HARUAN *Channa striatus* a **Drug Discovery** in an **Agro-Industry Setting**

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Contents

PREFACE

The information provided in this book is brief and more along the lines of an introduction. This is necessarily so because detailed information cannot be made available in the public domain as new technology, discoveries and even some trade secrets are involved, where most are to be patented in due time

This is a natural product drug discovery in an agro - industrial setting, where all the raw materials are produced and standardized according to Good Agriculture Practices (GAP) based on Standard Operating Procedures (SOP) established by Abdul Manan Mat Jais. It is now beyond the stage of biomedical properties laboratory screening, and is at the commercialisation stage, whereby in this case Haruan Traditional Extract (HTE), a natural product, is bioactive.

All activities and efforts are being channelled towards ensuring compliance with local and international monitory as well as regulatory requirements, for registration of products, producing clinical batches and prototypes at GMP facilities.

ABSTRACT

Malaysia was ranked twelfth in world ranking of Mega biodiversity countries, as declared by UNESCO in 1997. BUT the question is SO WHAT?

Since independence in 1957, none of our natural products have been developed to produce pharmaceutical drugs. Further, no single indigenous species has been made into a tradeable COMMODITY.

By 2004, we were no longer ranked among the top twelve mega-biodiversity countries, as we were ranked 14th among the 17 countries listed in 2004. This is because most of our forests have been logged, stripping off the nation's bio-wealth (Malaysia's Mega-diversity under threat, 2004 http://www.greenpeace.org/international/press/reports/malaysia-s-mega-diversity-unde). Even now, no one knows for sure what we still have, and what has already been eradicated. Logging has destroyed our forests which we have replaced with mono exotic species i.e. either rubber or palm oil.

Terrestrial, freshwater and marine ecosystems are under constant threat. Although 70 % of the earth's surface is covered by water, the freshwater ecosystem comprises only 2%. However, 12% of all animal species, and 40% of all the recognised fish, which totals about 8,400 species, are in the freshwater ecosystem (http://www.fao.org/sd/EPdirect/EPre0044.htm). Unfortuntely with freshwater ecosystems being reduced, at least one fifth of all freshwater fishes are already extinct or seriously endangered. Further, since 1995, 70% of the world's marine fishes have been either fully exploited or over fished and depleted.

One should also remember that fish is accountable for approximately 17% of the animal protein in the normal human diet, and around 29% in Asia. Hence the loss and degradation of biodiversity in the marine ecosystem is very alarming and will

have phenomenal implications on the food and livelihood security of humans.

Previously, 75% of the fishes consumed were from nature i.e. wild species, while the remaining 25% was from aquaculture production. Today however, approximately 85% of fish supplies are from aquaculture (http://www.fao.org/sd/EPdirect/EPre0044.htm). In Malaysia, the aquaculture industry is now a priority and the government has projected a 200% increase in production to 600,000 tones in 2010, from 200,000 tonnes last year (http://www.fao.org/fishery/countrysector/naso_malaysia/en).

Today, there are 290 freshwater fish species identified in Peninsular Malaysia, more than 100 in Sarawak and 200 in Sabah (http://www.nre.gov.my/opencms/opencms/NRE/BM/Services/Biodiversity/biodiversity.html), and the Haruan *C striatus* is one of them. Most if not all freshwater aquatic species face fewer risks as compared to land animals which are at risk from diseases such as smallpox, Bovine Spongiform Encephalopathy (BSE) or Mad - Cow Disease (MCD), Japanese encephalitis (JE), Bird Flu (H5N1) and Swine Flu (H1N1) (http://en.wikipedia.org/wiki/Aquaculture). This, among others, is the reason why aquaculture is becoming increasingly more important and hence why the Haruan is now an important option in the field of food and drug discovery.

WHY HARUAN?

In 1984, soon after completing my Ph.D at University of Southampton in England, I was asked to lecture at the Department of Biology in the UKM Kampus Sabah in Kota Kinabalu. It was one of the most challenging and heart breaking times for me because I was scheduled to leave for Kota Kinabalu on 31 December 1984, and I was also expecting my first child anytime from mid to early March. All my requests and applications to postpone or delay my departure fell on deaf ears, whereby UKM and the related authorities were just not concerned about my dilemma. I forgave them BUT will never forget. I do pray and sincerely hope that no one else will be subjected to experience similar circumstances.

To add to my distress, on the eve of 19 February 1984, upon receiving news that my wife was facing complications, my friend invited me to a diner. Around 5 pm on 18th February 1984, my sister-in-law called to inform me that my wife would have to undergo a caesarean section operation the following day. Well, it was mere coincidence but after our meal, at about 8pm, the TV programme 'Drama Minggu' televised the story of a man losing his wife during child birth on the operating table. I just stood up, walked directly to the television set and switched it off. Of course it was rude for a guest to do such a thing but what else could one do in such circumstances???

Alhamdulillah, I received good news early the following morning that both my wife and my first child, a daughter, were doing fine! My mother-in-law gave my wife Haruan as a supplement, and this provided me the initial inspiration for this project. I have never looked back since then and have always remained optimistic and fully confident about my idea.

INTRODUCTION

Haruan *C striatus* is part of the **ETHNOPHARMACOLOGY** of Malaysia, used as an oral remedy for wound healing among women after child birth, and considered almost compulsory by those undergoing caesarean operations throughout the country. Although there is no formal documentation on whom, how and when Haruan was first used as supplement, alternative as well traditional medicine, the practice seems to be well known and well received by almost all races (namely Malay, Chinese, Indian, Bajau, Bugis, Kadazan - Dusun, Melanau, Iban and Bidayuh), communities and tribes in Malaysia. Although, the Haruan was initially consumed by those who have undergone caesarean section operation, the fish is now sought after by even those who incur external injuries due to road accidents, and those suffering complicated chronic diseases. Other members of the family Channidae, also appear in old Chinese and Indian transcripts as a remedy which provides nutrients after prolonged illnesses.

In many countries, especially in the Mekong Valley, the Haruan, due to its taste and its having very little bones, is an extremely important staple food for rural people, and a favourite main table fish dish in town. In Myanmar, among the Karen tribe, snakehead *C marultus* is believed to be the reincarnation of people who are punished for their sins, and that those who eat this fish would be transformed into lions.

Research on Biological Information of wild Haruan in Malaysia has been carried out since 1985, using seed money given by Universiti Kebangsaan Malaysia, Sabah Branch and funds from the International Foundation for Sciences (IFS). In fact, it was IFS which specifically requested that the Biological Information of Haruan to be studied in detail. This includes morphological study, distribution, ecology and behavioural studies. Concurrently,

proximate analysis was carried out, before the start of biochemical analysis, to understand amino and fatty acid profiles in collaboration with the University Department of Medicine, Royal Perth Hospital, University of Western Australia, and University of Chulalongkorn, Thailand. This biochemical analysis uses the conventional approach towards identifying bioactive compound(s) responsible for wound healing.

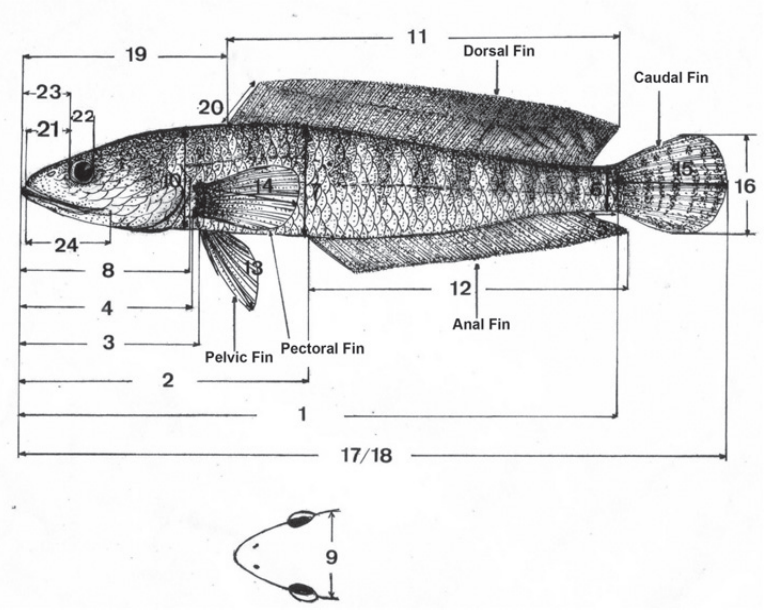
BIOLOGY OF HARUAN

Morphology

290 species of freshwater fish have been identified in Peninsular Malaysia, more than 100 species are in Sarawak, and 200 in Sabah (http://www.nre.gov.my/opencms/opencms/NRE/BM/Services/Biodiversity/biodiversity.html). Among these is the Haruan *Channa striatus* (or previously known as *Ophiocephalus* or *Ophicephalus striatus*) which belongs to the family Channidae, together with Toman *C. micropeltes* and Bujuk *C. Lucius*. There are a total of 30 species of Channidae in the world, of which eighth are found in Malaysia

In Semenanjung Tanah Melayu, or Peninsular, or West Malaysia, based on Restriction Fragment Length Polymorphisms (RFLPs) works, there are three main stocks of wild *C striatus* in the North West - Penang, the North East -Kelantan and the South - Johore. The RFLPs of mitochondria DNA (mtDNA) were performed on the three populations to estimate genetic differences and variability. Five 6 - base recognizing restriction endonucleases, *Hin* dIII, *Eco* RI, *Pst* I, *Kpn* I and *Bam* HI, were used based on the method described by Kajima, *et al*., 1994 where wild haruan, *Channa striatus*, with a mean size of 22.4 cm total length and mean weight of 121.4 g will be sampled randomly, and the heart, liver and eggs, if available, are

used for the RFLPs analysis of mtDNA. It is highly recommended to establish a regional DNA Finger Printing of Haruan to relate, and confirm the indigenous status of the *C striatus*, as well as to counter false claims of products containing Haruan.



