The Role of Research and Development Strategies in Food Safety and Good Agricultural, Manufacturing and Distribution Practices in the Malaysian Palm oil Industry**

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ABSTRACT

Globalization has expanded the Malaysian palm oil export market to over 140 countries. Research and development strategies carried out by Malaysian Palm Oil Board (MPOB) continue to provide information to demonstrate proactively food safety with negligible risk in its global supply chains. By examining the factors of air, water, soil, agricultural input, raw material and human used in the production, processing and manufacturing operations, the sound knowledge of science and technology from the 209 MPOB innovations, when combined with business and application of the widely accepted rigorous and systematic method of assessing and controlling hazards through the food chain, has ensured that palm oil remains an agricultural product that is healthy and safe to the customer. Throughout the food supply chain, the general principles of hazard analysis by critical control points (HACCP) have been incorporated into food safety legislation, long before they were officially introduced, to check the hygiene requirement and to use as a practical means of standardizing international food quality control and assurance practices. Every stage of preparation, processing, transport and distribution of palm oil is examined so that the final palm oil products for retailing to customers indeed are safe and nutritious. An effort is made to communicate new R&D findings to retain the credibility and trust of customers who will understand what lies behind such a food safety assurance scheme.

The value-add throughout the supply chain covers good agricultural practices (GAP), good manufacturing practices (GMP) and good distribution practices (GDP). Built into a database, the information gathered allows the effectiveness of the good practices in food safety

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management, detection of contaminants, toxicology, novel processing, packaging and application of risk management to be evaluated. The harmonization of these good practices towards standardization provides a high level of confidence to the operational entities and the customers. The auditors and assessors when benchmarked by accredited bodies that are internationally recognized, the industry will attain integrity by their assessment. Knowledge that Malaysian palm oil products are produced to an agreed standard will further boost consumer confidence by making them even more acceptable by people the world over.

INTRODUCTION

The Malaysian palm oil business has over nearly a century and a half of growth. The oil palm, introduced to Malaysia (Malaya then) in 1870, is today a multibillion-ringgit industry. Palm oil is exported to over 140 countries. Throughout the past 150 years, the impact of R&D strategies and policies on the industry has been one of continuous strengthening of the industry through the application of good science and technology. In particular over the past 25 years, the Malaysian Palm Oil Board through the merger of its fore runners, the Palm Oil Research Institute of Malaysia (PORIM) and Palm Oil Registration and Licensing Authority (PORLA) has accomplished much. Working closely with the industry members, MPOB R&D findings have helped to raise palm oil production from 2.5 million tonnes in 1979 to 13.5 million tonnes in 2003, an expansion feat unparalleled in history. The capability of the industry also expanded with employment of over 1.399 million people working in its 3.804 million hectares of oil palm, 370 mills, 47 refineries, 39 kernel crushing plants, 17 oleochemical plants and 33 bulking installations at the end of 2003 (MPOB, 2004a).

Starting with a humble beginning of about 38 thousand (K) hectares in 1950, the growth in planted area in each decade had been phenomenal. Initially, the increases were small at 54.6K ha in the 1960s and 261.4K in the 1970s, but thereafter the growth was tremendous with the area reaching 1023.0K ha in 1980s and 2029.5K ha in the 1990s. Since then, the area has reached 3067.4K ha in the 2000s with the area at end of 2003 standing at 3.80 million hectares. Over the past six years from 1998 to 2003, after the Asian financial crisis in 1997, the industry had performed well and earned foreign exchange of RM 22.6, 19.2, 14.9, 14.1, 19.6 and 26.5 billion in each of years respectively. By end 2003, the Malaysian oil palm industry had indeed flourished under a tight world oils and fats supply situation.

The 2003 production of crude palm oil (CPO) rose by 12.1% to 13.35 million tonnes from 11.91 million tonnes in 2002. The production of crude kernel oil also increased from 1.47 to 1.64 million tonnes (MPOB, 2004b). The exports of CPO and crude kernel oil were 12.248 and 0.870 million tonnes respectively. Besides CPO and crude kernel oil, palm kernel cake at 1.910 million tonnes and oleochemical products at 1.801 million tonnes were also exported. The average price of palm oil strengthened in 2003 to an average CPO price of RM 1544/t, an increase from RM 1363/t in 2002. It is heartening to note that the massive increase in production was supported by an increase in the price. Of the export, 90% was used as food and 10% for oleochemicals. Based on the 2003 performance, the production growth in 2004 for palm oil is expected to be lower because of its cyclical nature. However, the oil palm industry in 2004 is forecast to remain bullish (Yusof, 2004).

