

Science Last Fortnight

Fighting Bacterial Resistance

Citral potentiates antibiotics

Antibiotic-resistant bacteria are a global health issue. Methicillin-resistant *Staphylococcus aureus* is one such bacterium. Infections caused by the superbug are difficult to treat with existing antibiotics.

Darokar and collaborators from the CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow used citral, a phytochemical, and its combination with various penicillin derivatives, against this resistant strain. Citral is a constituent of volatile oils present in plants such as tulsi, lemongrass and citrus fruits. It is known to possess antimicrobial properties.

The team worked on six resistant clinical isolates of *Staphylococcus aureus*. They found that citral alone is bacteriostatic while its combination with antibiotics is bactericidal. Using an ethidium bromide efflux assay, the team found that the test compounds inhibit the efflux pump of the pathogen. They observed that citral and its combinations with the antibiotics alter the osmoregulation of the bacterial cell. This, in turn, reduces the resistance of the pathogen. Though citral alone showed encouraging results, its combination with antibiotics increased the potency of the antibiotics 32 fold!

Animal studies confirmed that citral and its combination with norfloxacin reduced bacterial load and did not exhibit toxicity. Earlier research had shown that bacteria cannot develop resistance against citral even after long use.

The scientists say that norfloxacin, in combination with citral, is a potential therapeutic option against methicillin-resistant *Staphylococcus aureus*.

Phytomedicine, **34**: 85–96

Exit Enteric Diseases

Probiotics protect people

Enteric diseases are endemic in India. The drugs used to treat such diseases have side effects. Probiotics, containing live *Lactobacillus*, are already being marketed as natural protection against these enteropathogens.

However, there are many strains of *Lactobacillus*. Which is the best for the

purpose? Are there potent strains in the guts of Indians that can be used instead of the existing *Lactobacillus* spore capsules?

Recently, researchers from the ICAR-National Dairy Research Institute, Karnal, isolated 35 *Lactobacillus* strains from Indian gut microbiome and screened their activity against two serotypes of *Salmonella enterica*, Ty2 and LT2. And they identified 11 strains that inhibit the growth of the pathogens.

To become active in our body, these strains have to colonize the human gut. The scientists used cell surface hydrophobicity and auto-aggregation assays to confirm that these strains can indeed colonize the gut.

They then performed a coaggregation assay to demonstrate that the probiotic could prevent colonization by *Salmonella*. The *Lactobacillus* prevented the pathogen from adhering to and colonizing the gut. The scientists feel that a yet to be discovered mechanism is involved in *Salmonella* interference.

The team examined the regulation of *TRL2*, a gene involved in innate immune response in humans. They found that *TRL2* is upregulated when the *Lactobacillus* strains colonize the gut. This upregulation may also work to resist other enteropathogens.

Similar large scale screening of human microbiome is needed to manage other enteric pathogens in the Indian sub-continent.

LWT-Food Sci. Technol., **84**: 851–860

Melamine in Milk

Gold nanocomposites detect adulterant

Melamine, a white, nitrogen-rich, odourless and cheap adulterant, is mixed with milk to increase its apparent protein level. Consumption of melamine adulterated milk leads to reproductive damage, kidney stones, bladder cancer and even death. Conventional techniques to measure melamine in milk and milk products are costly, time consuming and complicated.

Gopi Kalaiyaran and James Joseph, from the CSIR-CECRI, Karaikudi with

K. Anusuya, from the Madurai Kamaraj University have now developed a new method for melamine detection.

‘We know that melamine is a nitrogen-rich molecule and has strong electron donating ability. In our previous work, we had observed that the electron donating molecules enhance light emission by fluorescent materials. As the melamine molecule has three NH₂ groups, it enhances the fluorescence of gold nanocomposites’, says Anusuya.

The team synthesized glutathione protected gold nanoclusters. When milk with melamine was added to the nanoclusters, absorbance did not change much in the UV and visible region. However, the researchers observed one broad peak in the near infrared region. They suggest that the melamine was inducing aggregation of gold nanocomposites, leading to fluorescence quenching.

‘This is a simple, cost effective and highly selective reliable detection method to quantify the amount of melamine in milk and milk products’, says Gopi.

‘Compared to conventional sensing methods, ratiometric determination methods provide high precision results’, claims Joseph James.

The Food Safety and Standards Authority of India can use these results to detect melamine adulteration in milk. Entrepreneurs can come forward to commercialize this technology.