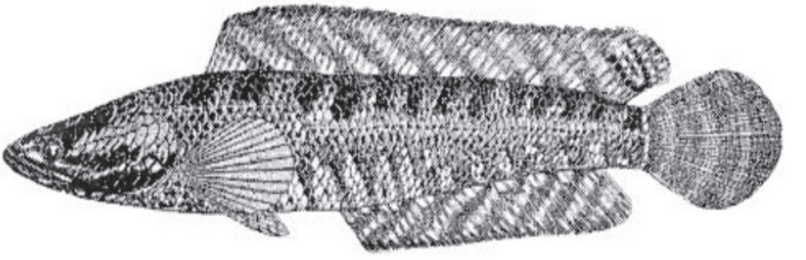


Figure 1 Morphology of Haruan, and the Genetic Materials, the DNA Sequence

Through research, we are now finalizing and establishing the biological information especially environmental physiology, genetic background, reproductive behaviour and feeding habits, as specifications and standards in Good Agriculture Practices (GAP) for farming technology.

Ecology

All members of the Channidae are either warm Tropical or Sub - Tropical species, and most of the species are carnivorous and air breathing. In the case of the Haruan, the fish is commonly found in shallow, slow moving or stagnant water with temperatures of between 20 - 30^{o}C, good level of dissolved oxygen, low turbidity and conductivity. The water quality for each station was checked using HORIBA UK Model U10, to measure pH, temperature, turbidity, conductivity and dissolved oxygen. The exact location of the stations were confirmed using Global Positioning System (GPS), using Nokia N95 Series mobile phone, through the nominal GPS Operational Constellation, which consists of 24 satellites that orbit the earth in 12 hours.

The physical - chemical parameters of the natural habitat were mainly DO ranging from 3.77 to 31.28 mg/L^{-1}; pH between 5.16 to 6.98; temperature within 29.43 - 31.86^{o}C; turbidity of the water between - 10.00 to 14.57 NTU; conductivity of 0.06 to 0.97 mS/cm^{-1} and salinity of 0%. All the measurements were carried out using the HORIBA Water Checker.

Physiology

As an air breathing species, the Haruan *C striatus* prefer shallow water for ease of swimming up for fresh air that could last a few hours. Its dark green top and wide ventral provide the Haruan camouflage from bottom up and top down while swimming up, breathing and hiding from enemies and gives it an advantage in strategy when attacking prey. It undergoes slight changes in colour to blend with the environment, and also indicate aggressive behaviour during the mating season.

Air breathing is an advantage as there is a limited amount i.e. 30 to 40 percent less of oxygen in water, and it is far more energy consuming to extract oxygen from water. This is because of the high viscosity and density of water as compared to air, making it harder to pass it across the gills. For this reason, oxygen has a far greater influence on the lives of fish than on terrestrial animals.

This carnivorous fish is a good swimmer, known to be a fighter and hence one of the game fishes popular among anglers. It is relatively calm and loves live fish, frog and other aquatic animals. The fish is also known to attack small birds, and even small terrestrial rodents.

Normally found in shallow, 3 to 4 feet, slow running more or less stagnant and clear water, the Haruan likes to rest and hide. As a carnivorous fish, the Haruan require some hiding places and is very territorial. It is also a migratory fish and has been known to crawl across to other water bodies for various different physiological reasons, mainly due to degrading quality of the water, food shortage and during the dry season. Mostly the Haruan bores into mud during the dry season.

Most of Channidae, especially the Haruan, are monogamous and display good parental skills. Both male and female take turns to guard and nurse their young. The phrase 'Haruan Makan Anak' is totally wrong as the Haruan swallow their young to protect them, and release them again in safer conditions.

Biochemistry

Being carnivorous, top of the food chain and feeding on living animals makes the biochemistry of the Haruan interesting

Haruan contain high 78.32 $\pm$ 0.23% protein with interesting amino acids, where 14 of the ones detected are essential to humans (very high percentage of Glycine and Cysteine), low total lipid of

2.08 ± 0.08% with good profile of fatty acids, especially high in Arachidonic Acid (AA) and Docoxahexanoic Acid (DHA), and almost all the nutritional minerals expected from an animal, in levels which are below toxic level for humans. Hence it provides a source of protein, with balanced nutritional values, as a remedy to induce healing of wounds due to various complications.

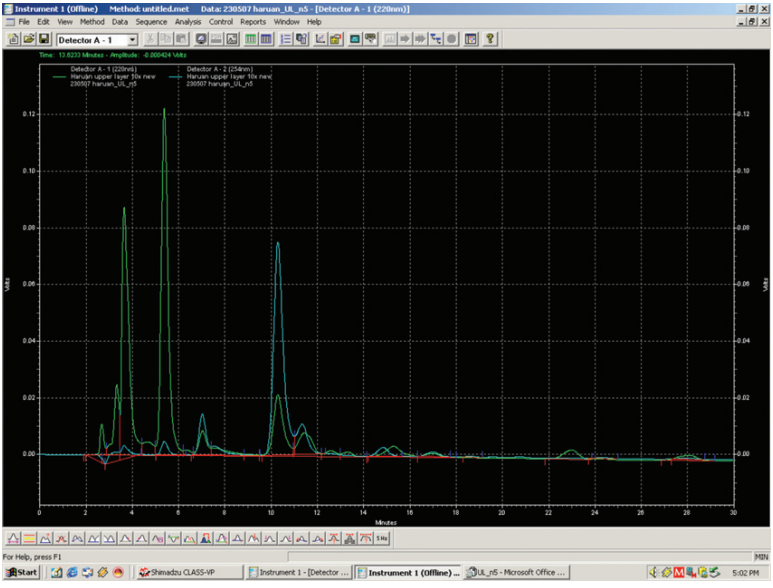
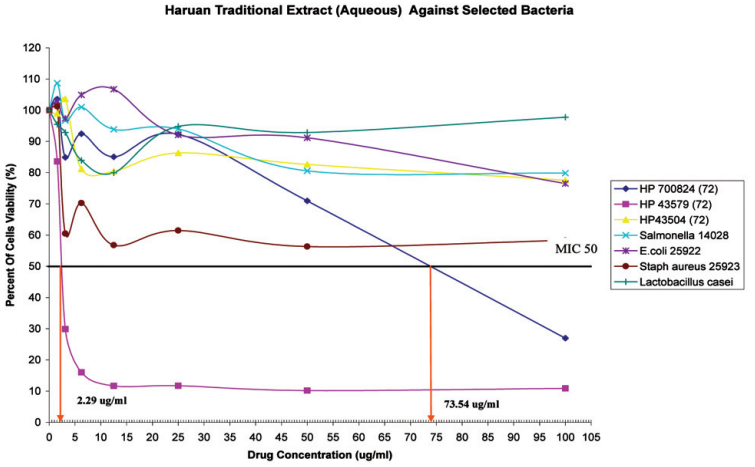


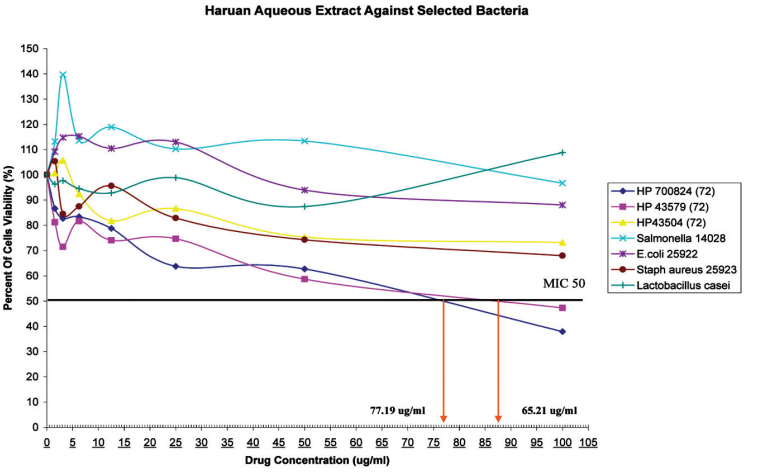
Figure 2 Amino Acid Profile of Wild Haruan *Channa striatus*