STRATEGIES

The transformation of the oil palm industry to its present diversified industry has been due to good R&D support and government policies, such as the Agricultural Diversification Policy in the 1960s which shifted from rubber to oil palm. This was followed by the land settlement schemes spearheaded by the Federal Land Development Authority (FELDA). Subsequently with the large supply of palm oil, other strategies were implemented with the establishment of kernel crushing facilities, refineries and oleochemical plants. This stimulated the growth of downstream products with value-added for the commodity being exported. Yet another success factor is the research cess that allows the industry to fund R&D to enhance its progress. The cess also funds the Malaysian Palm Oil Promotion Council (MPOPC). All these strategies have enabled the industry to deliver high quality products competitively. The Malaysian palm oil industry indeed is truly one of the best organized for any internationally commodity.

Promotion has allowed worldwide acceptance of palm oil which is continuously enhanced by R&D. Quality assurance efforts have developed trade specifications for palm oil products which has facilitated market development. The set properties of palm oil have enable preparation of standards for the Codex Alimentarius. The industry has branched out into three major areas in the food sector, non-food or oleochemicals sector and biomass and fibre-composite sector. The latest strategy is to produce carbon credit by carbon dioxide sequestration to reduce greenhouse gas emissions.

To sustain such a large palm oil production, R&D is the key to continuously improve competitiveness, increase profits and gain market share (Yusof and Chan, 2003).

The palm oil industry is no stranger to using R&D to improve its competitiveness, especially food safety. The issue of food safety is not new. Green consumerism and greening of the supply chain are increasing what the NGOs want. The recent call to consider the EUREPGAP protocol allows Malaysia to review in repackage of good practices used. EUREP stands for Euro Retailer Produce and GAP for Good Agricultural Practice. It is primarily targeted for a limited sector of fresh produce, flowers, livestock grains and feeds. With strong traditions of R&D, the Malaysian oil palm industry is in an even better position to produce good palm oil products for European Union (EU). As the ability to offer safe and nutritious foods improves further, higher prices can be justified with the higher margins and profits. Consumers will pay a premium for foods that taste better are more nutritious, healthier and safer.

Thus, the aim of this paper is to demonstrate the role of R&D in maintaining the food safety of palm oil by providing an understanding of the structural relationship between food production and the environment, humans, physical and regulatory systems and institutions.

AWARENESS OF FOOD SAFETY IN THE CONTEXT OF THE OIL PALM INDUSTRY

The industry is fully aware of the scrutiny palm oil, as a food is subjected to by regulatory systems and institutions. In palm oil production, therefore, food safety must be a priority.

All countries must have a Food and Drug Act or its equivalent to improve food safety and nutritional quality. This has prompted most governments today to establish an agency to enforce food standards. Some examples of such agencies are the Food and Drugs Agency (FDA) in the United States, Food Standards Agency (FSA) in the United Kingdom, Canadian Food Inspection Agency (CFIA), India's Central Committee for Food Standards (CCFS), Japan's Ministry of Agriculture, Fisheries and Forestry (MAFF) and European Food Safety Authority (EFSA). All these agencies serve similar functions within their respective jurisdictions.

There is also, under the banner of the Joint Food and Agriculture and World Health Organization (FAO/WHO) Food Standard Programme, the Codex Alimentarius Commission (CAC) which several committees provides a global discussions on various aspects of food, including safety and labelling practices. Malaysia is a party to the negotiations. As the CAC and its subcommittees have no mandatory powers, the responsibility resides in the individual governments' food safety agencies to enforce.

Particular attention is paid to the ingredients and the nutritional qualities that need legal compliance by the appropriate government regulators. There is a need to provide the right type of information, based on the consumer's rights to know, to be able to choose food that is safe and nutritious. It is with this premise that the following section is written to inform the consumer of the R&D input to ensure the safety of palm oil and its products.

ASSURING FOOD SAFETY OF PALM OIL THROUGH CURRENT R&D STRATEGIES

The objective here is to inform the participants of the role played by MPOB in palm oil safety. There are two major requirements:

- ⥣ the first requirement is that the market has invariably combined food safety with eight other issues *viz.* human food need, public health, nutraceuticals/ functional, pharmaceuticals, nutrition, biotechnology, ecology and sustainability, and governance; and
- ⥣ the next requirement is for MPOB to take a proactive approach in tackling these eight issues simultaneously. By doing so, it will allow the industry to benefit from its R&D which must ensure negligible risk throughout the value-added supply chain so that palm oil remains an agricultural product that is healthy, nutritious and safe to the customer.

