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MULTIARRAY BIOSENSORS AND BIOCHIPS: TOWARDS THE DREAM OF TOTAL FOOD SECURITY ANALYSIS

Total analysis of food components has been a long cherished dream and is an integral part to ensure food security from farm to fork. It has never been realized but essential for the safeguard of public health, religious and cultural faiths, biodiversity and endangered species in natural habitats. It has also the great potential to bring tremendous opportunities in business, employment and economy. Regulatory measures, public awareness and comprehensive market monitoring are key players to ensure total security in safe and healthy foods. This research project is a bold initiative for the development of a point of care portable device for the total analysis of food components and reduces the gap between the science and religions (Fig. 1).

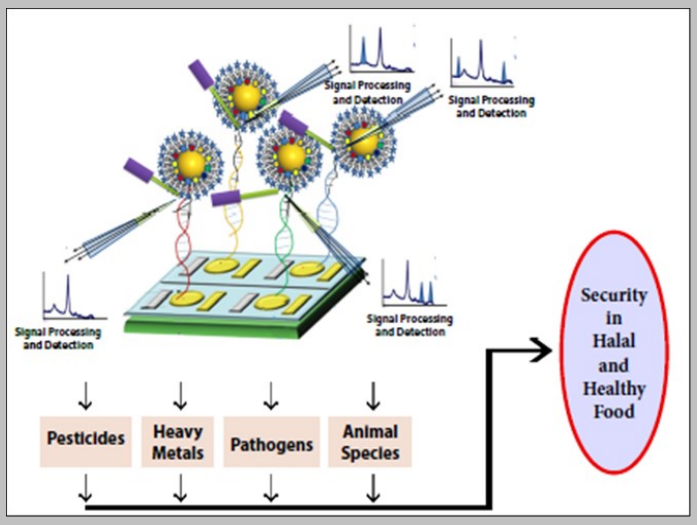

Figure 1. Summary of the Grand Challenges Project

The program has already generated 2 patents and 12 Q1 papers. One of the recently published papers has made international news in the prestigious ACS (American Chemical Society) https://www.acs.org/content/acs/en/pressroom/presspacs/2016/acs-presspac-august-10-2016/frankfurter-fraud-finding-out-whats-in-your-hot-dog.html.

The five components of the program are a transdisciplinary endeavor to support industry and law enforcing authorities to ensure health and religion compliant food products from farm to fork:

Sub-program 1: To develop biomarkers (DNA and miRNA) from meats, fish, amphibian, reptiles, selective plant and pathogens for biosensors and microarray fingerprints.

Sub-program 2: To synthesize functionalized nanomaterials (nanoparticle, quantum dots, graphene and CNT hybrids) with biomolecular fingerprints.

Sub-program 3: Biosensor and microarray assembly to fabricate device and enhanced detection signal.

Sub-program 4: Market need assessment and commercialization of the novel biochip product for food security detection.

Sub-program 5: Islamic Shariah issues in Halal Food Authentication Technologies and reduction of gap and conflicts between science and religion.

Collaborators:

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DESIGN, SYNTHESIS AND FUNCTIONALIZATION OF NANOMATERIALS WITH RAMAN AND BIOMOLECULAR FINGERPRINTS FOR BIOSENSOR AND MICROARRAY INTEGRATION

Food products with appropriate labeling ascribing the product profile are the key features to satisfy the consumer's right, comply with quality as well as regulatory requirements. Hence, qualitative and quantitative detection of meat species are of immense important for fair trading to ensure strong adherence of quality and firm religious certainty. This can be achieved by controlling the admixture of unwanted species, healthy life-style by preventing the spread of zoonotic diseases, and ecological balance by conserving the endangered species. In this context, lots of analytical techniques mostly based on the lipid, protein and DNA have been developed for the detection of the meat species. The inherent limitations of lipid and protein based methods have made the DNA based technique to be a better alternative as far as the processed food items is concerned. PCR, DNA barcoding and DNA hybridization are the recent discoveries but still with limitations namely steps, laborious, time consuming, expensive, non-portable and still challenging in quantitative and the multiplex detection.