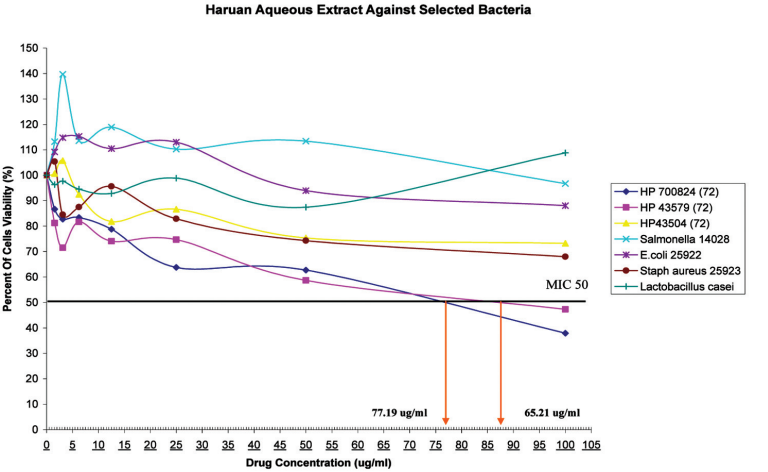
Furthermore, Haruan *C striatus* contain all the essential amino acids and good combination of fatty acids required for wound healing and regeneration of human skin (Mat Jais, *et al*., 1994, 1998 and 2005).

BIOMEDICAL PROPERTIES OF HARUAN

Fillet and mucus extracts of *C. striatus* have been proved to possess antinociceptive activities, exhibited by dose-dependent properties in mice (Mat Jais, *et al.,* 1997). The activity is mainly through the peripheral rather than central nervous system since they only showed the effects when assessed by the abdominal constriction, but not the tail flick test (Mat Jais, *et al.,* 1997). In this instance, it was suggested that certain peptides and lipo-amino acids (arachidonylglycine), behave similar to the Haruan antinociceptive properties (Huang *et al.,* 2001). Furthermore, all the amino acids present in *C. striatus*, expected to serve as building blocks of various types of peptide components and high amino acid content, may conjugate with glycine to form lipo-amino acids (Mat Jais, *et al.,* 1997; 1998).




Haruan Aqueous Extract Against Selected Bacteria
Percent Of Cells Viability (%)
Drug Concentration (ug/ml)
MIC 50
77.19 ug/ml
65.21 ug/ml
HP 700824 (72)
HP 43579 (72)
HP43504 (72)
Salmonella 14028
E.coli 25922
Staph aureus 25923
Lactobacillus casei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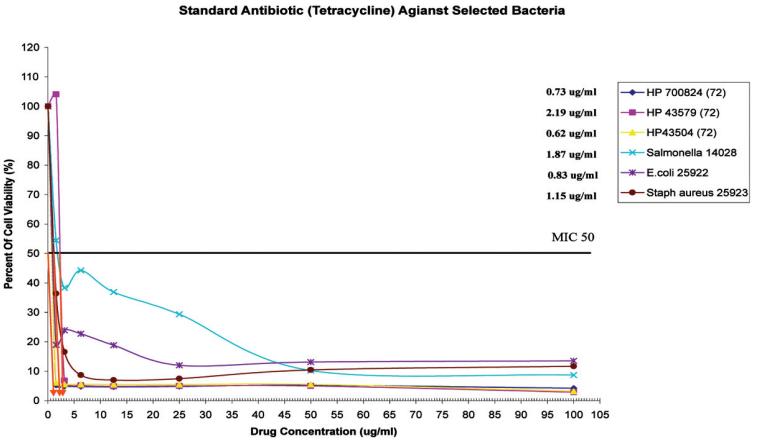
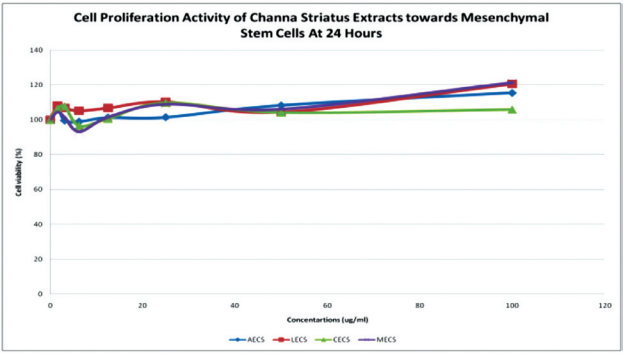
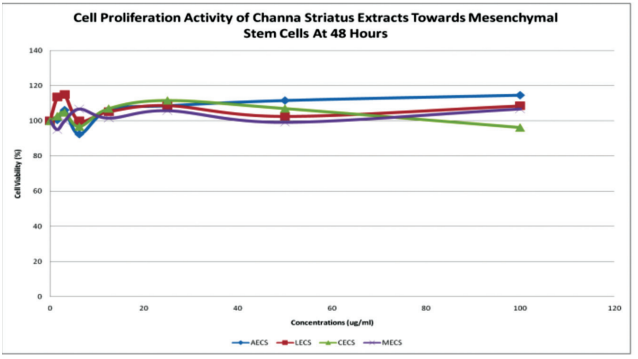


Figure 3 Antibacterial property of Haruan *Channa striatus* against pathogenic bacteria *Escherichia coli* (ATCC 25922), *Salmonella typhimurium* (ATCC 14028), *Staphylococcus aureus* (ATCC 25923) and different strains of *Helicobacter pylori* (ATCC 700824, ATCC 43579, ATCC 43504)

Even the roe or eggs of *C. striatus,* contain unsaturated fatty acids as a major component, and in a high percentage as compared with the mucus extracts, which probably have anti-pain properties (Mat Jais, *et al.,* 1997). The mucus extract is relatively heat stable, similar to the fillet extract (Dambisya, *et al*., 1999).





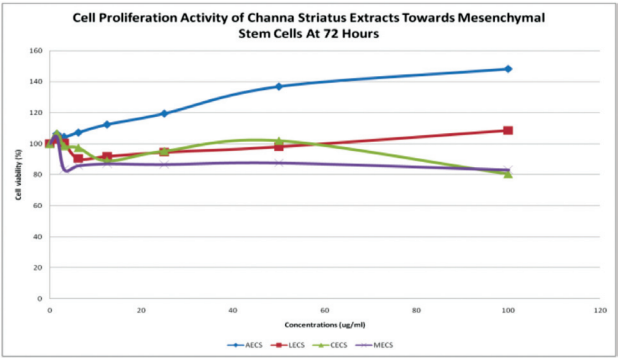
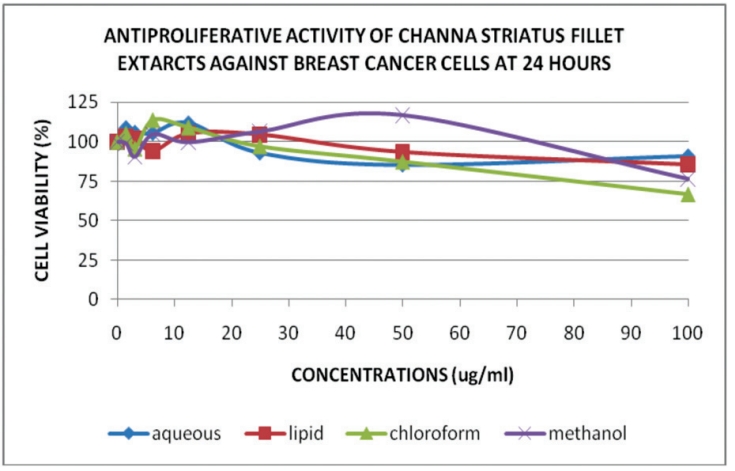
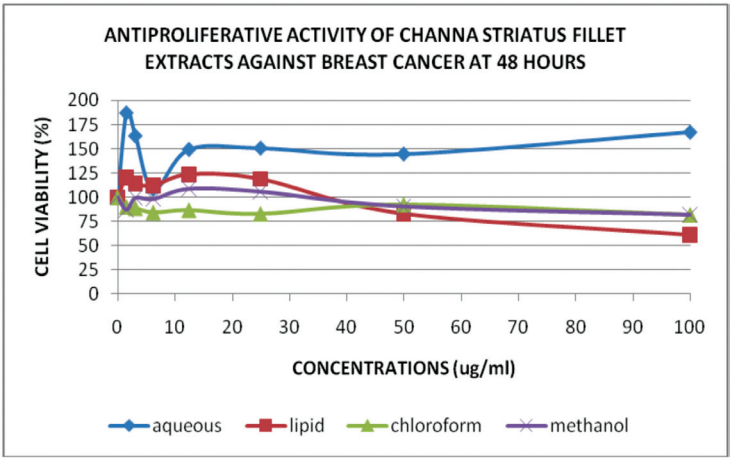


Figure 4 Haruan *Channa striatus* extracts inducing and promoting cell proliferation of Mesenchymal Stem Cell (MSC)

The Haruan extract has shown very strong anti-inflammatory properties in chronic inflammation (Somchit, *et al*., 2004). The bioactive compound responsible for the antinociceptive property is very stable (Dambisya, *et al*., 1999; Zakaria, *et al*., 2004).





