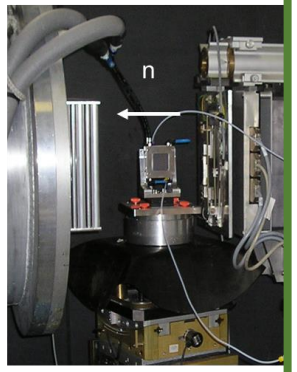
30 m SANS, NIST Center for Neutron Research (NCNR), Maryland, USA



D22 and D11, ILL, Grenoble, France

SANS2D – ISIS, Rutherford, UK

BT5 USANS, Loading Samples, NIST Center for Neutron Research, Maryland, USA



D17 reflectometer ILL, France

Moringa tree

Dry pods

Seeds

De-shelling

Seed kernels

Grinding

Seed Powder

Extraction of oil

Moringa Seed Oil

Seed Cake

Extraction with water

Filtrate

Precipitation with ammonium sulphate

Solid

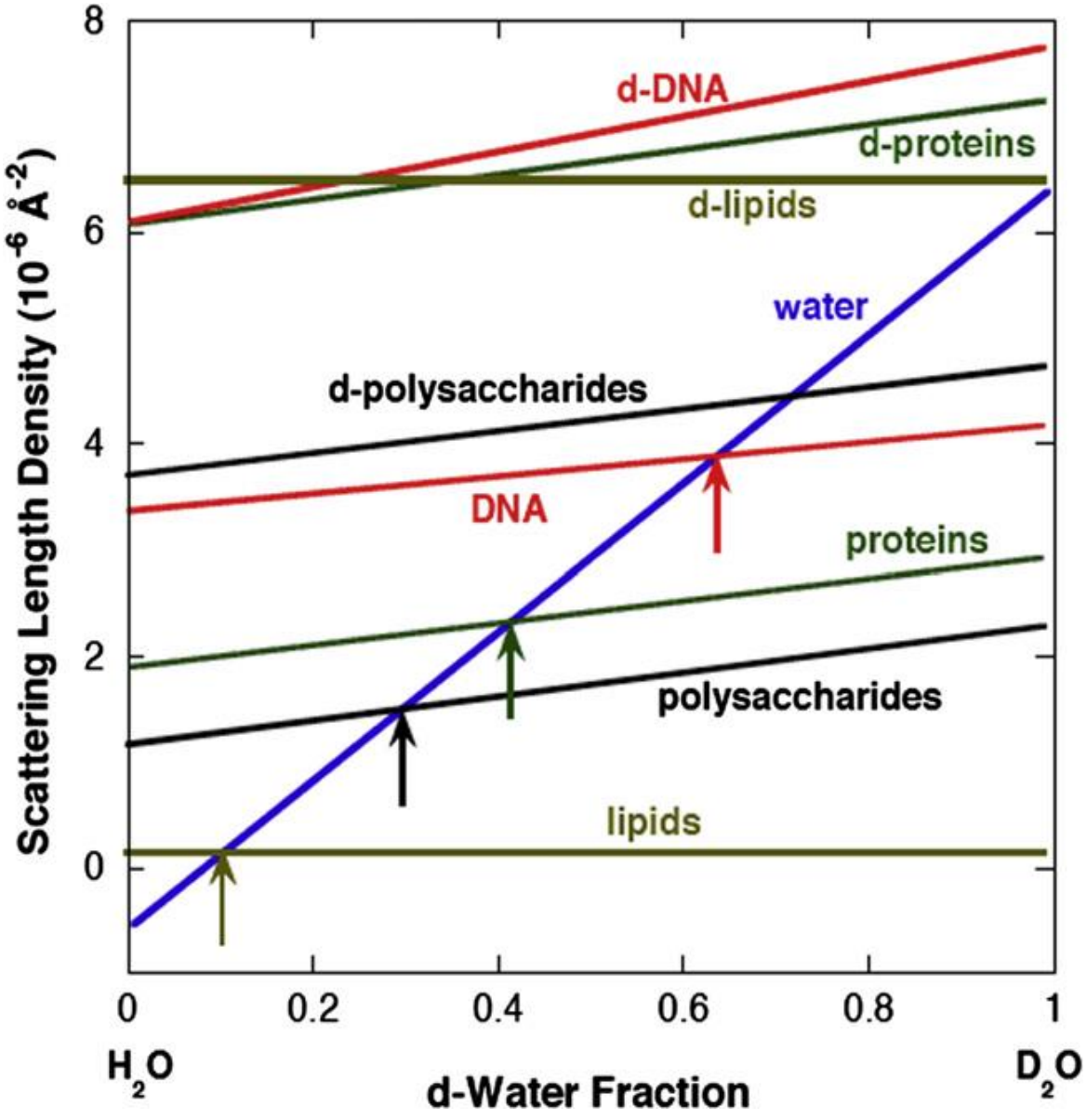
Dissolution with water and dialysis (12-14 kDa)

Dialysate

Adsorption on CM column
Elution with sodium chloride
Dialysis (12-14 kDa)
Freeze Drying

Moringa seed proteins powder

Neutrons and Contrast Variation in Action



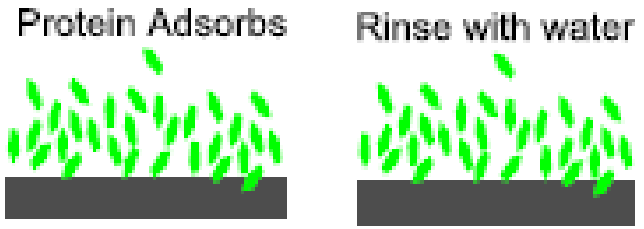
Lopez-Rubio & Gilbert *Trends Food Sci. & Techn*. 20,2009 576-586

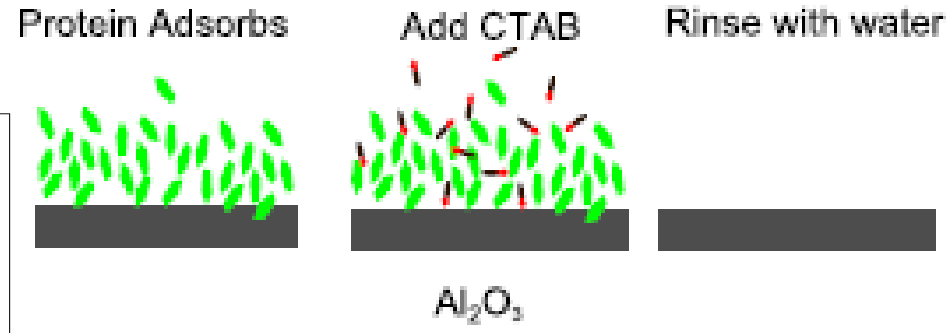
When the monster came, Lola remained undetected. Harold, of course, was immediately devoured.

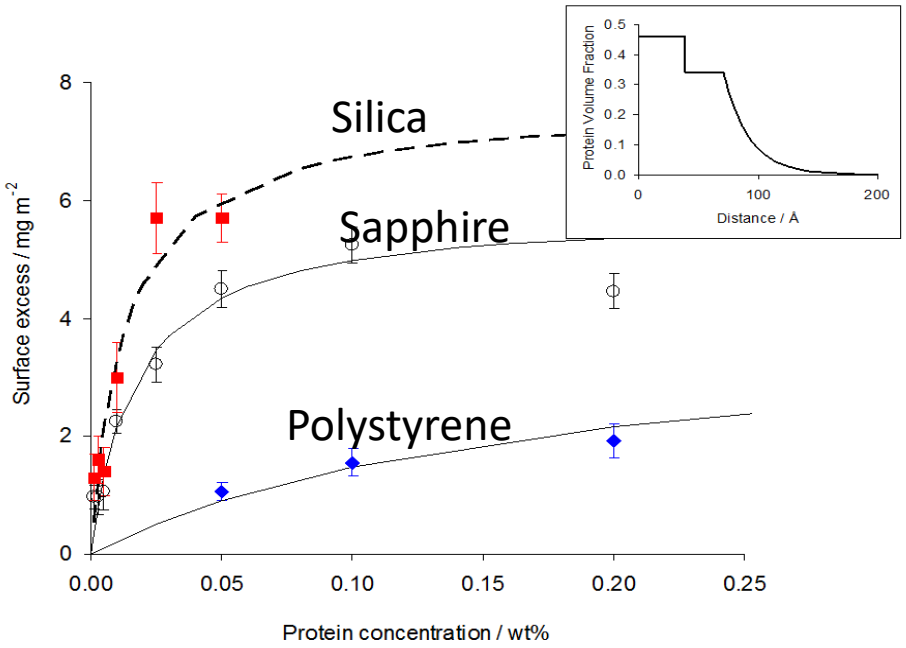
NUST/UB
(Moringa seeds proteins research)