Appl. Surf. Sci., **420**: 963–969

Migration of Dengue Virus

South Indian genotypes are a clue

Dengue – a viral disease – spread by the *Aedes* mosquitoes, can reach epidemic proportions. The outbreak in 2012 in Tamil Nadu had high fatality rate. Larger outbreaks are often associated with introduction of new genotypes of dengue virus.

Last fortnight, a group of scientists from the ICMR-National Institute of Virology and the Christian Medical College, Vellore reported their studies on the molecular characteristics of the dengue virus circulating in South India during the period 2012–2015.

Dengue virus has four antigenically defined serotypes and multiple genotypes within each serotype. The researchers isolated the viral RNA from patients with dengue and found that all the four serotypes of the virus were circulating in Tamil Nadu during the period 2012–2015.

They sequenced the envelope gene from all four serotypes and compared the sequences with those available in the GenBank. The scientists found that all the Indian isolates of dengue virus-1 from 1962 to 2005 and the one from Vellore in 2015 belonged to the American/African genotype while all the dengue virus-1 from Tirunelveli, Kerala and one from Vellore during 2012–2015, belonged to the Asian genotype. As the Asian genotype has not been reported from India earlier, it is considered as a new introduction.

Then they performed phylogenetic analyses to identify the genotypes of each serotype and phylogeographic analyses to delineate the possible source of virus migration to India.

The dengue virus-1 Asian genotype from Tirunelveli has 99.5% identity with the dengue virus-1 from Singapore and Sri Lanka. Indeed, the diversity between Tirunelveli and Vellore dengue virus-1 was greater. The Asian genotype of dengue virus-1 has been reported to be responsible for huge outbreaks in Singapore in 2005 and in Sri Lanka in 2009.

Phylogeographic analyses suggested Thailand as an important hub for the distribution of the Asian genotype of dengue virus-1. The Asian genotype of dengue virus-1 has been introduced into India and in parallel into Sri Lanka from Singapore during 2005–2009. The study shows that the magnitude of dengue outbreaks can be affected by the introduction of new genotypes and signifies the importance of continuous molecular monitoring of dengue virus.

Virology, **510**: 40–45

Elephants as Frugivores

Indispensable for seed dispersal

Animals, as seed dispersal agents, are vital for a diverse ecosystem. Many plants depend on animals for seed dispersal. However, so far, scientists have been unable to quantitatively demon-

strate the role of animal mediated seed dispersal.

Here is a study from the IISc, Bengaluru and the Princeton University, USA that showcases the indispensability of elephants in seed dispersal. The researchers investigated the dispersal mechanism of three dominant tree species – *Artocarpus chaplasha*, *Careya arborea* and *Dillennia indica* – in the dry tropical forests of the Buxa Tiger Reserve. They also estimated the level to which alternative dispersers, such as gaur and other bovids, macaque, giant squirrel and small rodents, could compensate in the absence of elephants.

Using a focal watch and camera trap method, the team collected data on the proportion of fruit consumed by the frugivores, seeds that survive passage through the gut, gut retention time and the probability of the germination of the defecated seeds. They fed the data into an empirical model to compute dispersal distance and the probability of successful germination.



Image: S. Suresh Ramanan

The researchers found that the elephants dispersed 28% of *A. chaplasha*, 33% of *C. arborea* and 71% of *D. indica* seeds. Even though other frugivores contributed to seed dispersal, in the absence of elephants, there was a significant reduction in the percentage of successful dispersal. The dispersal percentage of *D. indica* seeds, plummeted by 23% in the absence of elephants.

Based on this research, the scientists emphasize that the conservation of a flagship species, such as elephants, could have a positive impact on biodiversity. These findings add impetus to conservation efforts. And provide evidence to persuade policy makers and the public about the need for wildlife conservation.

Conserv. Biol., **31**(5): 1152–116

Dandy Planter for Candy

Intercropping made easy

Sugarcane planting is labour and cost intensive. It is usually cultivated as a single crop. As it takes four months to mature, intercropping with potato is a good strategy to recover costs. However, though there are planting machines both for sugarcane as well as for potato, there is, as yet, no machine for the simultaneous planting of these crops.



Image: Phil, Creative Commons

Scientists from the ICAR-IISR, Lucknow have now devised a sugarcane-cum-potato planter. The planter consists of a furrow opener, a seed cane tray and reversible shovels for covering planted sugarcane setts with soil. For potato planting, there is a seed potato hopper, miniature furrower, and a potato seed metering cup. An insecticide solution container and tamping roller for pressing the soil cover are also provided.

The team conducted field trials in the sandy loam soil of IISR, Lucknow. They used the machine to plant two varieties of potatoes in ridges and a sugarcane variety in furrows, in one pass.