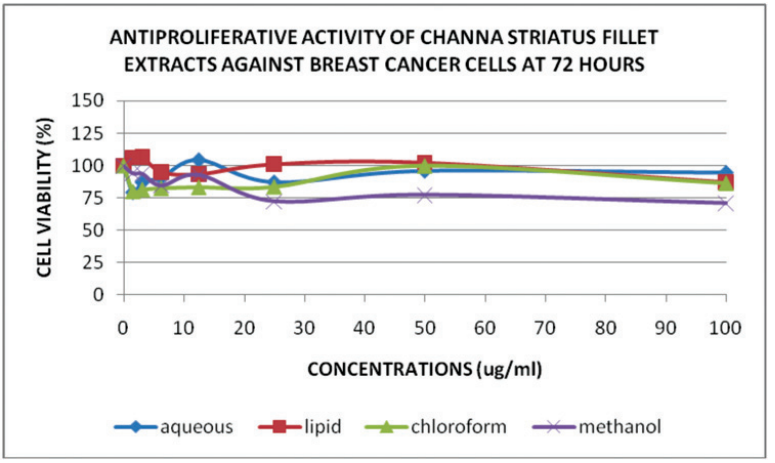


Figure 5 Haruan *Channa striatus* extracts promoting cell reduction MCF - 7 cells

OPERATIONS AND INDUSTRIAL PLANNING

Development of the operational blueprint for the project began in 2003, with much of the efforts invested in navigating government agency regulations, support requirements and establishing inter-agency cooperation. With that almost complete we are now focusing on securing and confirming aquaculture sites for the project. We are therefore seeking significant financial investment from the government to establish our Haruan Agro-Pharmaceutical activities, which will involve development of the Planning Blueprint, breeding and farming at Satellites Project areas, as well as developing the first commercial scale extraction process and product prototypes (utilizing GMP facilities), manufactured in GMP facilities with totally hygienic settings.

Aquaculture

This is to produce sufficient high quality sustainable raw materials, i.e. the Haruan *C striatus,* and selected botanicals, to be used in product formulations. This involves comprehensive integrated aquaculture and post-harvest activities tailored to produce Haruan *C striatus* as fish food supply and as a raw material source for our proprietary Haruan Traditional Extract(HTE).

The operations include overseeing administration, financing, facilities and other activities. This will include **BREEDING,** where firstly there needs to be a collection of wild species as Brood Stock for both natural and induced reproduction. Selected young fishes from the natural breeding are then used for future Brood Stock thereby maintaining a continuous supply. Production of juveniles will be a business on it own, but all the supplies for this project involves inbreeding. All the newly hatched juveniles are nursed with specific feeding regimes and graded before release into growth ponds. The other main component of this self - sustainable integrated farming venture is our own **FEED MILLER** to produce feed for every stage of the project, utilising our own formulation.

The starting point is the wild species of Haruan *C striatus* being collected and certified as Brood Stock for breeding purposes. The Haruan *C striatus* DNA sequence as Genetic Marker has already been established, a technology to counter fraud. Hence, success of this aquaculture project is very much dependent on the quality of the Brood Stock. We then developed our proprietary processes for farming, breeding feeding, nursing, grading and extracting the key actives, which we have detailed in our Standard Operating Procedures (SOP). Our aquaculture regime allows us to produce a biochemical standardized and physiologically healthy source of Haruan *C striatus*, which meets GAP and SPLAM regulatory

guidelines. In addition to preparing and using the fish extracts, the sale of Haruan fillets offers us an additional line of income.

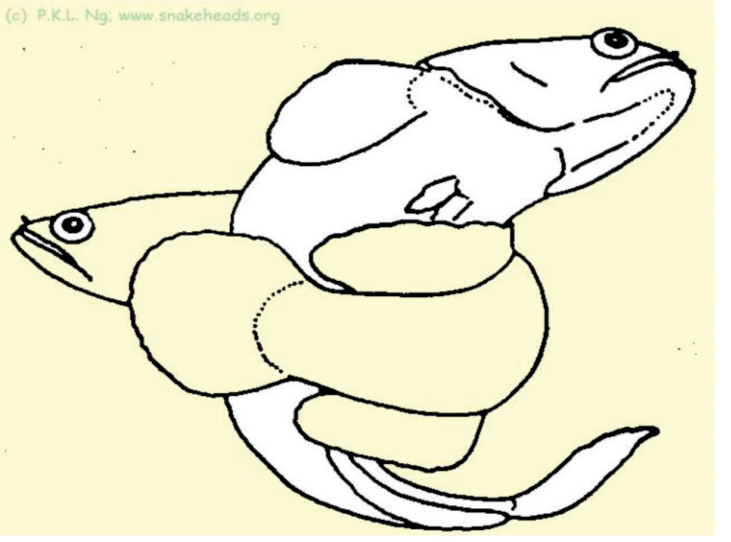


Figure 6 Pictures of natural and induce breeding of Haruan *Channa striatus*

Breeding and hatching is performed under controlled environment in a hatchery unit using UV Filtered water. The fry is graded and placed in the nursery for FOUR weeks to introduce pellet eating, to improve feeding habits thereby ensuring uniform growth and less than 5 % mortality.

Further growth is in polyethylene tanks and concrete ponds, for easy maintenance. The entire range of aquaculture activities, right from breeding to harvesting as a cycle, covers FOUR months, producing 250g Haruan per tail, or four tails to a kilogram. This is the ideal size providing optimal biomedical quality. Bigger sized 300, 500 and 1000 gram per tail Haruan are farmed as food and table fish, tailored to demand. Feed for all the fishes at different ages are formulated and produced in our own facilities, and this is another TRADE SECRET. This is our technology to sustain Quality Assurance and Standardization.

This integrated, commercial scale agriculture project, comprising the aquaculture farming of Haruan *C striatus* and farming of all the botanicals required as ingredients in the formulation and manufacturing of our Biomedical Products, is set to be launched as soon as possible. The botanicals we are growing will be used in our products for colour, flavour and preservative purposes. Post-harvest activities will include preparing and packaging the extracts for outsourced product manufacturing at GMP Facilities. All the catches are treated to cleansing before making fillets and extractions. All the fillets are hand sliced and seasoned with selected herbs before extraction. This aquaculture activity utilises Green Technology in a closed ecosystem, recycling as well as utilizing all resource materials to minimize power and waste, where as an air breathing species the Haruan do not need 24 hours aeration. The entire process is therefore environmentally friendly and the products almost fully organic.

Haruan Traditional Extracts (HTE)

The main activity in post harvest processing is to produce standardized fresh Haruan for food and for the extractions. Some of the fishes will be sold directly to the local market, restaurants and consumers, mostly on contract basis for food, and the cohort for biomedical products are immediately treated overnight (12 hours) in chilled salted water, and processed into fillet the next day. The fillet is rinsed and seasoned with selected local herbs before extraction, done in a specially designed pot, a technology owned by Abdul Manan Mat Jais.

The end product from the extraction processing is the Haruan Traditional Extract (**HTE**), which comes in two forms, i.e. essence of Haruan *C striatus*, the liquid portion, and solid form. The solid form is blended into Health Food Products namely, biscuits, and Haruan fingers and balls. Some of the solid form is ground into powder for the making of body scrubs and medicated creams.

The liquid portion is further processed into tonics, and dried up into powder for personal care and biomedical products.

This is an organic product with no chemicals added. All the colour, flavour and preservatives are natural, obtained from Haruan and herbs. We produced **HTE** in powder form using Spray and Freeze Dryer Technique for easier formulation, transportation and storage. Now **HTE** is made into powder form using Supercritical Fluid Extraction for more standardized products.