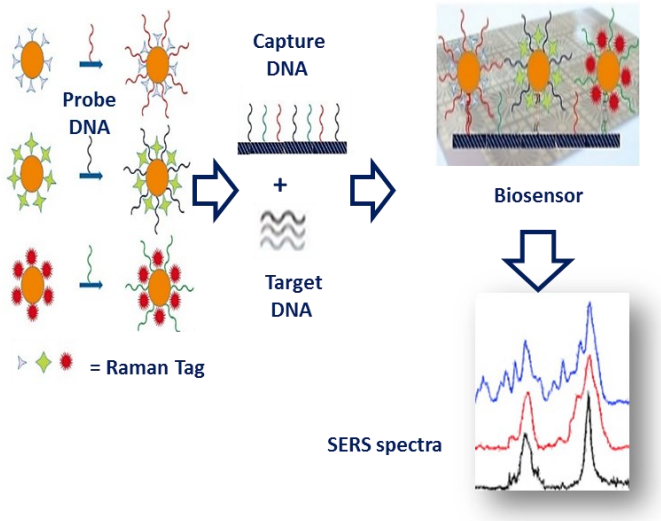

Figure 1. DNA fingerprints for biosensor detection

To minimize the difficulties faced currently, we have approached the biosensor/biochip/ microarray model (Fig. 1). Gold and graphene-gold nanoparticles have been selected as the biosensor platforms for their ease of preparation, surface chemical properties, higher chemical stability, catalytic activity, and inherent biocompatibility. Short length DNA biomarkers as the probe sequence ensures the uniqueness, and traceability of the meat species even in the highly processed products. Nanoparticles functionalized with single stranded thiolated DNA sequences and thiolated Raman Tag (dye) will serve to identify the fingerprint of the corresponding target species. Immobilized probe DNA will specifically and selectively hybridize with the corresponding target DNA sequences and generate identical SERS spectra. By this way, different Raman tags and probe sequences fabricated nano-biosensor will be selectively used for multiplex detection in a single laser excitement. Nanoparticle will provide greater SERS enhancement by the combined effect of electromagnetic and charge transfer mechanism and it will facilitate the identification of single nucleotide morphism with outstanding specificity. Thus, gold/ graphene-gold nanoparticle - DNA biosensor offers the detection and quantification of many targeted meat species present in minute amount ranging from nanomole to femtomole (10^{-9} – 10^{-15}M) or even attomole (10^{-18}M) level in single experiment within very short time. Therefore this can ensure steady and smooth supply of the food products with superior quality.

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DETECTION OF DOPAMINE – A SENSITIVE AND CHEAPER ALTERNATIVE

Biological molecules such as dopamine plays an important role in neurotransmission, is synthesized in kidneys and brain. The loss of dopamine secretion amounting to low levels of the neurotransmitter can be an indicator for Parkinson disease, a disorder in the central nervous system. Whilst there are several methods to monitor the concentration of dopamine such as spectroscopy and chromatography but the methods mentioned are expensive. On the other hand, it might not be possible to detect dopamine at very low concentrations using these methods, as dopamine exists with other molecules in high concentrations in biological samples, which causes poor selectivity and sensitivity.

Electrochemical detection, which is based on the oxidation/reduction of an analyte on the electrode surface may offer several advantages such as sensitivity, selectivity and fast response, apart from its relatively cheaper and robust instrumentation compared to spectroscopic and chromatographic instrumentation. Dopamine can be oxidized on an electrode surface, which is the basis of detection of the molecule using electrochemical techniques. This is also the basis of discriminating dopamine from other non-oxidative biological interferences found in body. However the electrode surface alone is insufficient as dopamine is a conjugated molecule and will not be attracted to any kind of electrode surface. Based on this, we have carefully modified our electrodes by using conducting polymers such as polypyrrole (PPy) (Fig. 1). The presence of conjugation in PPy is able to attract and immobilize dopamine. It is also a conjugated molecule through the weak van der Waals attraction. The immobilization of dopamine onto the electrode surface is the first step. Next, a catalytic centre must be selected for the oxidation of the immobilized dopamine, therefore we have selected platinum (Pt) nanoparticles due to its high electro-catalytic activity for the detection of dopamine. The preparation of the modified electrode, was achieved by chemical oxidative polymerization of ultrathin pyrrole monomers, followed by the reduction of K_2PtCl_4 to produce the Pt nanoparticle on the PPy matrix. The modified electrode, Pt/UltraPPy, gave a detection limit of 0.67 nano molars for dopamine, lower than most reports in ranges of micro molars. In addition, the presence of ascorbic acid and uric acids, commonly found with dopamine in biological samples, do not affect the detection of dopamine using this method (Fig. 2).