The researchers estimate the cost of the planting operation at around Rs 3,000 per hectare. Manual planting comes to some Rs 13,000 per hectare. Thus, the team claims that this technology saves more than 70% of the input cost. The labour requirement was also significantly lowered: 50 hours per hectare with the planter, where manual planting required more than 500 hours.

The team also ascertained the effectiveness of the planter by conducting crop performance experiments. The yield in intercropping was significantly higher than that in relay cropping. These results indicate the superiority

of potato–sugarcane intercropping over relay cropping.

The scientists say that this easy and efficient potato–sugarcane intercropping could be profitable for farmers. The team is now seeking to improve the planter for effective operation by farmers. Entrepreneurs can take up the challenge and make it available and affordable to farmers.

Sugar Technol., **19**(5): 517–525

Biofuel from Tree Borne Oilseeds *An agroforestry-based approach*

Perennial oil-seed producing trees are major contributors of non-edible oils. Biofuel, from oil-rich tree seeds, have twin advantages: energy generation from non-food sources and productive use of barren, uncultivable lands.

There are some 150 common tree species in India that bear oil seeds. The Hassan Rural Biofuel Model, set up in 2007, was one of the first to use such trees. The Amity University, Noida, the University of Agricultural Sciences, Karnataka and the World Agroforestry Centre, New Delhi got together to train farmers from the Hassan district, Karnataka and to support tree borne oilseed plantations in non-cultivable lands in the area. Approximately 2500 trees from 7 different species were planted.

Last fortnight, the team reported that this social agroforestry approach led to benefits without much investment. The farmers used a part of the seeds to produce oils using motorized expellers and sold the remaining seeds for fuel extraction.

The team extracted oil from the seeds to produce biofuel and compared it with fossil fuels in terms of net energy balance, net energy ratio and greenhouse gas emissions. The fuel was found to be useful for running tractors, irrigation pump-sets. It could be used by the soap industry as well.

The researchers claim that such agroforestry-based systems are an environment friendly strategy to meet growing energy demands. Moreover, their model has the potential to be extended to other areas in India for biofuel production, providing farmers with extra income from non-cultivable lands.

J. Cleaner Product., **164**: 905–917

Safer Leather

Sultan champa oil-fat liquor

Bacteria and fungus can deteriorate the quality of leather. They also cause pigmentation in ‘wet blue’ leather, tanned with chromium. This results in poor quality products. Therefore, leather industries use fungicides. Moreover, they apply fat liquors for softening tanned leather. But these chemicals are not eco-friendly and cause skin problems.



Tomascastelazo: Wikimedia Commons

Recently, researchers from the Central Leather Research Institute, Chennai investigated the possibility of using natural materials for treating leather. They chose the oil of sultan champa – *Calophyllum inophyllum* – as fat liquor. They observed that leather treated with the transesterified oil is resistant only to *Aspergillus niger*.

The scientists then chose water extract from ajwain – *Trachyspermum mammi* – as an antifungal agent. Thymol, and carvacrol in the ajwain extract are known to have antifungal activity.

They mixed ajwain extract with the transesterified oil in various ratios for comparison. The blending enhances antifungal activity further against common fungi. The emulsion gave better results than transesterified vegetable oil, semi synthetic and synthetic fat liquors!

The team estimated the particle size of the emulsion and found that it has appropriate size to fill even the constricted diameter of wet blue leather.

They also studied the surface morphology of the treated leather. Leather treated with transesterified oil exhibits soft grain. It has properties comparable to leather fat liquored with other vegetable oils. The leather also has

improved shrinkage temperature, and tensile and tear strength.

Sultan champa oil is a commercially available natural product. It is found to be safe on skin and environment. Therefore, treatment using this fat liquor is a step towards cleaner and safer leather production.

Ind. Crops Prod., **105**: 104–112

Environment-friendly Packaging *Using waste from leather industry*

Packaging materials derived from petroleum-based products pose health hazards upon disposal. There is a need to find renewable alternatives.

Recently, researchers at the Central Leather Research Institute and the Madras Institute of Technology Campus, Chennai suggested gelatin, a solid waste from the leather industry as a suitable alternative.

They analysed the gel strength, viscosity and nitrogen content of gelatin to determine its functional properties. They found that gelatin had medium gel strength grade and viscosity. Moreover, it was of high purity.

However, gelatin is highly water soluble. To overcome this, the researchers created a composite film using gelatin and poly-vinyl alcohol in 1 : 1 ratio. They cross linked this film using glutaraldehyde. The resulting material was resistant to water. They used glycerol as a plasticizer to impart higher flexibility to the films.