Haruan *C striatus* has traditionally been used as a remedy to help patients heal from post surgical wounds and internal injuries. This is the biochemical and physiological criteria that has to be sustained and maintained in the commercial extraction processes. Therefore special blending, treatment and preparation techniques were developed to produce the Haruan Traditional Extract (**HTE**). The materials still contain a good amino and fatty acid profile which

is necessary to facilitate wound healing. Furthermore, both *In Vitro* as well as *In Vivo* animal models indicate that **HTE** exhibits the following biomedical activities: antinociceptive, anti-inflammatory, antimicrobial, anti-cancer cell proliferation, stem cell proliferation inducing, platelet aggregation stimulation and cognitive functioning enhancement.

In addition to high levels of amino and fatty acids, **HTE** also contains high percentages of Glycine and Cystine; as well as Arachidonic (AA; 20:4ω6) and Docosahexaenoic Acid (DHA; 22:6ω3).

Figure 7 Fresh fillet is used for preparation of Haruan Traditional Extract (HTE)

Basically **HTE** possesses good biochemical composition for wound healing and shows exciting biomedical properties.

As a product **HTE**, which is formulated to sustain and maintain the biochemical and biomedical properties of Haruan *C striatus*,

is produced using our own unique technology. The extraction procedure was invented after much laboratory screening, using standard organic and inorganic solvents, namely chloroform, chloroform:methanol, methanol, ethanol, DMSO, double distilled and ionized water. The **HTE** developed using this procedure proved to sustain, and even have a better biochemical profile and biomedical properties as compared to using chloroform:methanol extraction methods. This extracted **HTE** is raw material for product formulations, and all related R & D and clinical trial works. Our recent R & D efforts showed that the **HTE** contained antioxidants, induced in vitro proliferation of Mesenchymal Stem Cells (MSCs), has neurogenerative effects on PC-12 Cell Line (from rat phaechromocytoma) and antimicrobial activities against 4 human pathogenic bacteria, namely *Helicobacter pylori*, *Escherichia coli*, *Salmonella typhimurium* and *Staphylococcus aureus.* Interestingly the HTE does not inhibit the good bacteria *Lactobacillus casei*. As the results show, HTE has promising antibacterial effects, especially against, Helicobacter pylori and other three pathogenic species.

BIOMEDICAL PRODUCTS

All the activities were in an agro-industrial setting where cultivation and development of by products from the local species, Haruan *Channa striatus*, are core. Developing these products into a globally available line of pharmaceutical and OTC products is the goal. I have developed a proprietary method to extract the actives from the raw material for the production of the Haruan Traditional Extract (HTE). The HTE is the bioactive, and the main ingredient in all product formulations of developed.

Health Food

Each **HARUAN HEALTH FOOD PRODUCT** namely biscuits, fingers, serunding and balls; is formulated to contain 20 to 50% of the freshly prepared **Haruan Traditional Extract(HTE)** which is developed in line with a **HOMEMADE** and **HALAL** concept. The entire production process uses over 80% local materials, exploiting traditional processing methods for making an oral remedy to heal various wounds, especially in preparing the Haruan extract. The **HTE** contains and retains all the biochemical and biomedical goodness of Haruan *C striatus*. Hence, the products provide a source of protein with well balanced nutritional value, as a remedy to induce healing of wounds due to various complications. Furthermore, our **Haruan Based Health Food Products** are formulated and made into common acceptable, ready, easy to consume form. These products take into consideration various individual physiological and clinical conditions, and accommodate the needs of different age groups.

Haruan Tonic

This product is formulated to contain 20 to 50% freshly prepared **HTE** in a **HOMEMADE**, **NON-STEROIDAL** and **HALAL** form. The whole production process uses over 80% local materials in a Good Manufacturing Practices (GMP) facility, and the production activities exploit decades old traditional processing methods in making oral remedies for healing various wounds. The product provides a source of protein, with well balanced nutritional value, and is also a remedy to induce healing of wounds due to various complications, and as a mouth rinse. Furthermore, this **Tonic** is formulated and made into common, ready, easy to consume, acceptable form taking into consideration various individual physiological and clinical conditions, and accommodates the needs of different age groups. The **Haruan Tonic is** in principal a food

supplement, with specific targets as an oral wash and care with anti-bacterial properties, promotes tissue repair, pH balance and soothes mouth ulcerations, especially among those undergoing chemotherapy. Gel products are also formulated for mouth ulcers.

Personal Care

The products are formulated to capture the physiological wonders of the Haruan in repairing and inducing healing of wounded or injured tissue, especially skin. Accordingly, all the ingredients are chosen carefully and specially blended to produce synergetic effects that soothe, moisturize and provide the much needed materials, in an optimal physiological setting, to bring back the natural healthier skin one used to have. Each of the selected ingredients on its own is non-toxic and traditionally used as a remedy for skin related ailments, and most are edible. The blending of all these selected local natural products with the Haruan extract, makes the product uniquely Malaysian. Colour and fragrance of the products are also natural, ideal for the colourful relaxing easy-going daily lifestyle in warm humid Malaysian weather. In Malaysia and other countries people are conscious of their hygiene and carefully groom themselves for a presentable image and status. Hence these products are specially formulated using homemade **Haruan Traditional Extracts (HTE)**, together with over 80% local materials, and manufactured in GMP facilities to maintain a high standard of hygiene. Furthermore, all of the products are set at **Neutral pH**, are **HALAL** and contain **Non-steroidal** materials. We use only natural colouring, and reduce the use of artificial or chemical additives and preservatives to the utmost minimum. Each of the products is suitable for the whole family, individuals of all age groups, and/or as toiletries for the service industries, namely restaurants, airlines and hotels.

These product lines are non-soap, natural product blends which are packaged well targetting both households and travellers, especially for use in warm humid tropical weather, not only for cleaning and washing, but also for protection against microbes and parasites and to care for the skin physiology. The base formulations are similar to the medicated cream mentioned earlier, with less than 10% HTE and non-alcoholic perfumes used to scent the product.

Health Spa

The products used are totally natural, and also categorized as organic using green technology similar to the personal care products. With other natural resources blended together with HTE, the resultant products are able to provide sensational THREE DIMENSIONAL experiences. The products revitalise dead parts of one's skin, reconditioning and re-establishing the tissues to healthy normal physiological settings.

All the processes are at a neutral pH setting, which is the most optimal condition for reconstruction, rejuvenation and repair, minimizing physiological stress on human skin.

The HEALTH SPA PRODUCTS comprise a full set of spa itineraries for comprehensive treatment including isotonic solutions, saline solutions, body lotions, scrubs, ointments and powders. The products are developed to commensurate biochemical profiles and biomedical, especially physiological, pharmacological properties of Haruan *C striatus,* which among others is to heal, repair, replace and rebuild damaged or injured cells and tissues of the human skin. The products are formulated to contain 10 to 30% of the homemade Haruan Traditional Extract (**HTE**) which is blended with standard personal care recipes within a GMP facility that observes HALAL certification requirements and Non-Steroidal composition in Neutral pH conditions. It is the POLICY of this

production to use ONLY natural product colouration, minimising additives and preservatives to avoid allergy or toxicity. A schematic and systematic regime has been introduced, as a doctrine in the SPA PRODUCTS AND TREATMENT so as to provide optimal, effective and desired end-results. The treatments are applied either by well-trained therapists, or under supervision if it were to be carried out in private to ensure complete satisfaction. The products provide alternative, new experiences and give CHANCES for new experiences for one's skin, and a BREAK from products which are not environmentally friendly. People of all ages can use this natural product. This product also addresses super sensitive, oily, hormonal imbalances, cellulite and dermatological exfoliation, dealing with conditions that can potentially affect one's confidence, happiness and self-esteem. This product, which is marketed under the commercial label 'CHANCES', can amend any physiological imbalance experienced by one's skin.

There are four lines of products (isotonic liquid, salt solution, body scrub and medicated cream) all with natural local based ingredients or materials, including virgin coconut oil, natural juice and mud. Silica from local beaches is used as a warming wrap for patients as part of the treatment, before ending with medicated cream just before final cleansing. The whole process takes about an hour.

Medicated Cream

The CREAM is produced using the Traditional Haruan Extract or **the,** the bioactive, as an alternative to induce wound healing, repair, moisturising, revitalising and create freshness of the skin.