These requirements are achieved through productive dialogues and collaboration in surveys carried out by MPOB. They offer valuable market feedbacks from the various stakeholders and consumers for incorporation in R&D programmes in MPOB.

Meeting the Need for Palm Oil as Human Food

Although Malaysian palm oil is exported to over 140 countries, the bulk is exported to only four countries/region. China, India and Pakistan in Asia which respectively took 2.546, 1.594, 1.099 million tonnes, and the EU, as a region, which took 1.695 million tonnes.

Palm oil is attractive to the developing countries because it is usually cheaper than the other imported oils and fats and this has been a significant feature in increasing palm oil consumption in these countries. There has been a smear campaign on the health attributes of palm oil by other oilseed competitors. But palm oil is not detrimental to health, and the developing countries are aware of this. But very soon the consumers will all be demanding the same food safety and nutritional standards as the developed countries. The industry has to be prepared for this.

Meeting Palm Oil as a Health Food

Palm oil contains roughly equal amounts of saturated (mainly palmitic) and unsaturated acids (mainly oleic) and is a valuable source of carotenes and tocopherols/ tocotrienols. Particularly in the advanced and emerging economies, the change in life style resulting from living in large cities has led the people to functional foods with health and disease prevention claims. R&D, for example, has shown that palm oil can be a good partner in the current dietary fat recommendation for many foods. This has led MPOB to launch a patented health margarine called *Smart Balance*. Basically, the product balances the lipoprotein cholesterol in humans. Today, the world is also looking increasingly at palm oil to avoid *trans* fatty acids in foods since palm oil with its natural saturated palmitic acid is the natural choice for many of the food formulations. The palm oil margarine available in the market today has the body and texture that do not need modification of the oil by hydrogenation unlike that of oilseeds. Palm oil therefore provides a *trans*-free choice of margarine for the consumer.

Meeting Palm Oil as a Functional/ Nutraceutical Food

The interest in diet and health has spawned a whole new food requirement since the 1990s functional/nutraceutical and pharmaceutical benefits of palm oil that collectively are referred to as functional foods. Functional food is a broad category encompassing nutraceuticals, designer foods, medical foods, pharmafoods and phytochemicals. The functional/ nutraceutical market was estimated to be USD 80 billion in 1998 but is set to grow to USD 5000 billion by 2010 (Stuart, 1998).

Meeting Palm Oil as a Base for Pharmaceuticals

There are also other trends where vitamins and supplements together are now the 10th largest category across all food, drug and mass merchandizing outlets. Herbal sales are growing and it was estimated to be USD 5 billion in 2000 (American Botanical Council, 1995). Again thanks to R&D strategies, inroads have been made into this health arena of food by palm oil. Already there have been successful launchings of vitamin E and red palm oil technologies. Both have strengthened palm oil's grip on the niche market in health food. For example, vitamin E tocotrienols are the current trendsetter in fat soluble antioxidants. Further, palm oil tocotriennols with antioxidant effects, cholesterol lowering properties and possible anti-cancer properties are emerging market leaders and their claims are being researched widely in clinical trials to confirm the results. Already, red palm oil technology is a process that retains the pro-vitamin A carotenoids in the oil. This has already become Malaysia's gift to the children of the world simply because its consumption can restore the vision of children and reduce the risk of children going blind due to vitamin A deficiency.

Meeting Research in Biotechnology and Genetically Modified Foods

Currently, palm oil is completely GM-free and the industry is strategically exploiting this fact to Malaysia's advantage given that a large proportion of the soyabean produced in the world today is genetically modified. Biotechnology, however, as a powerful tool, which should not be overlooked in view of the potential benefit it has for the betterment of the oil palm industry.

This high growth area has allowed the impact of biotechnology in manipulating plants to express their properties in their compositional changes to result in improved oils and even proteins for the food market in the future. This will advance our competitiveness even further as we move away from the traditional uses. The trend has been such that initially palm oil is widely used as a cooking and frying oil, in spreads and in shortening and as a salad oil. Next, with fractionation, palm oil extended its use as palm olein, palm stearin and palm mid fraction. Now it appears that like many other major crops in competing with palm oil, they had to resort to biotechnology to improve their competitiveness. These oilseeds do eventually have some transgenic products in them.