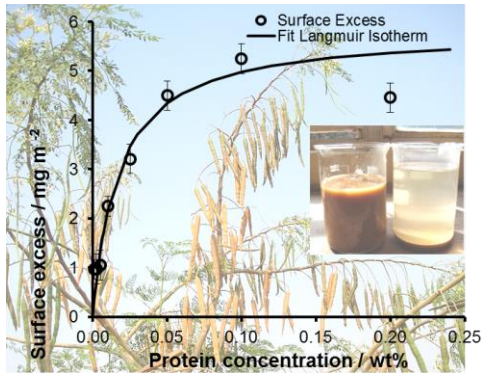
Adsorption of Protein from *M. oleifera* Seeds to a Silicon oxide and Sapphire Surfaces Studied by Neutron Reflection

ILL, Grenoble, France







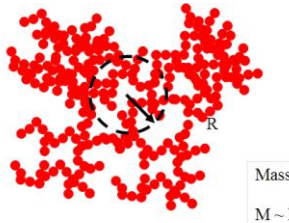


- **Kwaambwa, Hellsing & Rennie, *Langmuir* 2010, 26, 3902-3910.**
- **Kwaambwa et al., *Journal of Colloid and Interface Science*, 2015, 448, 339–346.**

Fractal Dimensions of Flocs Caused by Different Materials

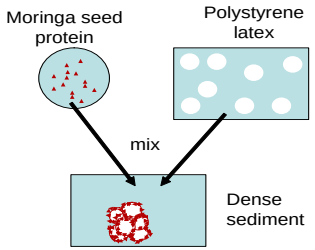
Note:

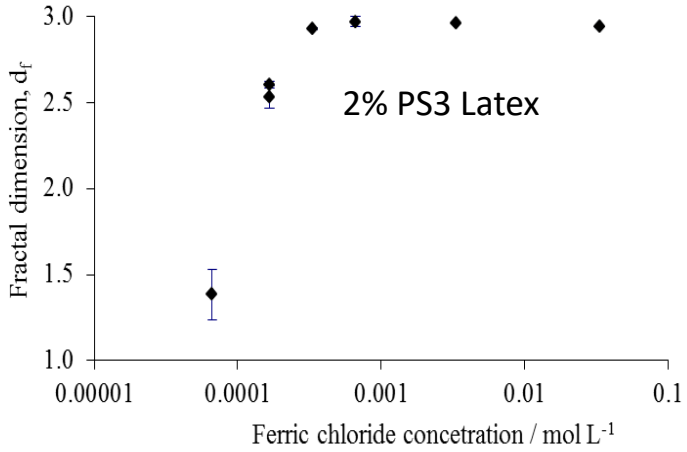
- **Moringa induced fractal dimensions approach the theoretical maximum of 3**
- **Cf: Conventional ionic flocculents give flocs with flow dimensions in the range 1.75 to 2.3**