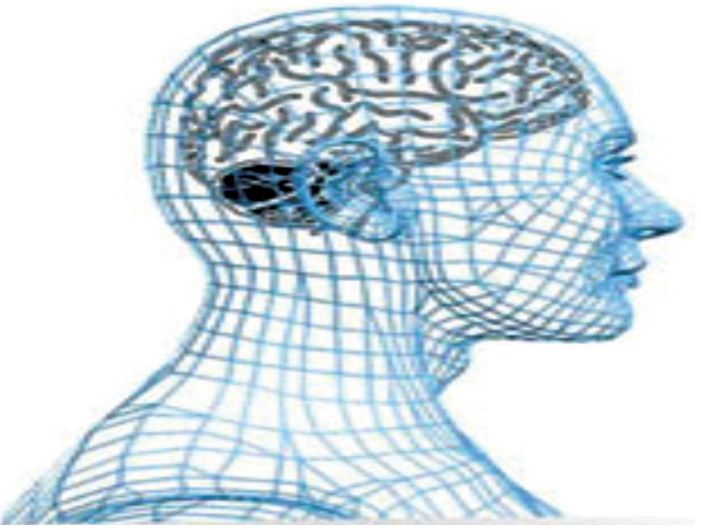
This formulation is based on the prototype which was awarded a Bronze Medal at the MINDEX INNOTEX 1996 event in Kuala Lumpur. Subsequently, the anti-nociceptive or anti-pain activity of

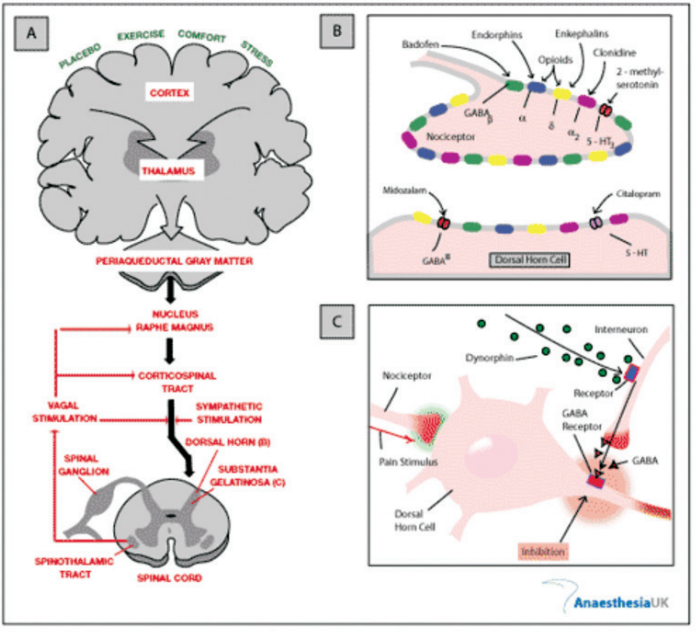
the haruan extract, was well received, recognised and awarded the 'Most Original Paper Communication' Award at the International Society of Anaesthesiologist Annual Scientific Meeting in Singapore on 17th September 1997.

Haruan *C striatus*, has biomedical properties for tissue repair, growth, cell proliferation and wound healing. A significant amount of Glycine, the most important component of human skin - Collagen, plus other essential amino acids are found in Haruan which are definitely the main factors contributing to the effectiveness of the product. Furthermore, the good lipid profile in Haruan has proved to be interesting, contributing toward blood clotting, repair and growth of tissue. These are the basis of our formulation. Furthermore, we use more than 80% fresh local, naturally grown herbs, and other natural products. Moreover, there is no artificial colouring or additives and we also minimise the use of chemical preservatives. The product also strictly observes the **HALAL** concept, at **Neutral pH**, **Non-steroidal** and **Fully Organic.**

Anti-pain Tablet

It is an alternative medicine for pain relief for conditions such as arthritis. It is to be developed as a pharmaceutical product after successful Clinical Trails. Up to 15% of **HTE** Powder produced through Spray Dryer (and Supercritical Fluid Extraction) is formulated into tablets as well as soft gel for oral consumption, and also made into creams as an external pain reliever.

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VAGAL STIMULATION
SYMPATHETIC STIMULATION
DORSAL HORN (I)
SPINAL GANGLION
SUBSTANTIA GELATINOSA (C)
SPINOTHALAMIC TRACT
SPINAL CORD
B
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Endorphins
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2 - methyl-serotonin
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Nociceptor
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AnaesthesiaUK


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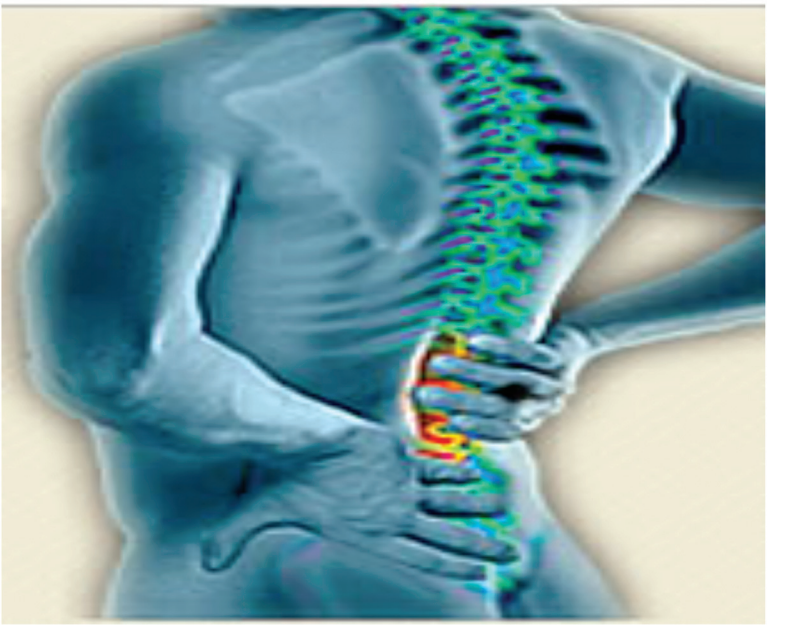

Figure 8 Pain either acute or chronic, need care, and drug to stop it. To fight pain is essential, and Haruan *Channa striatus* is a new opening as strong candidate to do the job

PRODUCT MANUFACTURING

This is purely a **NATURAL PRODUCT DRUG DISCOVERY**, with almost no, or very little, use of chemical additives such as colour, flavour and preservatives. The goal is to develop a range of products utilizing almost every part of the fish, thereby minimizing excess waste and environmental impact.

Our intent is to employ stringent Green Technology Standards and become a model in Green/Clean construction and site maintenance. As part of that initiative, our product lines will not contain chemical additives (colour, flavour and preservative) and instead utilize local

natural products. All the products will be HALAL. Todate, our Standardization, Certificate of Analysis (COA) and Prototypes have been produced through collaborative outsourcing at GMP facilities, including Clinical Batches for Trials at local and foreign Hospitals.

MARKETING

The intension is to initially sell our products locally, followed by marketing it to ASEAN and Middle East regions, eventually leading up to global distribution through licensing & partnering relationships.

COMMERCIALISATION

This is a DRUG DISCOVERY in an AGRO - INDUSTRY setting, to explore, exploit and utilize an indigenous species, which is also part of the local ethnopharmacology i.e. the Haruan *C striatus,* as a COMMODITY and part of our NATIONAL BIOWEALTH.

BUSINESS MODEL

This drug discovery and personal care product development project is built upon a sophisticated aquaculture infrastructure. We consider our enterprise to be an **AGRO-PHARMACEUTICAL company**

We have established a comprehensive set of Standard Operating Procedures (SOP) established by Abdul Manan Mat Jais, the Founder of the Haruan Research Group, in line with the Good Aquaculture Practices (GAP) and guidelines set by the Malaysian Aquaculture Certification Board, SPLAM **(SKIM PERSIJILAN LADANG AKUAKULTUR MALAYSIA).** The result is a company that can produce sustainable high quality Haruan extract (along with other

selected indigenous botanicals) to be used as a base for all of our product lines.

The enterprise will engage in the following core activities: Ingredient development, processing and manufacturing observing HALAL requirements, with utilising natural products as the core concept. It is still work in progress as the whole process requires proper planning. Although essential networking ties have already been established, actual or formal arrangements still need to be strategised. Links and formal collaborations with relevant local government agencies have also already been established. Nonetheless, discussions and agreements on marketing have not been carried out as yet.

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BIOGRAPHY

Prof. Dr. Abdul Manan Mat Jais was born on 8 March 1954, in Tanah Merah Kelantan to a lovely couple, Mat Jais b. Talib and Noranuar bt. Awang, both were from Pahang. He is now happily married to Pn. Shakinah Arshad for 28 years (1982 to 2010) and blessed with five wonderful children, Siti Aishah, Siti Khadijah, Ahmad Shahid, Muhamad Nasir and Abdul Rahman.