In the future, as the food processing industry learns to deal with the many possibilities for nutrient or phytochemical modifications that occur in genetically modified food, oil palm R&D through biotechnology will have to be in a position in the future to provide a strong base for producing a whole spectrum of high-value food products through genetic engineering which increasingly will be given emphasis. Food safety must invariably be linked to biotechnology in the future to produce tailored oils for niche markets. Although the initial R&D efforts in oil palm have been dealing with the genes of resistance to weeds and diseases, the next wave will see compositional changes with improved oils and proteins.

Meeting Ecology and Sustainability of Food Production

The urgency of increasing palm oil for food production should not be underestimated. Over the past decade, the average yield of Malaysian palm oil has stagnated at 3.5-3.8 t/ha although some plantations achieve much higher yields. One factor for the yield stagnation is the low replanting rate coupled with low uptake rate of new higher quality germplasm that can yield as much as 7.5 t/ha, *i.e.* double the current yield. Doubling the yield would bring in revenue of another RM 4 billion (Murphy, 2003). It is vitally important to ensure that the R&D strategies to increase productivity on the short-term can be sustained and effectively integrated with the long-term policies. Luckily, the MPOB strategy to increase palm oil production on a sustained basis has always taken the environment into account. The advances have been incorporated into the GAP and GMP.

There is avoidance of environmental pollution. At the same time, by ensuring that in the development process emphasis is on the maintenance of the productive capacity of the basic natural resources of food and agriculture, the sustainable practices are enhanced. This includes use of biopesticides like *Metarhizzium* fungus and virus for rhinoceros beetles and grubs, Bts for bagworms, integrated pest management like barn owls against rats and planting of beneficial plants to increase the number of predators thereby reducing the use of chemical pesticides in the long run.

There is also reduction in the use of chemical fertilizers through recycling by empty fruit bunches, effluent, frond mulching and planting of legumes during the immature period. The ecology of the oil palm plantation is well taken care of. In fact, technology transfers have been successful because of the proper consideration of the social, cultural, educational, economical and ecological conditions of the local regions. The latest technologies are always adjusted to the local conditions to the highest degree so as to gain wide implementation.

While not forgetting to raise productivity per hectare, the planters need to be good conversationalists by working closely with the NGOs to achieve the common goal of sustainable development with biological diversity preservation and good stewardship of the environment. The reduction of use of herbicides and pesticides during production will auger well for preservation of the environment and improving the food safety of palm oil. One such effort to communicate the good result to the retailers is the Round Table of Sustainable Palm Oil (RSPO) negotiations between the producers, retailers with participation by the NGOs.

Meeting Good Governance Requirement

Finally, as food moves through the system from the producer to the consumer, there must be put in place good governance. There are different sets of regulations, standards and policies to ideally ensure palm oil food safety and nutritional quality. However, as different departments of the government are involved in policy making, *e.g.* transport, customs and excise and police, there must be good cooperation between the departments to overcome inadequacies and for better enforcement.

Though palm oil is GM-free, a good example of the legislation required may be cited from the oilseed producers that have resorted to use GM technology to compete with palm oil. The legislation passed by the European Parliament concerning the production of GM crops in the area of biotechnology requires the need to show a general obligation for labelling and traceability on the part of the suppliers over the entire chain. The main provisions are:

i) all GM foods and ingredients of human foods and animal feed are to be labelled;
ii) in refined ingredients, there should not be any trace of transgenic DNA or protein detectable in oils, starch and lecithin;
iii) full traceability is required to demonstrate that that the source is not GM and that the produce had been effectively segregated at all stages;
iv) even when item (iii) has been met but with technically unavoidable mixing with detectable amounts of GM material, the GM level is now set at 0.9 %; and.
v) a special allowance has been introduced to permit up to 0.5% of unapproved GM to appear in legally imported materials.

GOOD AGRICULTURAL PRACTICES (GAP), GOOD MANUFACTURING PRACTICES (GMP) AND GOOD DISTRIBUTION PRACTICES (GDP)

The field, milling, refining and transport practices contributing to improvement of quality of palm oil have also been supported by advances in knowledge and equipment of storage, handling and transportation to improve the palm oil and kernel oil quality and preservation of the refined oil quality. The various best practices have been incorporated into the GAP, GMP and GDP. As a result of the GAP, GMP and GDP being in place, many plantations, mills and refineries, some since the 1980s, have qualified for the competency certification awards by MPOB - the oil palm nursery competency certificate (OPNCC), the mill competency certificate (MCC) and refinery certificate of competency (RCOC).