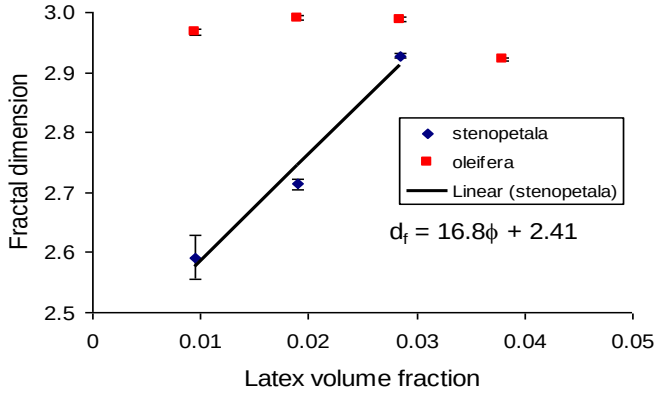


Mass fractal

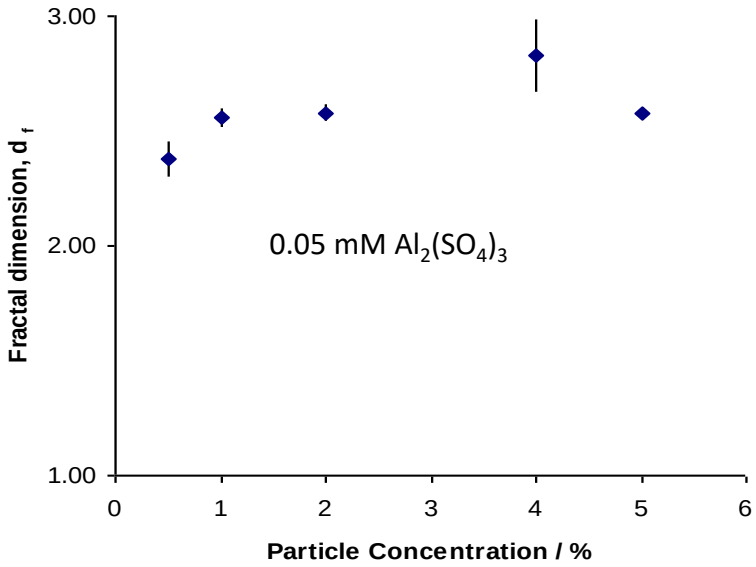
$M \sim R^d$

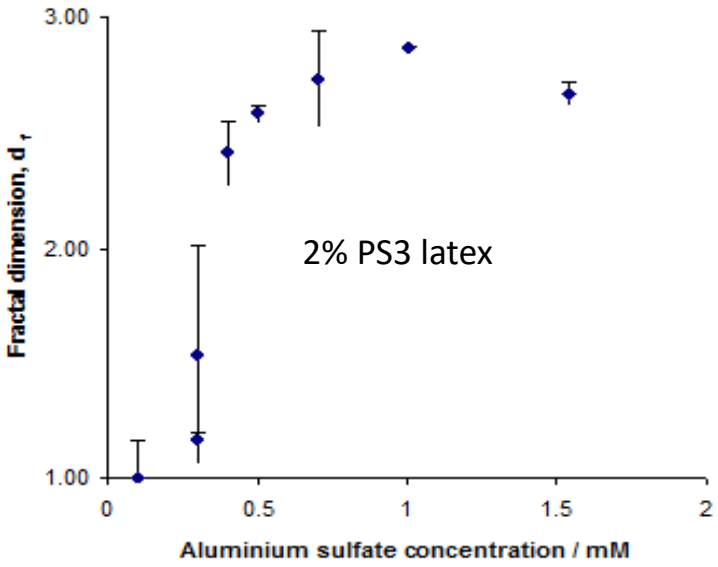


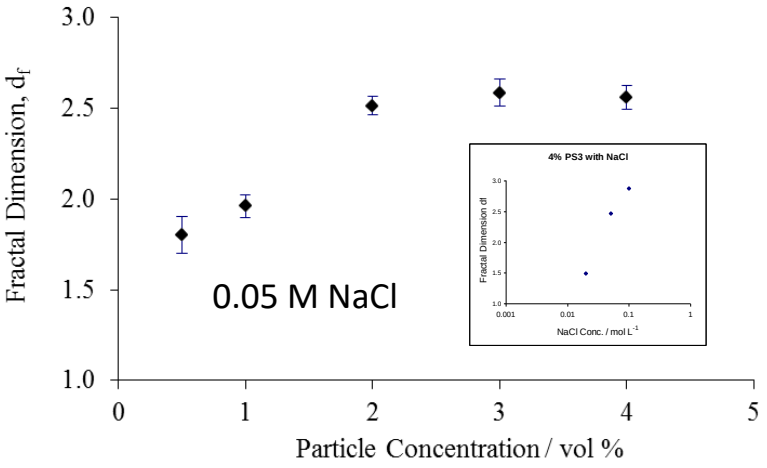




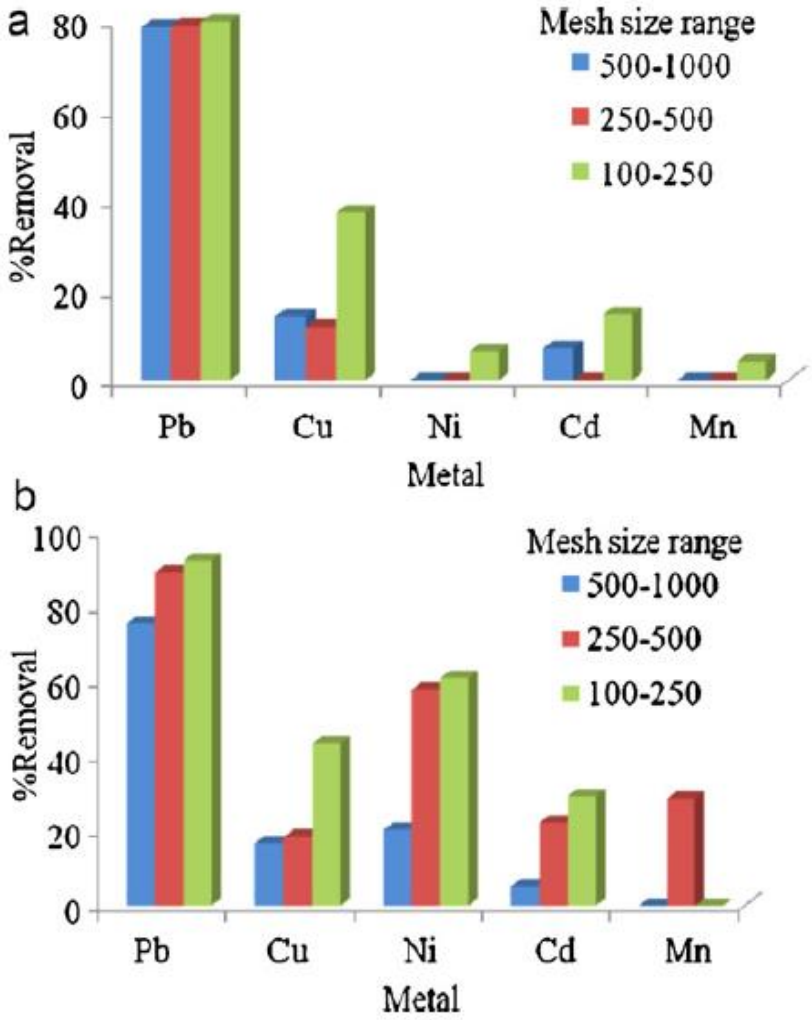
Fractal dimension for samples with mass fraction 2 mg/mL of Moringa



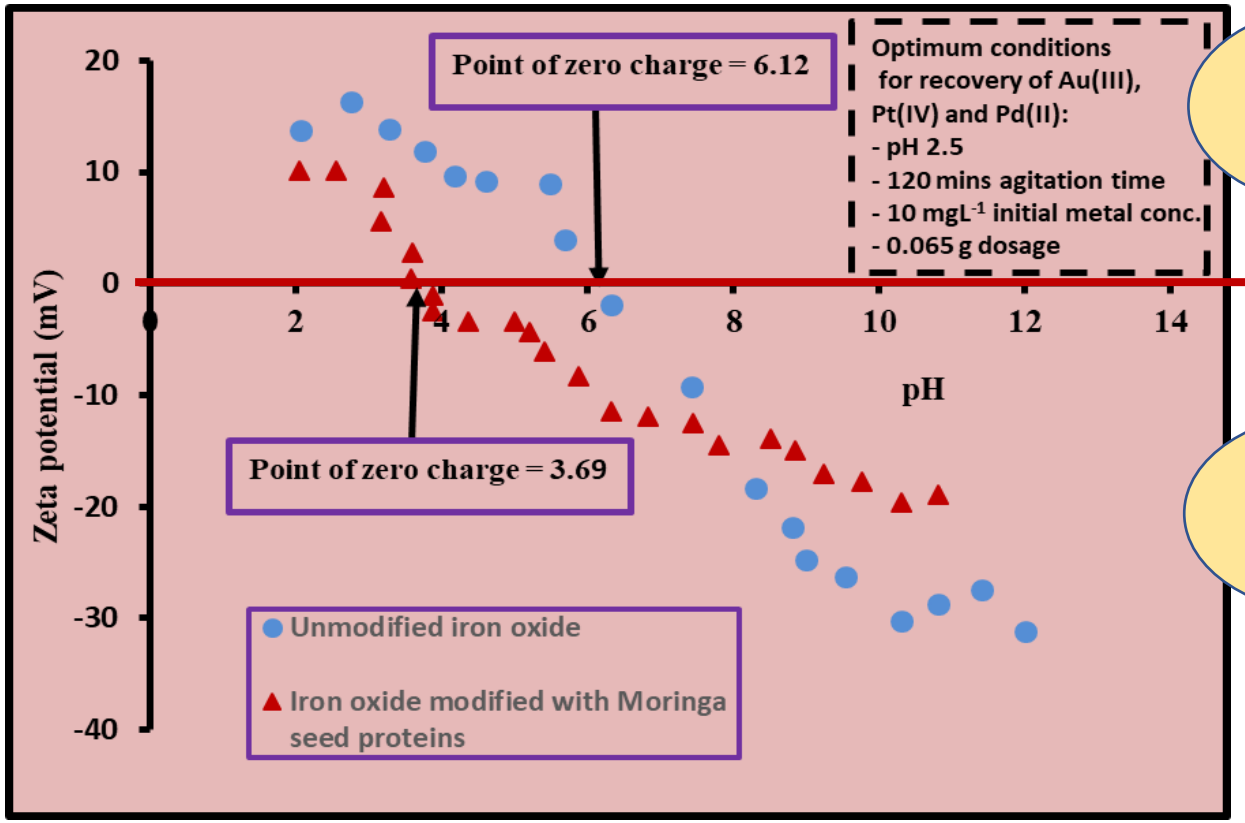




Heavy metals removal[1]



Precious metals or Platinum Group Metals (PGMs) interaction & removal



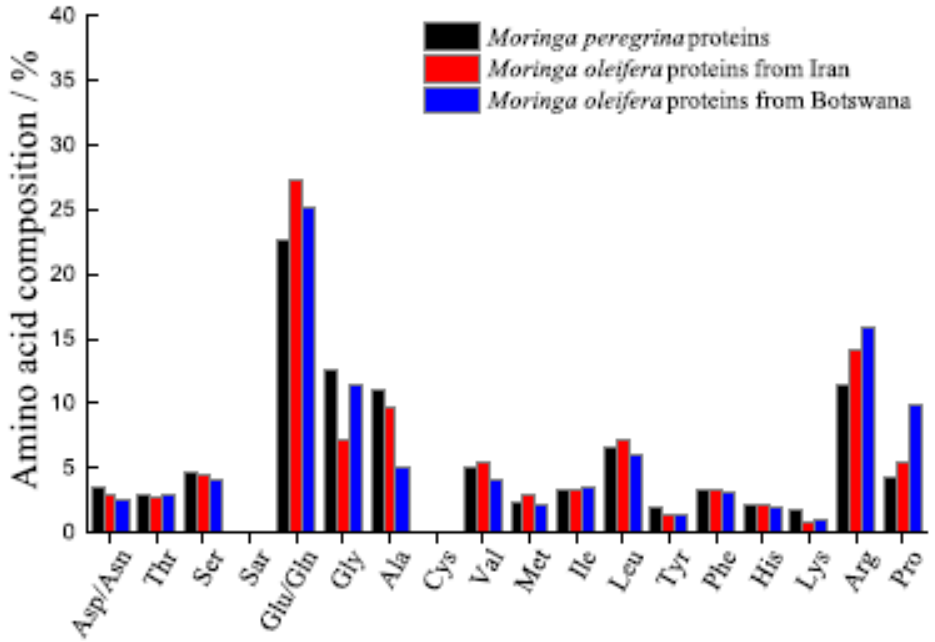
Maximum recoveries:

- Gold - 99.8%
- Platinum - 87.7%
- Palladium - 72.7%

1. Kwaambwa et al, *Analytica Chimica Acta* 730 (2012) 87– 92
2. M.O.N. Amuanyena, M. Kandawa-Schulz & H. M. Kwaambwa, *J. Biomaterials & Nanobiotech*., 2019, 10, 142-158

Possible explanation of the Moringa proteins-heavy metals interaction from determined amino acids composition