His received his early primary education in Kuantan, at Sungai Lembing and Galing Besar before moving to Beserah in 1963. He enjoyed his interesting lower secondary school life in Johor Bahru until 1969. He got his upper secondary education at Alam Shah in Kuala Lumpur (1970 - 1974). He had graduated with his first degree B.Sc (hons) in Zoology/Physiology in 1979 at University Malaya, Kuala Lumpur and got his Ph.D in Neurophysiology/Pharmacology from University of Southampton, England in 1983.

Prof. Dr. Abdul Manan is now a senior lecturer and Professor at Department of Biomedical Sciences, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia.

Upon completion of Ph.D. Program in neurophysiology/ pharmacology at University of Southampton United Kingdom in 1983 under the supervision of the late Prof. Dr Gerald Kerkut and Prof. Dr Robert Walker, his name was posted to the Department of Biology, Faculty of Sciences and Natural Products, Universiti Kebangsaan Malaysia Sabah Branch to start academic experiences. He was there at the branch campus together with others for more than eight years and had strengthened the academic team at the newly established Faculty by setting up curriculum, programs and research development. All these were to capitalize every opportunity, where he had gained various academic, research and administrative experiences as well as establishing academic protocol zooming into neurosciences and toxicology, and

developing interests in environmental and human toxicology, and ethno-pharmacology or traditional medicine. These interests still remained and the research is on-going up to now at Department of Biomedical Sciences, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia (UPM), since 1992. All the assignments had provided great opportunity and chances to develop teaching skills, networking and research capability that came with various fellowships and grants such as Friendship Programs for 21st Century, Japan by JPA/JICA, 1986; British Council for Human Toxicology works at University of Guilford, 1987; Royal Society London, sabbatical leave at University of Southampton, 1994; The Guest Scholarship Council of Europe The Swedish Institute for a 4 months attachment in 1989; International Foundation for Sciences (IFS), 1989; The Network of Biological Important Natural Products and University Development Assistance Committee, University of Western Australia, 1990, 1992 and 1996; International Brain Research Organisation (IBRO) and UNESCO, 1991 and 1994, Academia Sinica Beijing, Third World Academy of Sciences (TWAS) and South-South Fellowship Programs that widening the scope of my academic life. Furthermore, the inclusion into American Association for the Advancement of Science, since 1995, 1996, 1997 Membership and the award as **Fellow to Malaysian Scientist Association in 1998**, in a ceremony graced by the then Minister of Science Technology and Environment (MOSTE) himself on 25th February 1999, and all of those mentioned above had really glorified both his academic and research activities. Prof. Dr. Abdul Manan had been appointed Executive Board Member of Society for Environmental Toxicology and Analytical Chemistry or SETAC Asia Pacific since 1998, and he is also member of various relevant local and international associations or societies namely International Society for Neurochemistry, Federation of Asian

Oceanian Biochemistry, International Brain Research Organisation, American Association for the Advancement of Science since 1996, Malaysian Society of Pharmacology and Physiology since 1995, Malaysian Biochemistry Association since 1990 and Malaysian Applied Biology Association since 1990. This is truly a recognition to both the local and international scientific community, especially in biomedical sciences. Participation at 4th European Colloquium of Ethno-pharmacology in France 2000 to begin with, followed by the Drug Discovery Conference Japan January 2001, and subsequently the 10th Annual Pharmaceutical Conference, 30 - 31 May 2002, Singapore as an observer as well as other conferences locally are among his achievements, where it induced greater knowledge, created interests and exposed him to current scenario of the domestic-regional-global industry, regulations, businesses, marketing, trends and the Intellectual Property Right in the pharmaceutical industry. Furthermore, his involvement as a secretariat and an active participation in drafting and organizing the first National Conference on Rainforest Knowledge Industry in May 2001, officiated by the then Deputy Prime Minister, our former Prime Minister of Malaysia Y.A.B Tun Abdullah Hj Ahmad Badawi had given good opportunities in meeting and get to know the 'who's who' in Malaysian biodiversity-biotechnology, government agencies, policy makers, private players as well as providing a general outlook on the country's status and future industries. Similarly, the opportunity working with the Y.A.B Prime Minister's team towards establishing the Agro-Industri Haruan Project or PAIH as national industry were promising.

Nevertheless, the most satisfactory of them all was the **Excellence Services Award** or "Anugerah Perkhidmatan Cemerlang" earlier in 1997 awarded UPM that will always be the one remained sentiment. Besides, he is also very proud to be one of those who pioneered

the establishment of the Biomedical Program at UPM back in 1995 and later in 1996/1997 collectively put efforts in forming Medical Program and the relevant Departments, which were now fully developed into MD Program at UPM. Subsequently, in collaboration with University Malaya (UM) and Universiti Kebangsaan Malaysia (UKM) as a team, UPM had successfully acquired accreditation for our B.Sc Biomedical by the International Institute of Biomedical, London in 1999. Furthermore, as a Dean of School of Health Sciences at Kolej Universiti Teknologi Pengurusan Malaysia (KUTPM), which was known as MSU or University College of Technology Administrative Malaysia, now he had lead the team for accreditation of B.Sc Biomedical in 2003 and B.Sc of Food Services Technology in 2004, by our National Accreditation Board. These were among his success stories. He will forge ahead to establish Bioinformatics and Drug Discovery as a program in Malaysia to supplement other discipline into realising Malaysian's envisage to become a big player in Pharmaceutical Industry in a very near future. Prof. Dr. Abdul Manan is a self satisfied academician with more than 20 years of teaching experiences, invigilating, supervising undergraduates as well as postgraduate students attending local and international seminars, conferences, workshop and courses and also with experiences as an undergraduate student, under the academic system of University of Malaya and University of Southampton, UK during the Ph.D program, as well as both UKM-UPM systems as lecturer, and as a Dean at KUTPM. His role and position as Faculty Safety Officer and Head of Department of Biology at UKM; Deputy Dean at Faculty of Biomedical and Health Sciences, UPM and Dean at School of Health Sciences, University College of Technology and Management or KUTPM had all given the much needed and enough experiences to be an outstanding open minded and well verse with local and international educational outlook,

curriculum, examinations systems, accreditation and administration as a whole. Attachment opportunities and visits to various foreign universities especially University of Southampton UK, University of Gothenberg Sweden and University of Western Australia on sabbatical leaves; University of Chulalongkorn Thailand, National University of Singapore (Department of Anaesthesia, National University Hospital), University of Otago New Zealand, Hong Kong Chinese University and Academia Sinica Beijing had given further opportunity to understand the academic cultures, vision and mission of others. Personally, he is now putting efforts into a better perspective to develop further biomedical and health sciences academic in Malaysia, particularly to incorporate drugs discovery, ethno-pharmacology, pharmaceutical, bio-wealth and biodiversity. If need be and with extensive networking Prof. Dr. Abdul Manan is always happy to help establish working collaboration with foreign medical school as to facilitate Malaysian's student to pursue degree either MBBS or MD, and other health related professionals namely Pharmacy, Dentistry and so on. These are very important and much needed for future sustainable development for Malaysia.

In research, Haruan Research Group had produced an extensive works on local environmental toxicology, and some of the data on biomarkers, heavy metals and pesticides contamination in Malaysia had been published or presented at local and international meets. Parts of the works were carried out by students and had produced an excellent undergraduate and post-graduate theses. Among those were exclusive work on Acetylcholinesterase and Cytochrome P450 as biomarkers, as well as the physiological effects of external calcium on various agents namely pesticides and heavy metals. These works were to establish Haruan *Channa striatus* brain tissue as tools for neuro-toxicological research.

Concurrently, he worked on ethno-pharmacological and biomedical properties of the indigenous fresh water fish Haruan *C. striatus,* where both amino acid and fatty acid profiles had been identified. The fish was proved to contain all the necessary biochemical elements for tissue repair and wound healing, as to support the beliefs. He is now focusing on anti-nociceptive activities of the extract, which is found to be of equally or probably better than morphine, with minimal addictive properties, and the identification of the bioactive compound(s) and the physiological-pharmacological mechanisms of the action. Haruan's extracts is also proved to have mild anti-fungal and anti-bacterial effects, to be explored and exploited into cosmetic and skin care products. The fish is definitely good as based for nutraceutical products and both the wound healing and anti-nociceptive activities are certainly worth to be explored for future pharmaceutical production. Medicated cream has been awarded a **Bronze Medal at MINDEX/INNOTEX 1996** (an annual Creative and Innovative Association under the Ministry of Science, Technology and Environmental) Kuala Lumpur, 1996 for the Haruan's based body scrub for exfoliation for dermatitis such as sclerosis, eczema and etc and preliminary research data on the anti-nociceptive properties of Haruan has been recognized as **the Most Original Paper Commendation Awards, at the Annual Scientific Meeting of Anaesthesia Association in Singapore, 17 April 1997.** Subsequently his preliminary finding on the anti-inflammatory activities of the haruan's extract was awarded a Bronze Medal by the Institute of Biosciences, UPM 2004.

