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ScienceTalk

From food waste to medical materials

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Look in the fridges and bins: The band-aid that we use after our booster shots could be made from our favourite fruit's spiky husk, while the usually discarded stems of our pasta herbs could be fermented into sanitiser that is softer on our hands.

As food sustains all form of life, a fundamental yet under-appreciated overlap exists between food science and medicine.

Besides the universally acknowledged concept of "food as medicine", or "yaoshitongyuan" in traditional Chinese medicine, there exists other diverse uses of food science and technology that are also applicable for clinical applications in medical testing and treatments.

If the materials are derived from the food we eat daily, it would also make sense that they would be accepted and compatible with our bodies in other senses.

Interesting examples of side-streams, or the by-products of food production, that could be re-injected into the medical industry include the leftover pulp from sugarcane and soya beans, herbs in our spice drawer, coffee grounds, and brewers' spent grain – the leftover material from making beer or Milo powder.

Up-cycling them and using them for materials for making face masks and sanitiser would save these useful and nutrient-rich items from adding to our landfills, giving them a second or third lease of life in our daily lives – and even improving them.

The advent of foodtech for medical and clinical purposes could not have surfaced at a more opportune time. The ongoing Covid-19 pandemic has exposed two aspects of medical materials: the increased waste of medical supply (gloves) and the improved functionality of protective materials (masks).

This is largely a reflection of the nature of current medical materials made from the petrol-chemical industry (gloves and masks), which means that they are not biodegradable, and their incorrect disposal would worsen the global waste problem.

Another seemingly unrelated source of environment pollution is from the food processing industry. Globally, the food processing industry, valued at US$11 trillion (S$14.8 trillion) in 2019, generates huge quantities of plant pulp and waste that have high reuse value.

Some examples we are familiar with may include soya bean residues from bean curd making, and barley spent grain from Milo or beer making. These are typically disposed of as waste.

Singapore alone has generated 23,000 tonnes of the latter on a yearly basis. Food waste processing and treatment through incinerator and landfill in turn results in a higher carbon footprint.

To reduce global food waste and the global carbon footprint, food tech innovations have been developed to recover nutrients and convert the solid residues to usable materials. Such innovations have unexpectedly connected the two sources of environment pollution: food processing side-streams and medical materials.

Here is an example.

During the current Covid-19 pandemic, all households in Singapore received reusable anti-bacterial face masks.

However, not many of us may know that its anti-bacterial properties come from the upcycling of cashew processing developed by the Food Science and Technology Programme at Nanyang Technological University, Singapore.

The same antimicrobial compound has also been incorporated in surface disinfectants and sanitisers available in local supermarkets.

This is the same team that has developed chitosan-based cling film from the fermentation of prawn shells.

These examples illustrate the huge potential of innovations from food science and technology in upcycling food waste to not only reduce waste but also generate high-value materials for our daily lives.

Some of such materials could well be natural "biomaterials" which are traditionally substances engineered to interact with biological tissues or systems for therapeutic or diagnostic purposes. The same natural biomaterials would also be naturally biocompatible with our body system such that they would not elicit undesirable immunological or toxic responses from the patient.

Clinical applications necessitate biomaterials to be biocompatible as well as certified medical grade to minimise immune rejection and infection risks.

For clinical biomaterial applications, natural substances have inherent advantages over synthetic petroleum-based or inorganic materials (glass, ceramic, metals), such as overall higher biocompatibility.

Food in all forms consists of some combination of all the different existing substances (carbohydrates, proteins and polynucleotides) and is by definition highly biocompatible for almost all clinical biomaterial applications.

The polysaccharides cellulose and chitosan tend to dominate, followed by fibrous protein-derived

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polypeptides such as collagen and gelatine.

The prevalence of cellulose in food makes it both highly viable and economical as a substitute for petrochemical-derived plastic polymers, particularly in wound care applications.

Chitosan's precursor, chitin, is the second most abundant biopolymer on earth, and found on the surface of insects, fungi, invertebrates and fish.

Plant crop and seafood processing side-streams are hugely underutilised and highly sustainable sources of cellulose and chitosan respectively, which are usually extracted via energetic hydrolysis-based approaches to then be fabricated into wound care and tissue scaffolding, among others.

Presently, synthetic polymers are commonly used in wound care but they are not ideal, with their low level of biocompatibility and biodegradability.

Hydrogel wound dressings made from durian husks demonstrate the strength of cellulose as a substitute, because of its natural biocompatibility, biodegradability and sustainability.

Antibiotic resistance is becoming a major global public health problem. A recent report by The Good Food Institute Asia-Pacific shows that animals raised in confined situations are consistently fed low doses of antibiotics to keep them healthy and to promote weight gain.

The use of antibiotics in animal agriculture is projected to grow by almost 70 per cent between 2010 and 2030.

Excessive use of antibiotics leads to the development of antibiotic-resistant superbugs (AMR) that already kill an estimated 700,000 people a year worldwide. The United Nations' interagency group on antimicrobial resistance estimates that could rise to 10 million per year by 2050.

Natural food antimicrobials, mostly plant-derived antimicrobial phytochemicals, may offer a new strategy against AMR superbugs. Similar to food-based biopolymers, food production side-streams represent rich and readily available bioresources to tap for antimicrobial phytochemicals of interest.

A large majority of these phytochemicals already comprise part of the healthy human diet via their existence in fruits and vegetables, thus are generally considered to have a low risk of negative side effects, contrary to the drawbacks of classical antibiotic therapy.

Plant antimicrobials are typically produced via large-scale extractions of medicinal or food crop biomass, which creates considerably detrimental environmental impacts via deforestation, waste generation and carbon footprint.

Agricultural crop by-products and food processing side-streams are typically phytochemicals-rich, and are highly economical yet environmentally friendly alternative sources.

An antimicrobial reusable face mask was recently commercialised in Singapore, wherein the active antimicrobial component in the mask fabric was derived from industrial nut processing waste.

This represents a tangible result from translational research between food science and medicine that is also highly environmentally sustainable.

Despite the sizeable body of work accomplished in medicine-directed translational food science research, significant challenges and obstacles remain to be overcome.

The useful natural biopolymers cellulose and chitosan are locked behind the complex plant structure which typically requires harsh physical and/or biochemical treatment approaches, and extraction from these waste bioresources has significant room for improvement in terms of efficiency and process sustainability.

Innovations from food science and technology to upcycle food processing side-streams are unlocking their potential.

In addition to the re-integration of the recovered nutrient in the food chain, the fibres and phytochemicals in these plant-based side-streams are beginning to emerge as natural and sustainable mainstream materials for medical applications.

More natural medical materials going beyond wound dressings and antimicrobials are expected to be generated from food tech innovations, which not only offer a new perspective on "food as medicine" but also reduce environment pollution from two unconnected sources, namely food waste and medical materials.

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