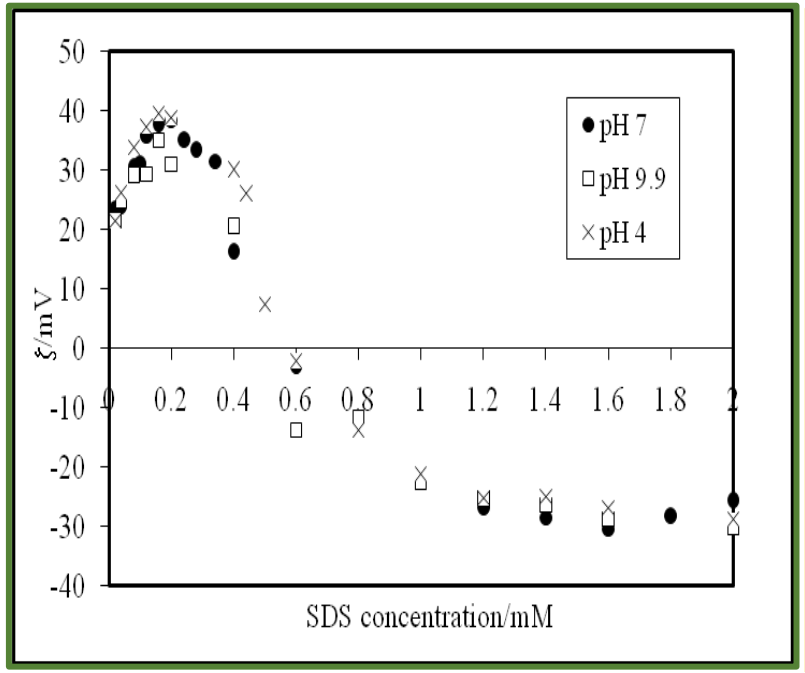
Component	Concentration nmol/mg			Mole fraction , X		
	Moringa oleifera 2009	Moringa oleifera 2012	Moringa Stenopetala 2012	Moringa oleifera 2009	Moringa oleifera 2012	Moringa Stenopetala 2012
Aspartic Acid	230.16	210.29	233.16	0.0294	0.0258	0.0285
Threonine	168.77	162.92	209.99	0.0215	0.0200	0.0256
Serine	334.80	345.62	370.19	0.0427	0.0425	0.0452
Glutamic Acid	1818.16	1989.17	1722.62	0.2319	0.2444	0.2103
Proline	552.48	593.66	534.57	0.0705	0.0729	0.0653
Glycine	972.33	896.55	1565.20	0.1240	0.1101	0.1911
Alanine	440.20	447.29	329.28	0.0561	0.0550	0.0402
Half-Cystine	479.81	557.04	490.50	0.0612	0.0684	0.0599
Valine	320.81	314.67	268.17	0.0409	0.0387	0.0327
Methionine	137.58	160.02	155.01	0.0175	0.0197	0.0189
Isoleucine	246.53	253.91	242.33	0.0314	0.0312	0.0296
Leucine	424.05	452.77	440.49	0.0541	0.0556	0.0538
Tyrosine	97.43	85.26	104.91	0.0124	0.0105	0.0128
Phenylalanine	233.72	219.50	189.09	0.0298	0.0270	0.0231
Histidine	149.75	148.24	146.86	0.0191	0.0182	0.0179
Lysine	72.34	54.58	153.71	0.0092	0.0067	0.0188
Tryptophan	28.31	27.06	14.26	0.0036	0.0033	0.0017
Ammonia	1742.16	1819.49	1617.79	0.2222	0.2235	0.1975
Arginine	1132.73	1221.14	1020.25	0.1445	0.1500	0.1246
Sum	**7839.95**	**8139.68**	**8190.60**	**1.0000**	**1.0000**	**1.0000**

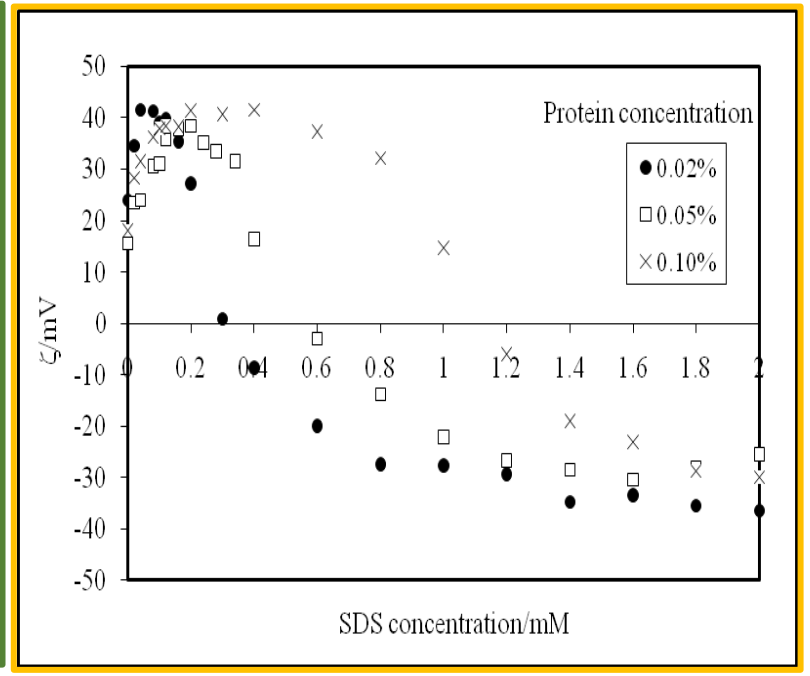


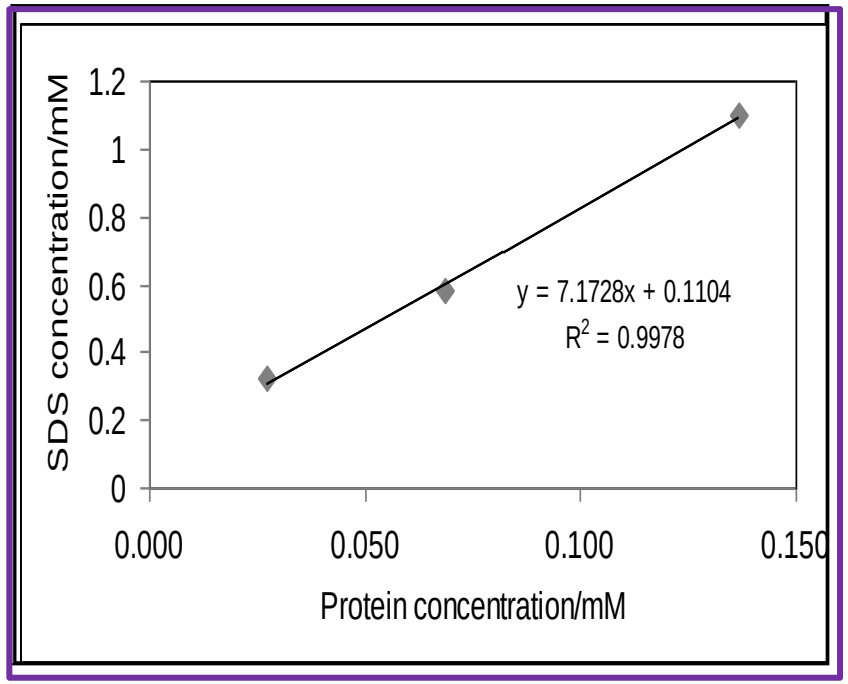
Point of zero charge (PI)

- Calculated pI for aspartic acid and glutamic acid is approx. 3
- pH < 3 Amino acids are positively charged
- pH > 3 Amino aids are negatively charged.
- Proteins are positively charged below pH 10, and hence can easily take up heavy metals (positively charged).