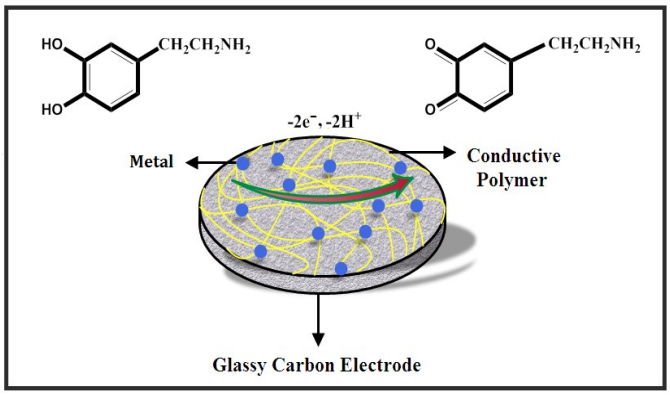

Figure 2. Model for the detection of Dopamine

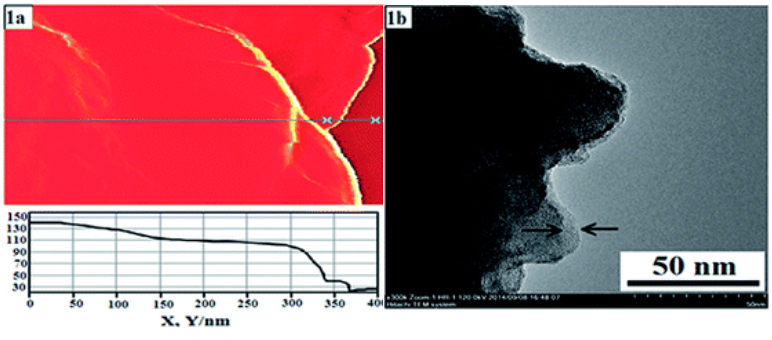

Figure 1. (a) AFM image of UltraPPy; (b) TEM image of UltraPPy

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MARKET ASSESSMENT AND TECHNOLOGY COMMERCIALIZATION OF BIOCHIP PRODUCT FOR FOOD SECURITY DETECTION

Food safety and security has always been a concern (Fig. 1). Consumers expect to access healthy, safe and nutritious food. Food safety related complaints, contamination, illness or even death incidents are still occurring and consumers' confidence level is adversely influenced. The food security and safety improvement depends on the ability to identify, detect and trace food pathogens. Detection technology for food safety enables the manufacturers to test products on-site which shorten the length of time that products must be held in inventory and subsequently lowering storage cost. Despite some of the detection devices has been available in the market for years, food manufacturers in Malaysia did not adopt them.
The research group led by Prof. Dr. Suhaiza Hanim Dato Mohamad Zailani, University of Malaya, has been investigating the determinants for adopting of detection technology to ensure food safety among food manufacturers. Based on questionnaire survey method, data collected from food and beverages manufacturers in Malaysia were analyzed using the partial least squares technique. The results show that the adoption of food safety detection technology is positively influenced by technological context and negatively influenced by customer risk perceived by manufacturers. The findings of this study are useful for managers of food manufacturers and policy makers to understand the factors leading to successful adoption of detection technology for safety and consequently promote this technology, which will lead to higher food safety and security.