The competency certification efforts from nursery to mills and refineries reflected MPOB's early emphasis on hygiene and food safety and quality over the entire food supply chain. The industry, spurred by the R&D innovations, had also an early start in quality assurance in food safety, long before the west introduced HACCP. Now with the impending consideration of the EUREPGAP requirements, it is time to review the quality standards in existence. As palm oil is a late comer to the oils and fats scene, the persistent efforts in promoting its hygiene, technical and nutritional attributes have been successful in convincing many new users that palm oil production is hygienic, its products versatile and consumption wholesome, thereby opening up many new markets. For example, some recent figures on the competency certificates for the nurseries are shown in *Table 1*.

As for 2004, it is intended that instead of the current voluntary submission of nurseries by their owners for inspection and certification, there will be 100% inspection of all nurseries in the future. The guidelines on the marking scheme for the certificate of competency for nurseries and the marking forms for the nursery inspection are extended to the nurseries and agreed upon by all the participating nurseries before the marking is done.

As for the milling certificate of competency (MCC), the scheme was started in 1984 by the Chemistry and Technology Division, PORIM. The number of mills certified to date is 200 but the actual existing mills in the scheme

TABLE 1. OIL PALM NURSERY COMPETENCY CERTIFICATES (OPNCC) AWARDED

Year	No. licenced	No. visited	No. certificates issued	% Awarded
2001	377	55	48	87.3
2002	357	65	47	72.3
2003	358	38	33	86.8
2004*	345	30	11	36.7

Note: *Certification as at 30 April 2004.
Source: Zulklifi Abdul Manap (per. comm., 2004).

as of May 2004 has only 187 (Choo Yuen May, per. comm., 2004). This is because over the years since the scheme was started, some mills have closed down or changed their management and subsequently dropped out. This gives about 50.5% of the voluntary mills covered out of the 370 mills in operation. Again the guidelines covering the marking scheme for the certificate of competency of palm oil mills (PORIM, 1990), together with the framework of the marking scheme for the mill inspection (PORIM, 1989), are extended to the mills before the inspection is done. Again the intention is to go for 100% inspection of all the mills in the future.

As for the refinery certificate of competency (RCOC), the percentage of refineries qualifying for the competency certificates is shown in *Table 2*.

Since the inception, it can be seen from *Table 2* that over the years, new parameters and analytical methods to better help characterize the oil and its quality has been introduced. Regular checks were carried out by the Enforcement and Licensing Division to ensure that the quality of the finished oil during storage, transport and shipments complies with the relevant quality specification. From the beginning, the RCOC has also been reviewed four times (Tang and Johari, 2002) with new audit areas added at each review, *e.g.* ISO 9000, HACCP and other accreditations such as OSHA. GMP and ISO 14001. HACCP indicates that the refineries are committed to food safety.

It is important to mention here that there is also 100% sampling and analysis of all Malaysian palm oil exported to Europe as our added assurance.

The importance of good quality palm oil is imperative for the good long-term stability of the refined oil that, in turn, will affect its usage in downstream/finished products. It goes without saying that palm oil quality is made in the field and the milling and processing, and the refining only helps to maintain it. Thus, improper handling of fresh fruit bunch (FFB) in the field, incomplete collection of loose fruits, delay in processing and improper handling, storage and transportation only serve to cause quality deterioration and sometimes the deterioration is caused by contamination of some foreign materials unintentionally.

TABLE 2. REFINERY CERTIFICATE OF COMPETENCY (RCOC) SINCE INCEPTION IN 1984

Year	No. refineries	% Awarded	Year	No. refineries	% Awarded
1984	19	78.9	1992	21	88.6
1985	21	79.9	1993	20	84.6
1986	25	80.4	1994	25	80.3[a]
1987	25	82.2	1995b	25	81.5
1988	25	82.7[a]	1996/7[c]	27	81.5
1989	24	86.0	1998/9[c]	30	81.9
1990	25	86.4	2000/1[ce]	28	79.6
1991	26	87.4	2002/3[c]	31	85.0
			2004/5[e]	31	86.7

Notes: [a]Reviewed and tightened marking scheme used.
[b]ISO 9000 elements introduced.
[c]Biennial inspection for those with scores of 70% and above.
[d]Deferred as companies were shifting location or under renovation.
[e]Elements of HACCP introduced.
Source: Tang Thin Sue and Rozita Baharuddin (per. comm., 2004).