Zeta Potential Measurements

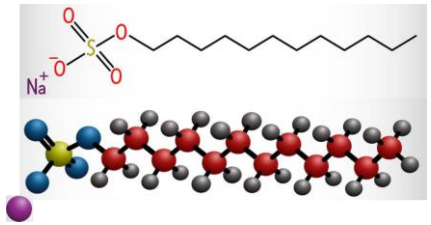






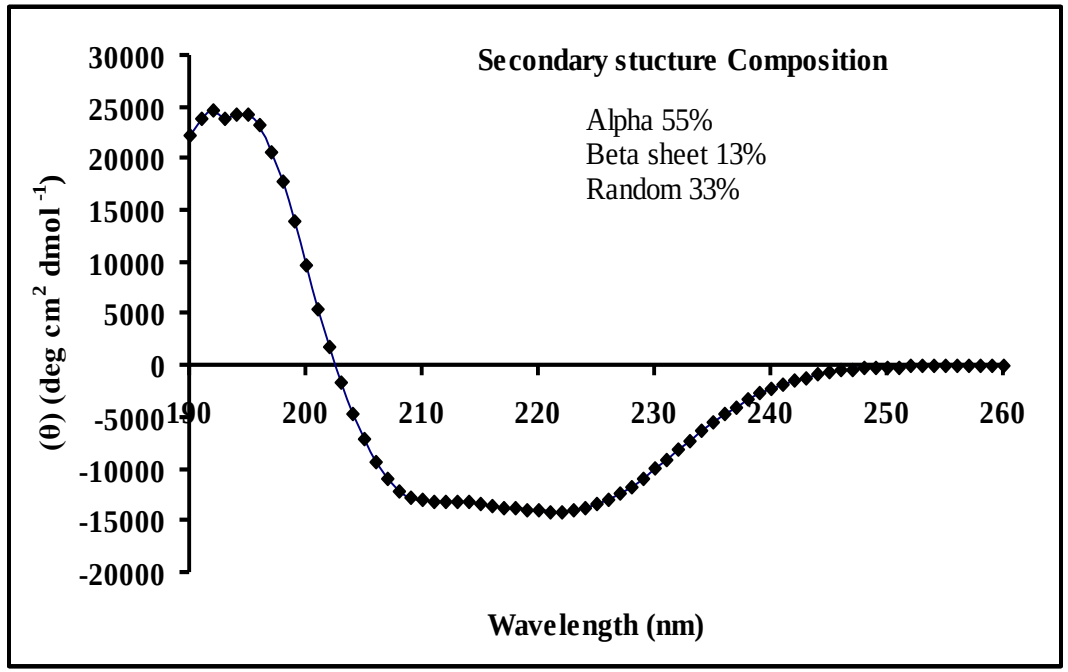
- **Effect of SDS concentration, pH and protein concentration on zeta potentials of the protein in water**
- **Mol. Wt. of protein of 7307 was estimated from amino acid composition using the Protein calculator v3.3 (http://www.scripps.edu/cgi-bin/cdputnam/protcalc.html)**
- **Maximum in zeta potential not as result carboxyl group**
- **Determination of SDS molecules associated with each protein molecule at ξ = 0**
- **Slope = 7 SDS molecules per protein molecule**
- **From amino acid sequencing by Gassenschmidt *et al.* and Broin, *et al*. reported 8 different negatively charged amino acid residues**

Broin, M et al. *Appl. Microbiol. Biotechnol*. 2002, 60, 114-119
Gassenschmidt et al. *Biochim. Biophys. Acta*. 1995, 1243, 477-481.

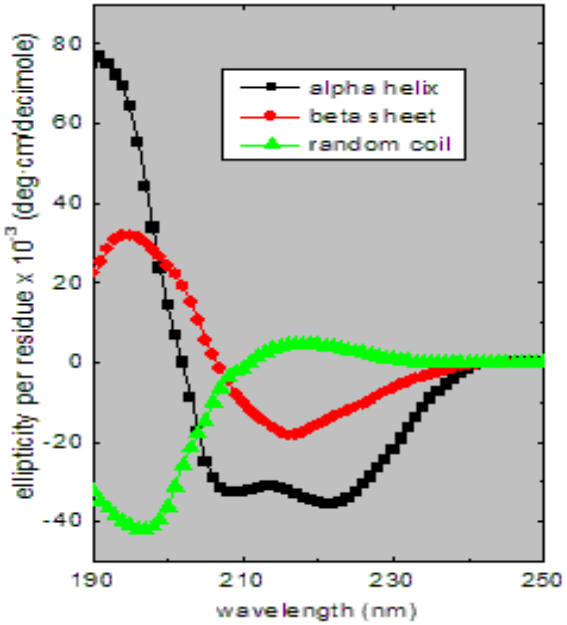


Sodium dodecylsulfate (SDS)

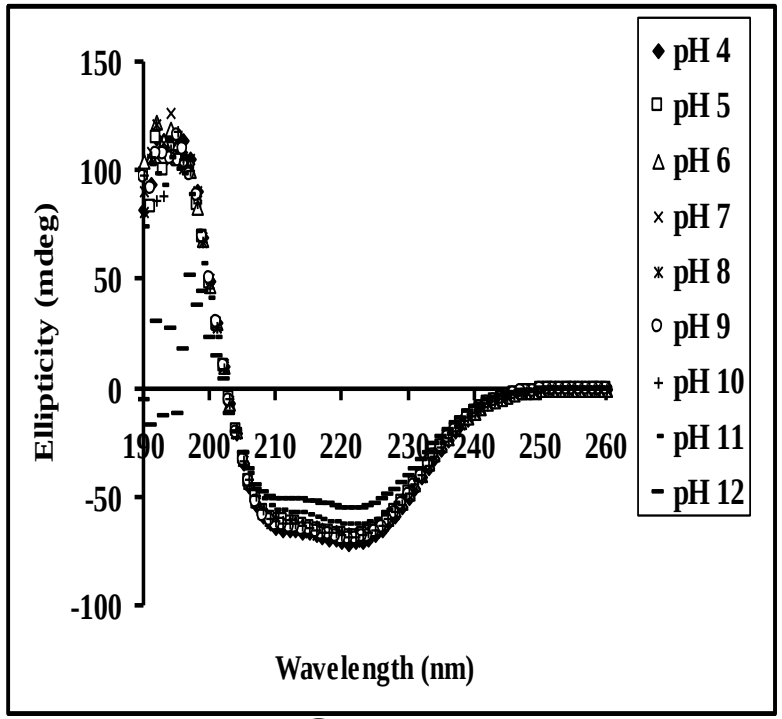
Circular dichroism (CD) of Moringa seed proteins



A

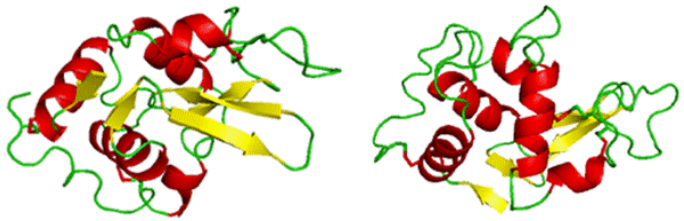


B



C

A: CD spectrum of aqueous *Moringa oleifera* seed coagulant protein (0.5 mg/mL) and the content of its secondary structures calculated using DICHROWEB K2D online program; B: Typical spectra for poly-lysine standard in three different conformations; C: Effect of pH on CD of the coagulant protein