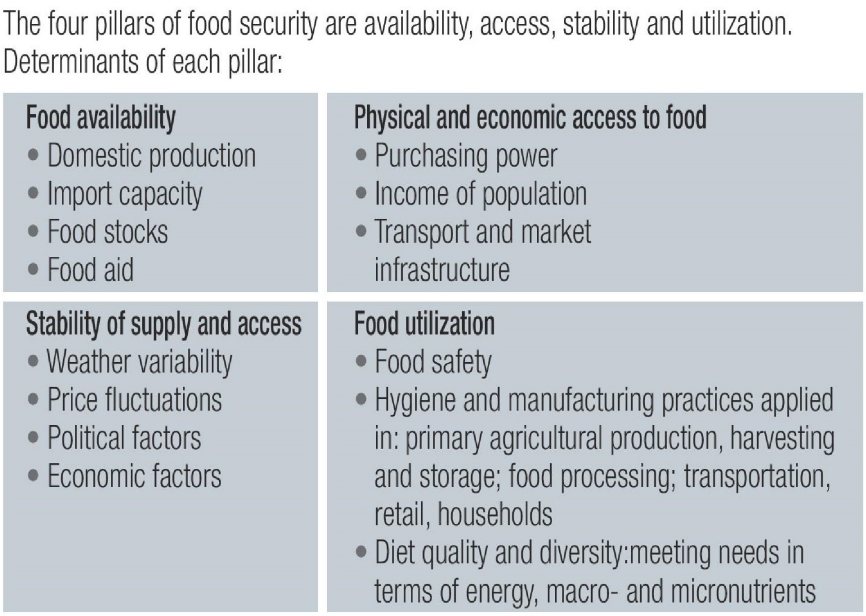

Figure 1. Food security and determinant factors.
Source: http://www.unicef.org/albania/Food_Security_ANG.pdf

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SHARIAH ISSUES IN HALAL FOOD AUTHENTICATION TECHNOLOGY

Issues about food products, including raw and processed food, gained main attention from Muslim consumers. This is because food is not only has function in developing the dimension of the human physical; it also influences the development of their spiritual's dimension. The rapid development of production technology and food processing has raised various issues related to halal and haram. The industry players used various approaches and modus operandi to minimize the production cost and maximize profit without thinking about the effects and the risk towards spiritual and the physical health of the consumer. Numerous forgeries and fraud has occurred, for example the production of fake meat and artificial meat. For instance, production of imitation meat which used pork and claimed as beef, horse flesh as beef, and dog meat as mutton. This also includes the mixture of halal animal meat with the haram ones, such as the mixture of pork with beef to confuse the consumer. Apart from that, the distribution of disease-infected meat such as the mad cow disease (BSE) also occurred in the market. This is worsened with the trafficking activity of wild animal meat and protected animal which is rampant in the market due to consumer demand, for example tiger meat, monkey, deer, anteater and so on. This issue of food fraud is in parallel with the advancement of science and technology. Not only the meat-based food products involve in the syndicate of imitation products, but also there are artificial rice and artificial egg in the market now. The production of such foods can raise the issue of halal haram, and can even cause negative effect towards the consumer safety. This is because there is risk of dangerous minerals, bacteria and viruses that threaten human life and the toxic composition that affect human's health. The condition can change the status of the food products which is originally halal to become haram. Because of that, various halal authentication technologies are being developed to tackle the issues raised and in order to assist the Islamic scholar to issue accurate law for the issue.

However, there are weaknesses in every of the technology developed beside challenges in the usage of this authentication technology. These weaknesses can be internal or external. The internal weakness is that the authentication technology cannot detect the content of analysis material accurately because of the short DNA cut. Meanwhile, the external weakness is the contamination risk of the analysis material, due to limited laboratory facility for analysis as well as the high cost to produce an effective authentication technique. In order to overcome these weaknesses, the view of Sharia needs to be considered if the development objectives of this halal validation technology are aimed to look after the spiritual aspect and the physical aspect of Muslim consumer. This is because it suits the Shariah objective, namely, to bring about maslahah and to reject mafsadah (damage). Nevertheless, it needs to be evaluated based on the hierarchy of Shariah objective, namely daruriyyat (necessities), hajiyyat (needs) and tahsiniyyat (embellishments). Sharia celebrates any technology that brings benefit to consumers. Having said that, Shariha does not burden with taklif (sharia obligations) which is difficult and troublesome, but on the other hand, it exists with the enthusiasm to celebrate benefits for human through the principle of convenience. Therefore, this study will provide a Shariah guide in the efforts to help facing the challenges for the development and usage of halal authentication technology especially in food products.

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CLEAN WATER SUPPLY FROM SELF-CLEANING SOLAR POWERED MOBILE ULTRAFILTRATION SYSTEM - FROM THE RESEARCH LAB TO THE COMMUNITIES

The Water Services Industry Performance Report by SPAN (Suruhanjaya Pengurusan Air Negara) stated that 10% of the residences in the rural areas are still without clean water supply and is especially critical during disaster incidents such as flooding. To tackle this issue, researchers from the Department of Chemical Engineering and Centre for Separation Science and Technology (CSST), have recently developed a self-cleaning, solar powered mobile ultrafiltration system to supply clean water (Fig. 1). This project is led by Prof. Dr. Mohamed Kheireddine Aroua and Prof. Ir. Dr. Mohd Azlan Hussain.