STRENGTHENING PARTNERSHIPS IN FOOD SAFETY: INTERFACE BETWEEN PLAYERS AND SCIENTISTS IN THE FOOD CHAIN

Certainly, in today's communication age, news spreads instantaneously across to the customer. Therefore, the industry, through its supply chain, needs to be fully aware of the happenings and provide accurate facts to assure the food safety of the palm oil products. Eight major requirements call for a plantation business enterprise to go beyond striving for greater efficiency alone when producing palm oil from the food safety aspect.

From the brief summaries of the eight requirements, the industry seems to be doing well thus far. We must not allow yesterday's success to lull us into today's complacency, for this is the great foundation of failure. We should subject ourselves to some sort of self-examination and this is a compelling factor to take this seminar as an opportunity to view new vistas in the food safety aspects in food production. From the eight issues summarized, there is a combined shift that points to three considerations that will drive the food safety business of the plantation company. They are:

- ⥣ firstly, palm oil has to be people- and health/safety food product-oriented;
- ⥣ secondly, palm oil must meet international demand; and
- ⥣ thirdly, palm oil must exhibit long-term thinking behind R&D.

People- and Health/Safety Food Product-Oriented

The basis for linking R&D to the food chain is the *Farm-to-Table* concept. Quality is the priority of the food chain and there are three dimensions:

⥣ social: affordable, convenience, easily available at retail stores, acceptable to all cultural and ethnic backgrounds, participation by the community and preservation of the environment;
⥣ health: related to nutritional and safety; and
⥣ economical: related to price performance.

R&D is the cornerstone to the palm oil assurance on quality. Currently, MPOB has 1300 staff spread worldwide and the R&D network examines the functional areas over the value supply chain as outlined in *Figure 1*. From *Figure 1*, the history of palm oil from production, processing manufacturing, distribution and transport will acquire positive and negative attributes as it moves along the chain. The elements of undesirable contamination can be introduced with the agricultural inputs, such as seeds, fertilizers, herbicides, pesticides and other chemicals from production practices, processing, manufacturing, distribution and transport. Besides the agricultural inputs, other sources of contamination can come about through recycling, or indirectly from natural resources like air, water and soil pollution. Some sources of contamination such as air pollution from industrialized activity can be carried over long distances through air circulation to other parts where they precipitate and contaminate the natural environment and enter the food chain.

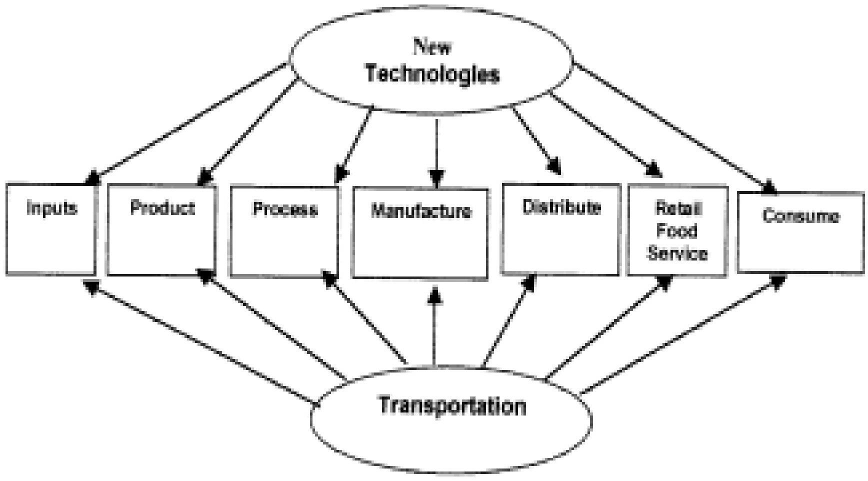

Figure 1. Schematic representation of food chain

A case in point is the persistent organic pollutants (POPs). In the Stockholm Convention on POPs, there are 12 POPs of which nine, *viz.*, Aldrin, Chlordane, DDT, Dieldrin, Endrin, Heptachlor, Mirex and Toxaphene, are pesticides; two, *viz.*, Hexachlorobenzene and polychlorinated biphenyls (PCBs), industrial chemicals and the remaining two, *i.e.* Dioxins and Furans, by-products of burning and combustion. Luckily in Malaysia, all the nine pesticides have been banned. Under the Stockholm Convention of POPs, the intentional production of the dirty dozen (of chemicals) will be eliminated except for the special public register of DDT for disease vector control. As for the unintentionally produced POPs like Dioxins, Furans and PCBs, they are released from chemicals through combustion and are therefore anthropogenic sources of pollutants. Dioxins are one of the unintentional air pollutants that the industry must be aware of.