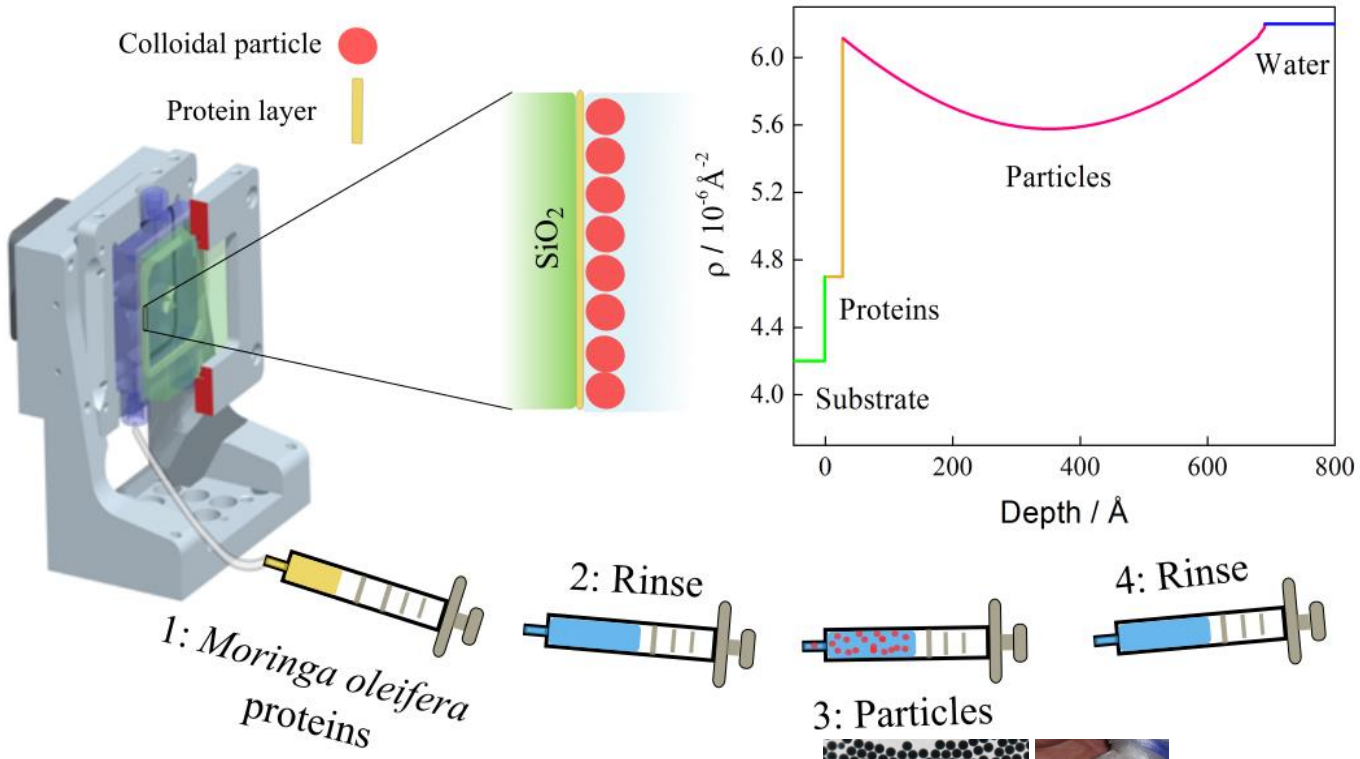


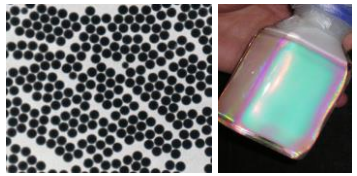
Red: α-Helix
Yellow: β-Sheet
Green: Random coil

- **Relies on the differential absorption of left and right circularly polarised radiation by chromophores which either possess intrinsic chirality or are placed in chiral environments.**
- **Rapid evaluation the secondary structure, folding and binding properties of proteins.**
- **Secondary structure - α-helix (55%), random coils (33%) and b-sheet (13%)**
- **Protein lost the tertiary (3D) structure at pH 11 and 12**

Kwaambwa & Maikokera, Coll. & Surf. B: Biointerfaces 64 (2008) 118-125

Sticking particles to solid surfaces using *MO* proteins as a glue





Monodispersed Polystyrene particles
TEM Size: 721 nm

Techniques Used:

- Atomic Force Microscopy (AFM)
- Quartz crystal microbalance (QCM-D)
- Neutron Reflection

Colloids and Surfaces B: Biointerfaces 168 (2018) 68–75

Contents lists available at ScienceDirect

Colloids and Surfaces B: Biointerfaces

journal homepage: www.elsevier.com/locate/colsurfb

Sticking particles to solid surfaces using *Moringa oleifera* proteins as a glue☆

Shirin Nouhi[a], Marc Pascual[a,1], Maja S. Hellsing[a], Habauka M. Kwaambwa[b], Maximilian W.A. Skoda[c], Fredrik Höök[d], Adrian R. Rennie[a,*]

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ARTICLE INFO

Article history:
Received 25 September 2017
Received in revised form 5 December 2017
Accepted 6 January 2018
Available online 8 January 2018

Keywords:
Latex particles
Moringa oleifera
Surface scattering
Adhesion
Quartz

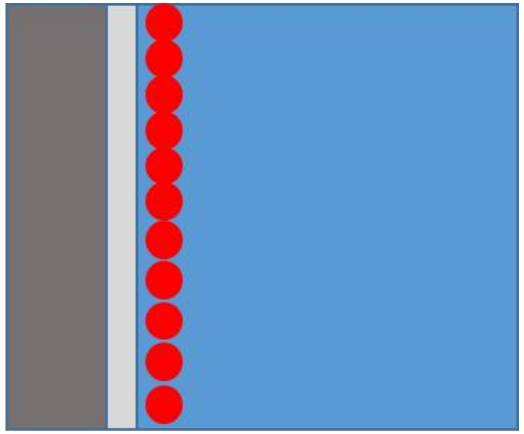
ABSTRACT

Experimental studies have been made to test the idea that seed proteins from *Moringa oleifera* which are novel, natural flocculating agents for many particles could be used to promote adhesion at planar interfaces and hence provide routes to useful nanostructures. The proteins bind irreversibly to silica interfaces. Surfaces that had been exposed to protein solutions and rinsed were then exposed to dispersions of sulfonated polystyrene latex. Atomic force microscopy was used to count particle density and identified that the sticking probability was close to 1. Measurements with a quartz crystal microbalance confirmed the adhesion and indicated that repeated exposures to solutions of *Moringa* seed protein and particles increased the coverage. Neutron reflectivity and scattering experiments indicate that particles bind as a monolayer. The various results show that the 2S albumin seed protein can be used to fix particles at interfaces and suggest routes for future developments in making active filters or improved interfaces for photonic devices.

Moringa seed crude protein extract

Mo-CBP3 purified protein fraction, which constitutes the largest single protein fraction from the seed extract

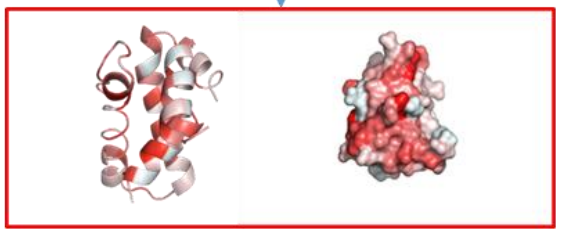
Adsorption



Monolayer adsorption on silica

- Purified MoCBP3 binds to a silica interface and none to the alumina interface
- MoCBP3-4 isoform has antimicrobial activity

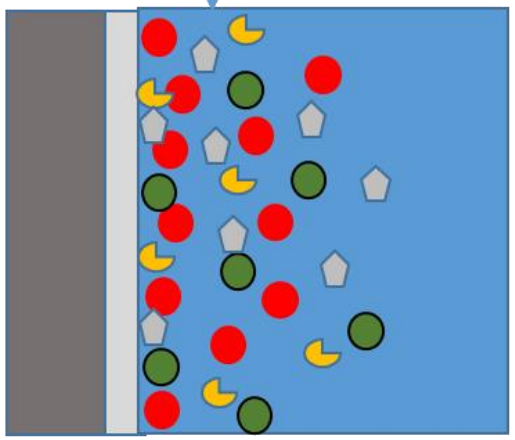
Isoform extracted and crystallized



Crystal structure of Mo-CPB3-4

Crystallographic structure of MoCBP3-4 (helix and surface representation) showing the polar versus non-polar areas of the protein.

Adsorption



Dense layer adsorption on silica and alumina

Journal of Colloid and Interface Science 554 (2019) 296–304

Contents lists available at ScienceDirect

Journal of Colloid and Interface Science

journal homepage: www.elsevier.com/locate/jcis

Regular Article

Towards a molecular understanding of the water purification properties of *Moringa* seed proteins

M. Moulin [a,b], E. Mossou [a,b], L. Signor [c], S. Kieffer-Jaquinod [d], H.M. Kwaambwa [e], F. Nermark [f], P. Gutfreund [a], E.P. Mitchell [b,g], M. Haertlein [a], V.T. Forsyth [a,b], A.R. Rennie [h,*]

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Journal of Colloid and Interface Science 589 (2021) 367–377

Contents lists available at ScienceDirect

Journal of Colloid and Interface Science

journal homepage: www.elsevier.com/locate/jcis

Regular Article

Modifying the crystallization of amorphous magnesium-calcium phosphate nanoparticles with proteins from *Moringa oleifera* seeds

Rita Gelli [a,1], Monica Tonelli [a,1], Francesca Ridi [a], Massimo Bonini [a], Habauka M. Kwaambwa [b], Adrian R. Rennie [c,*], Piero Baglioni [a,*]