If Given Opportunities and Responsibility

1. First together with others in the Department of Biomedical Sciences will strengthen, upgrade and develop the existing program to a world class level, or at least try to be among

the top in Malaysia. Biomedical Sciences is an interesting multidisciplinary program either on its own or as a complementary supplementary supporting subject, needed by different professionalism especially in health, pharmaceutical, nutriceutical and nutritional areas. As for now in UPM we only have the core or basic biomedical sciences subjects without any applied or professional element or component. The biomedical program in other developed countries namely US, Europeans, Canada, Australia, South Korea, Taiwan and Japan is more dynamic, challenging and in-line with global trend and needs. Mostly others are incorporated and combining industrial as well as professional courses to become Bioengineering, Biomaterials and Bioinformatics, as a part of the whole biomedical sciences under an institution or faculty. All the works are to introduce, to start to establish M.Sc degree by course, and to improve the existing M.Sc and Ph.D program by research. Together with other faculties, this will help to retain the status of UPM as a Research University in the future in line with the new global challenges.

2. Will develop Bio-informatics on Malaysian's ethnopharmacology, biodiversity and agro-industry through a smart-partnering with established local agencies namely Rubber Research Institute (RRI), Malaysian Palm Oil Board Malaysian (MPOB), Malaysian Timber Council (MTC) and Malaysian Agriculture Research and Development Institute (MARDI). Hopefully this will establish gene pool of our biodiversity through data mining, knowledge discovery and bio-informatics on local Biodiversity, ethno-pharmacology, environmental and eco-tourism.

3. Will start to look at every opportunity to commercialise both group and research findings through outsourcing or technological transfer from well established companies in the region and from the west or local. Promotion and awareness drive will be carried out locally and abroad to create platform for collaboration, partnering and technological transfer.

4. Will be a great aspiration to Establish Hubs for Bridging Clinical Trial, Bio-prospecting, Bio-partnering, Good Manufacturing Practices (GMP) and Official Certification especially on Halal Products from our local natural resources.

ACKNOWLEDGEMENT

Special mentions to people who care, believe, respect and love. The people who need people, and to those who look upon others as creation of god, never underestimate, discredit and look down on others are people with dignity, self esteem and more importantly bless by god

To the one I love, MUM and DAD, my wife and children you are all the every part of my physiology of life.

My sisters, brothers, grandma, grandpa, uncles, aunties, cousins, neighbours, teachers, friends, colleagues, students and associates you are all the colour of my life. You people I love.

To people I know and those who knows me, no matter where you are, no matter what you do, I cite 'doa' and may ALLAH bless us.

A word of appreciation and thanks to all sponsors in any space of times, government agencies, individuals, companies, soul and spirit, last but not least my employer. **Special thanks to Unit Biotechnology, MOSTI and UPEN Pahang for the grant under satellite program.**

You are the earth, water, wind and fire of my life.

The Almighty ALLAH, it is at every beat of my heart, at every breath that I take and every drop of water I sip, it is only to never stop thanking you. Not sure if I have done enough.

Muhammad s.a.w, phrases upon you, please forgive me if I disobey your teaching, arrogant and discontented. I only human, nonetheless your teaching put me on track to heaven.

LIST OF INAUGURAL LECTURES

1. Prof. Dr. Sulaiman M. Yassin
   The Challenge to Communication Research in Extension
   22 July 1989

2. Prof. Ir. Abang Abdullah Abang Ali
   Indigenous Materials and Technology for Low Cost Housing
   30 August 1990

3. Prof. Dr. Abdul Rahman Abdul Razak
   Plant Parasitic Nematodes, Lesser Known Pests of Agricultural Crops
   30 January 1993

4. Prof. Dr. Mohamed Suleiman
   Numerical Solution of Ordinary Differential Equations: A Historical Perspective
   11 December 1993

5. Prof. Dr. Mohd. Ariff Hussein
   Changing Roles of Agricultural Economics
   5 March 1994

6. Prof. Dr. Mohd. Ismail Ahmad
   Marketing Management: Prospects and Challenges for Agriculture
   6 April 1994

7. Prof. Dr. Mohamed Mahyuddin Mohd. Dahan
   The Changing Demand for Livestock Products
   20 April 1994

8. Prof. Dr. Ruth Kiew
   Plant Taxonomy, Biodiversity and Conservation
   11 May 1994

9. Prof. Ir. Dr. Mohd. Zohadie Bardaie
   Engineering Technological Developments Propelling Agriculture into the 21st Century
   28 May 1994

10. Prof. Dr. Shamsuddin Jusop
    Rock, Mineral and Soil
    18 June 1994

Haruan *Channa striatus* a Drug Discovery in an Agro - Industry Setting

11. Prof. Dr. Abdul Salam Abdullah
Natural Toxicants Affecting Animal Health and Production
29 June 1994

12. Prof. Dr. Mohd. Yusof Hussein
Pest Control: A Challenge in Applied Ecology
9 July 1994

13. Prof. Dr. Kapt. Mohd. Ibrahim Haji Mohamed
Managing Challenges in Fisheries Development through Science and Technology
23 July 1994

14. Prof. Dr. Hj. Amat Juhari Moain
Sejarah Keagungan Bahasa Melayu
6 Ogos 1994

15. Prof. Dr. Law Ah Theem
Oil Pollution in the Malaysian Seas
24 September 1994

16. Prof. Dr. Md. Nordin Hj. Lajis
Fine Chemicals from Biological Resources: The Wealth from Nature
21 January 1995

17. Prof. Dr. Sheikh Omar Abdul Rahman
Health, Disease and Death in Creatures Great and Small
25 February 1995

18. Prof. Dr. Mohamed Shariff Mohamed Din
Fish Health: An Odyssey through the Asia - Pacific Region
25 March 1995

19. Prof. Dr. Tengku Azmi Tengku Ibrahim
Chromosome Distribution and Production Performance of Water Buffaloes
6 May 1995

20. Prof. Dr. Abdul Hamid Mahmood
Bahasa Melayu sebagai Bahasa Ilmu- Cabaran dan Harapan
10 Jun 1995

21. Prof. Dr. Rahim Md. Sail
Extension Education for Industrialising Malaysia: Trends, Priorities and Emerging Issues
22 July 1995

22. Prof. Dr. Nik Muhammad Nik Abd. Majid
The Diminishing Tropical Rain Forest: Causes, Symptoms and Cure
19 August 1995

23. Prof. Dr. Ang Kok Jee
The Evolution of an Environmentally Friendly Hatchery Technology for Udang Galah, the King of Freshwater Prawns and a Glimpse into the Future of Aquaculture in the 21st Century
14 October 1995

24. Prof. Dr. Sharifuddin Haji Abdul Hamid
Management of Highly Weathered Acid Soils for Sustainable Crop Production
28 October 1995

25. Prof. Dr. Yu Swee Yean
Fish Processing and Preservation: Recent Advances and Future Directions
9 December 1995

26. Prof. Dr. Rosli Mohamad
Pesticide Usage: Concern and Options
10 February 1996

27. Prof. Dr. Mohamed Ismail Abdul Karim
Microbial Fermentation and Utilization of Agricultural Bioresources and Wastes in Malaysia
2 March 1996

28. Prof. Dr. Wan Sulaiman Wan Harun
Soil Physics: From Glass Beads to Precision Agriculture
16 March 1996

29. Prof. Dr. Abdul Aziz Abdul Rahman
Sustained Growth and Sustainable Development: Is there a Trade-Off 1 or Malaysia
13 April 1996

30. Prof. Dr. Chew Tek Ann
Sharecropping in Perfectly Competitive Markets: A Contradiction in Terms
27 April 1996

31. Prof. Dr. Mohd. Yusuf Sulaiman
Back to the Future with the Sun
18 May 1996

32. Prof. Dr. Abu Bakar Salleh
Enzyme Technology: The Basis for Biotechnological Development
8 June 1996

33. Prof. Dr. Kamel Ariffin Mohd. Atan
The Fascinating Numbers
29 June 1996

34. Prof. Dr. Ho Yin Wan
Fungi: Friends or Foes
27 July 1996

35. Prof. Dr. Tan Soon Guan
Genetic Diversity of Some Southeast Asian Animals: Of Buffaloes and Goats and Fishes Too
10 August 1996

36. Prof. Dr. Nazaruddin Mohd. Jali
Will Rural Sociology Remain Relevant in the 21st Century?
21 September 1996

37. Prof. Dr. Abdul Rani Bahaman
Leptospirosis-A Model for Epidemiology, Diagnosis and Control of Infectious Diseases
16 November 1996

38. Prof. Dr. Marziah Mahmood
Plant Biotechnology - Strategies for Commercialization
21 December 1996

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