Scientists tested the material for additional characteristics that are desirable in packaging films – thermal sealing, scribing and stamping. The film displayed strong sealing properties. Scribing and stamping with different inks yielded neat patterns. The film did not lose the ink when placed in water.

According to the team, these films are optimal for use as a packaging material.

Adoption of biodegradable materials is desirable and necessary. Gelatin used as a raw material to develop these films is a waste pouring out of leather industries. This research solves two problems – waste management and an alternative to plastic for packaging.

J. Cleaner Prod., **164**: 885–891

Reusing Sewage Water

Contamination of water resources has led to inaccessibility of potable water. Traditional disinfection processes involve the use of chlorine or ozone. These chemicals, though effective, produce harmful by-products. New technologies, such as UV irradiation, are also not effective due to limited penetration in wastewater. High cost and the chances of bacterial regrowth after UV treatment are other drawbacks.

Recently, scientists from the IIT Kharagpur and the Global Institute for Energy, Environment and Sustainability, USA developed a technology for disinfection of secondary treated sewage water using chitosan beads. Chitosan is abundantly available, non-toxic and biodegradable. It has some disinfection properties.

The researchers coated the chitosan beads with ZnO–Ag nanoparticles. Zinc oxide shows photocatalytic activity. However, pure ZnO is photocatalytic and antimicrobial only under UV light irradiation. To increase the antimicrobial property of ZnO in the visible light spectrum, the team surface coated it with silver nanoparticles. Their experiments show that the beads can disinfect secondary treated sewage, because of their strong antibacterial property and produce reusable quality water.

The scientists claim that these cost-effective beads can offer clean water for a minimum of five cycles of operation.

J. Chem. Technol. Biotechnol., **92**: 2334–2341

Perovskite Solar Cells

An emerging technology

Inorganic silicon solar cells are popularly used to harness solar energy. However, cost remains a challenge. Over the past six years, hybrid inorganic–organic metal–halide perovskite solar cells have emerged as lower cost alternatives.

Recently, a team of scientists from the CSIR-CECRI, Karaikudi in collaboration with the Ural Federal Univer-

sity, Russia reported fabricating methylammonium lead iodide perovskite solar cells using a moisture and humidity-free, fast solution annealing process.

Using a field emission-scanning electron microscope, the scientists demonstrated that the surface of the thin films is ultra-smooth and the material is deposited uniformly. They measured photocurrent–voltage to investigate the corresponding incident-photon to current conversion efficiency of the solar cells. The voltage-current parameters of the solar cells showed a power conversion efficiency of more than 12%.



Image: iStock photos

Though more than 20% efficiency for perovskite solar cells has been reported earlier, the team claims that their fast solution annealing method is cost effective.

In any case, we need more research on lead-free perovskite solar cells because lead, a toxic element, leaches out of the solar cells.

Mater. Lett., **205**: 130–133

Supercapacitors from Sugar Waste

After sugar is extracted from sugarcane, the leftover molasses is fermented to obtain ethanol and ascorbic acid. In this process, a semi-solid remnant obtained is used to produce methane. The wastewater produced during this process is known as biomethanated spent wash. Biomethanated spent wash is hazardous.

Now, a team of researchers from the CSIR-Central Salt & Marine Chemicals Research Institute, Bhavnagar has designed a simple process that converts the spent wash into an energy storage material.

They acidified the spent wash, and separated the slurry. Then they dried

the sludge overnight and ground the dried mass into a fine powder. They mixed the powder with ZnCl₂ in water. Once the reaction was finished, they dried, powdered and calcinated the mixture at elevated temperatures to obtain a carbonaceous material.

For the preparation of active material, the researchers mixed the carbonaceous material with acetylene black and polyvinylidene difluoride. They used KOH electrolyte and polyvinyl acetate–H₃PO₄ as polymeric separator. The team constructed two and three electrode systems to measure current and charge–discharge lifetime. Charge–discharge curves showed excellent capacitance retention property (>95%) even after 1000 cycles in the three electrode system, confirming good cyclic stability.

Using a scanning electron microscope, energy dispersive X-ray analysis, and X-ray photoelectron spectroscopy, they established the presence of metal particles and heteroatoms on the surface of the carbon. These particles increase conductivity and impart pseudocapacitance. The team concluded that the presence of ZnCl₂ is responsible for the entrapment of sulphur and nitrogen in the carbon material and this enhanced its electrochemical performance.

This method of producing supercapacitors is not only applicable to sugar waste but can also be used with similar biomass waste to produce value added products.

J. Haz. Mat., **340**: 189–201

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