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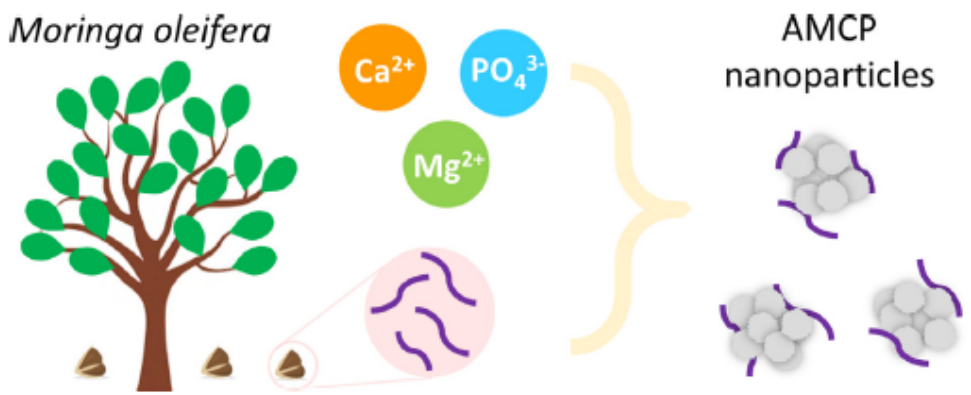
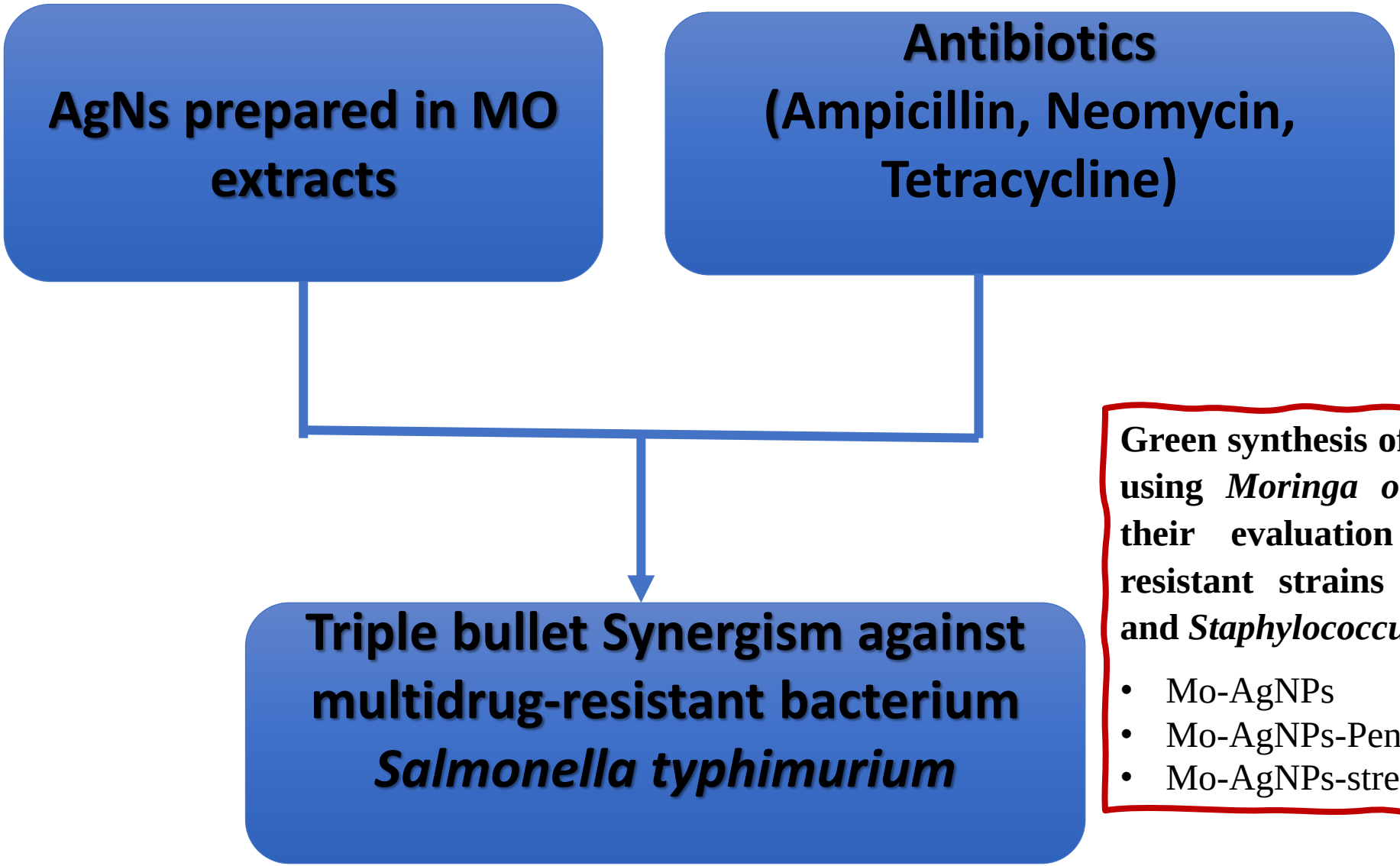
HIGHLIGHTS

- Proteins from *Moringa oleifera* enhance the lifetime of the amorphous Mg-Ca phosphates (AMCPs);
- The stabilizing effect of *Moringa* proteins (MO) is concentration-dependent;
- The crystallization pathway of amorphous particles is affected by *Moringa* proteins;
- The nano-scale structure of amorphous phases is related to the presence of proteins.

GRAPHICAL ABSTRACT



Bacterial Drug Resistance

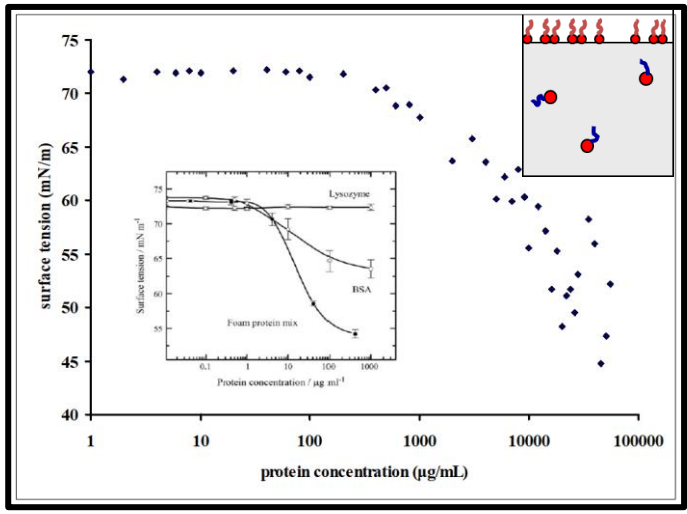


Green synthesis of silver nanoparticles using *Moringa oleifera* extracts and their evaluation against antibiotic resistant strains of *Escherichia coli* and *Staphylococcus aureus*

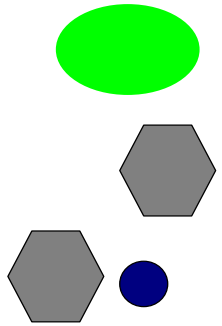
- Mo-AgNPs
- Mo-AgNPs-Penicillin G
- Mo-AgNPs-streptomycin

Peculiar Properties

- Surface activity - surface active but weak at low concentrations
- Protein charge neutralisation by surfactant
- Protein-Surfactant (e.g. soap/detergent molecules) interaction (anionic > cationic > zwitterionic > nonionic
- Protein not sensitive to pH range 4-9 (Fluorescence, CD, zeta potential) but pH greater than 9 affects the protein conformation. The elimination of the pH adjusting step for the adsorption process on a large scale is favourable, because it simplifies the process and reduces total costs.
- Effective to relatively high salt concentration
- Removal of heavy metals and precious metals from water
- Amino acid composition
- Adsorbs on differences surfaces
- Floc structure and fractal dimension (almost limiting value of 3)
- Sticking particles to solid surfaces using *Moringa oleifera* proteins as a glue
- Slows down crystallisation of amorphous Ca-Mg phosphate nanoparticles

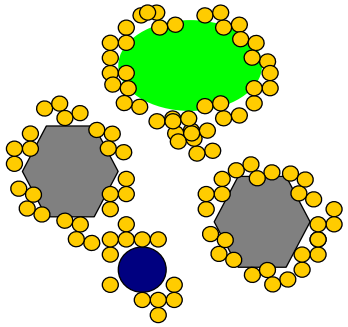


Moringa Seeds and Water Treatment Mechanism



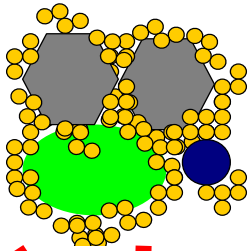
Impurities

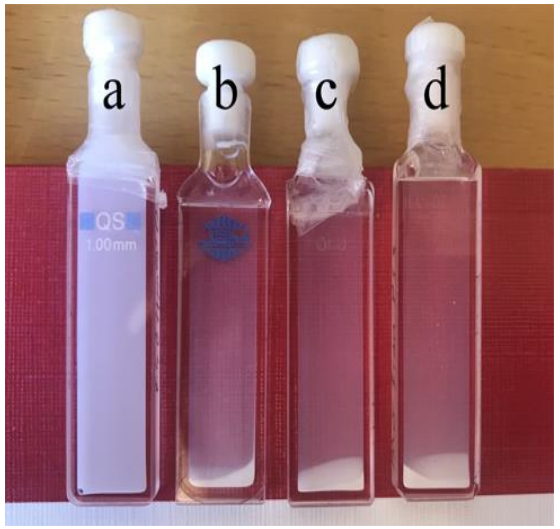
Add Protein



Adsorption to a range of different particles promotes heterocoagulation and sedimentation