The ultrafiltration system is a mobile unit that can be dispatched to any site in a very short time and is able to process significant quantities of water in the 500-1000 L/h range, depending on the quality of the raw water. It can produce clean water from various water sources such as river water, well water, lakes and rain water.

The unit is fully enclosed in a cabinet and operates through the front control panel. It is a "plug and play" module where connections to the water feed tank, outlet tank, backwash tank and power supply are located closely at the back panel.

One of the main advantages of the unit is its mobility where it can be dispatched easily to rural areas by lorry or truck. The installation is relatively easy and able to provide clean water within minutes after commissioning. The latest unit is installed with an auto-operated backwash system as per requirement of the membrane filter. A solar PV system has also been added to the unit recently to cater for rural areas without power supply.

The unit was initially used during the 2014-2015 floods in east coast Malaysia. It was operating in Kuala Krai for 2 months to supply clean water to villages and military camp that affected by the heavy floods. The manual units sponsored by the Ministry of Higher Education were later installed in two other remote villages in Gua Musang area, which are still in operation (Fig. 2). Besides that, the automated unit has also been installed in another rural village in Gua Musang area and 2 solar powered units we installed in Saratok and Sibu, Sarawak.

Figure 1. The ultrafiltration system

Figure 2. Prof. Ir. Dr. Mohamad Azlan Hussain explaining the ultrafiltration system to YB Dato' Seri Idris Jusoh, Ministry of Higher Education

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BIOBANK UNIT

The Biobank Unit, located in the Faculty of Medicine is a central repository facility that safely and efficiently stores, handles and tracks a wide variety of ethically-procured biospecimens and it was established in 2011.

The Biobank offers a complete suite of services from tissue procurement, processing, inventory and storage. Downstream services are also available for researchers who wish for their samples to be in the form of formalin-fixed paraffin embedded (FFPE) blocks or H&E stained histology slides.

Over the last 5 years, the Biobank has collected a wide range of cancer specimens. Its inventory consists of tissues from breast, endometrial, ovarian, renal, bladder, liver and embryonal cancers. To date, the Biobank stores approximately 8000 tissue samples from 5000 patients in liquid nitrogen tanks and more than 1000 FFPE blocks. In addition to tissues, the Biobank also collects and processes blood specimens into products such as plasma and serum to complement the frozen cancer tissue. As all stored tissues are also clinically annotated, the Biobank has developed into a valuable resource for cancer research in UM.

In May 2016, University of Malaya's Research Grant (UMRG) funded the Biobank Unit which expanded to include a new freezer facility (Fig. 1 & 2), located at Block M of FOM. This facility hosts 20 units of -80°C ultra-low temperature freezers to satisfy the biospecimen storage needs, not only of FOM researchers but also those in Universiti Malaya. At maximum capacity, the twenty 700 L freezers can store just over one million vials of samples.

The Biobank Freezer facility is equipped with a state-of-the-art triple-layer power backup system. Additionally, all freezers are connected to a real-time temperature monitoring system, which will notify Biobank staff via e-mail and text message if abnormally raised freezer temperature is detected.

The freezer facility is accepting specimen for storage and the biospecimens must be accompanied with copies of patient consent forms and Ethics Committee approval.

Figure 1. Biobank Unit of Universiti Malaya

Figure 2. New Biobank facility with -80°C ultra-low temperature freezers

Charges

RM 3.00 per box per month

RM 360 per compartment
(Comp A with 120 boxes capacity) per month

RM 432 per compartment
(Comp B with 144 boxes capacity) per month

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1ST JOURNAL EDITORS WORKSHOP IN UNIVERSITY OF MALAYA

Figure 1. UM journal editors in front of IPPP building

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The Research Support Unit (Unit Sokongan Penyelidikan, USP) in collaboration with Malaysia Citation Centre (MCC, Pusat Sitasi Malaysia) successfully hosted the 1st Journal Editors workshop on 26th May 2016 at IPPP (Fig. 1). UM has published over 56 journals, available online from the UM E-Journal website and My-Journal website. Some of these journals are indexed under ISI-WOS, SCOPUS and ESCI.

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