Adsorb & Flocculate





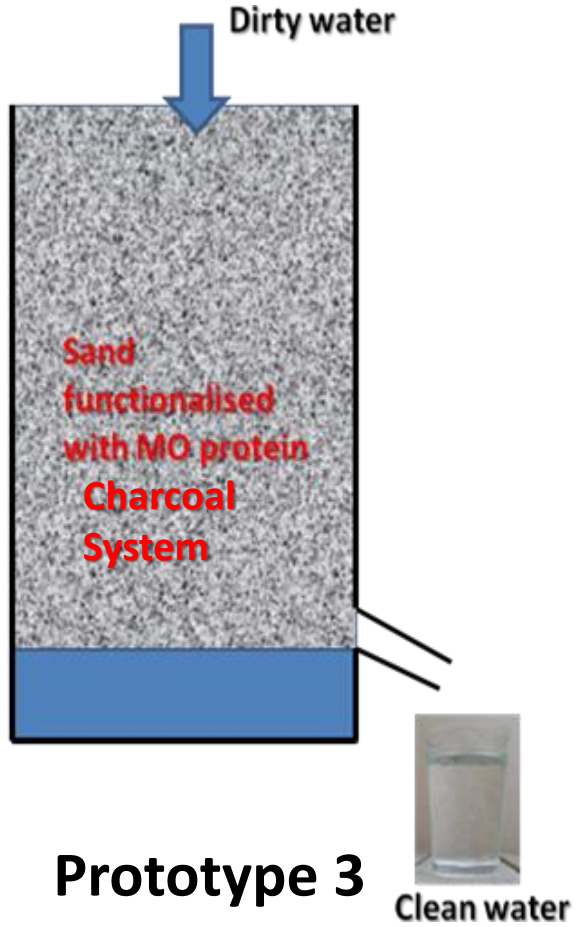
Water Treatment System Prototypes

Prototype 1

Prototype 2

Moringa Project - Final Video - Shortcut.zip

Prototype 2 Results: Reduction of turbidity (< 5 NTU) and microbial pollution indicators (total coliforms, faecal coliforms, *Escherichia coli* and *faecal streptococci*) by at least 96%.



Prototype 3

Feed for Livestock and Aquaculture Industry

Features of Moringa Pellets

- Cattle feed on Moringa free from additives
- Accurate composition
- Cattle on optimum freshness in Moringa
- Natural taste of leaf pellets
- Leaf pellets free from harmful additives
- Pellets free from impurities
- Long shelf life of pellets
- High nutritional value in feed
- Feed helpful for the milk producing cows, sheep, goats, pigs and horses
- Pellets processed with advanced methodology using premium quality Moringa parts

Benefits of Feeding Boer Goats with Moringa Leaf Supplement

Moringa leaf supplements had a reducing effect on gastrointestinal parasites (GIP) loads of Boer goats

Supplementing livestock, e.g. cattle, feed with the leaves and green stems of Moringa,:

- Increases weight gain (daily weight gain up to 32%)
- Enhances milk production by 43-65%
- Boosts immune system
- Improves the digestibility of food livestock eat and hence overall health and condition of your animals

Seed shells and husks for manure, animal feed and activated charcoal

CO_2

Moringa Seeds Circular Economy

Fertilizer/Soil Conditioner

Irrigation

Water Treatment

Seed Powder Capsules

Protein bioflocculant capsules for water treatment

Water Treatment

Seed Cake

- Cooking Oil → Commercial & Industrial
- Cosmetics → Emollients
- Personal Care → Bath soaps
- Perfumery
- Industrial Oil → Biodiesel
- Lubricants

Biorefinery

Moringa Honey

Agroforestry

Flowers

Tea Bags

Feed for Livestock, Poultry and Fish

Biostimulant (Plant growth enhancer)

Moringa Leaves Circular Economy

Leaf Powder

Leaf Powder Capsules

Moringa Tea

Biosorbent + Waste biomass

Moringa for Life

Job Creation

Income Generation

Moringa - the Multipurpose Tree

Climate-Smart Agriculture

Community Health

Food & Nutrition Security

Journal of Agriculture and Food Research 10 (2022) 100397

Contents lists available at ScienceDirect

Journal of Agriculture and Food Research

journal homepage: www.sciencedirect.com/journal/journal-of-agriculture-and-food-research

Moringa oleifera as a sustainable climate-smart solution to nutrition, disease prevention, and water treatment challenges: A review

Lydia Horn [a], Natalia Shakela [b], Marius K. Mutorwa [b], Erold Naomab [b], Habauka M. Kwaambwa [b,*]

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[b] Department of Natural and Applied Sciences, Faculty of Health, Natural Resources and Applied Sciences, Namibia University of Science and Technology, Private Bag 13388, 13 Jackson Kaujeua Street, Windhoek, Namibia

***Moringa* "The Mother's Best Friend"**

Conclusion – or call it "My Challenge to You"

1. **From Curiosity-Driven Ideas to New Insights and Improved Applications of Moringa in Water Treatment and Materials Research**
2. **Value Chain: A Case of Moringa from Laboratory to the Market - Lessons Learned**
3. **Climate-Smart Agriculture, Improving Community Health, Income Generation and Creating Jobs**

- **Get a piece of land and clear it, and we shall come a help you for free to plant Moringa and start a business!!!**
- Hazard Analysis and Critical Control Points (HACCP) - systematic approach to food safety protocal, i.e. processing facility layout and processing that meet food safety standards
- Organic farming and organic certification (requirement to demonstrate a product or operation has met the legal standards to produce organic foods and organic agricultural products)
- **Agroforestry**
- **Moringa value chains: Production through processing – local/international markets**

AU Anthem

O Sons and Daughters of Africa
Flesh of the Sun and Flesh of the Sky
Let us make **Africa** the Tree of Life

My Dream Version

O Sons and Daughters of Africa
Flesh of the Sun and Flesh of the Sky
Let us make **Moringa** the Tree of Life

The Waters of Marah and Elim

Exodus 15: 22-25

[22]Moses brought Israel from the Red Sea; then they went out into the Wilderness of Shur. And they went three days in the wilderness and found no water.
[23]Now when they came to Marah, they could not drink the waters of Marah, for they ***were*** **bitter**. Therefore the name of it was called Marah. [24]And the people complained against Moses, saying, "What shall we drink?" [25]So he cried out to the LORD, and the LORD showed him a **tree**. When he cast *it* into the waters, the waters were made **sweet**.

Could the tree Moses used be Moringa???????

ACKNOWLEDGEMENTS

Sida

NEUTRONS FOR SCIENCE

NIST National Institute of Standards and Technology U.S. Department of Commerce

UKRI Science and Technology Facilities Council
ISIS Neutron and Muon Source

THUTO KE THEBE
UNIVERSITY of BOTSWANA

NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY

UNISA university of south africa
Define tomorrow.

UPPSALA UNIVERSITET

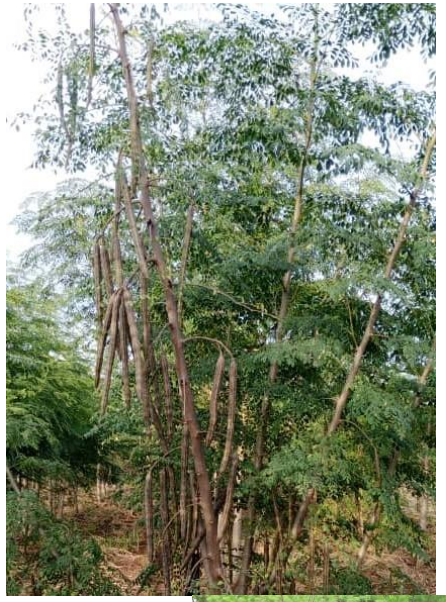
ROYAL SOCIETY OF CHEMISTRY

NCRST
National Commission on Research Science & Technology

DAAD
Deutscher Akademischer Austauschdienst
German Academic Exchange Service

NRF
National Research Foundation

- Raymond Maikokera
- Prof Adrian Rennie, Uppsala University
- Fiona Nermark, BITRI, Botswana
- Manoria Niingo, *NUST*
- Marta Amuanyena Elvin, *NUST*
- Morlu Korsor, UNAM



Thank You!