Thus, in the immediate- and medium-terms, scientific knowledge and understanding from R&D to be carried out by MPOB has policy implications in that any increases in yield, for example, must be balanced so that we do not compromise human health. In our view, the oil palm industry of the future is not one of just selling a lot of palm oil as a commodity but changing the paradigm to another of selling it together with other co-products with higher value-added.

Immediately, the two questions that come to mind are: *How will the players along the value-added food chain in the industry participate? Will the food producing and processing sectors be interested bystanders while phytochemical, nutraceutical and pharmaceutical firms invest in new technologies for the production of other value-added products?* These are strategic decisions and R&D will continue to provide the industry with new strategic directions on what is scientifically and technologically possible from the innovations. The linkage between technology push and market pull must once again be well communicated to players through out the value-added food chain.

The new knowledge will be needed to retain the credibility and trust of our customers especially now that the food safety issue will come to the forefront of our R&D work. The question is whether we have the capability to move in this direction? The answer is yes!

HACCP analysis and management. As alluded to earlier, the elements of HACCP were already in place before the official requirements were introduced (see *Table 2* item[e]).

From *Figure I*, the impacts of hazards on food safety of palm oil can be seen in three areas:

- ⥣ air, water, soil human, agricultural inputs and raw material entering the system have an impact on the safety and nutrition quality of palm oil as seen above;
- ⥣ the activities of the system have an impact on the environment. Air and water pollution by contaminants may re-enter the system at a different point;
- ⥣ as the action to increase a benefit in some part of the system, there may be increased risk to human health in another part. Hence, it is the totality of the system that has to be considered when studying the impact of a hazard or action on food safety.

Prior to developing a HACCP procedure, the prerequisites are product descriptions for all the ingredients, additives, production steps, handling procedures and intended end point of the product as outlined by CAC (1993) which should be adhered to. Thereafter, the five general principles in accordance with the HACCP procedure are used in food safety with emphasis on identification of the critical operation steps and the means of controlling and monitoring these steps. The steps are:

- ⥣ hazard analysis of risk;
- ⥣ identification of all points or operation steps where hazards may occur;
- ⥣ identification of critical control points (CCPs) to food safety;
- ⥣ implementation of control and monitoring procedures at CCPs; and
- ⥣ periodic review of food hazards, CCPs and monitoring to ensured effectiveness.

Risk assessment involves recognizing that a hazard exists. Hazard identification puts it as whether harmful. Defining its characteristics considers how harmful is it? Considering the extent of exposure to the hazard, what levels are humans exposed to?. After that, determine the potential for inducing adverse health effects. After the risk is assessed, it is good to classify the risk as unknown (development risk), suspected (precaution), proven (prevention) and realized (compensation).

Chemical hazards are generally classified as (a) applied chemicals which are intentionally applied to increase crop production like fertilizers, (b) accidental chemicals applied unintentionally or generated unintentionally during production. Examples are chemicals from contaminants, accidental spillage or accidental fire and (c) background chemicals which are environmental contaminants that enter the food chain at almost any stage of production. An example of this are Dioxins. Environmental contaminants are of particular concern if they are persistent, bioaccumulative and toxic. Therefore, methods have to be developed to identify priority chemicals. Currently, MPOB is establishing the methods to determine the maximum residual levels of some pesticides. To date, 10 methods for determination of pesticides in oil matrix and nine methods for determination of pesticide residues in water, soil and leaves have been completed (Ainie Kuntum, per. comm., 2004).

Meeting International Requirements

There is little doubt that as more and more business is conducted on a global level. Malaysian companies will take advantage of the economies of scale in production, distribution and advertising that can ultimately be cost saving. The success of using R&D innovation to drive the industry is to put in place the appropriate measures of policy, standard, regulation, GAP, GMP and GDP and code of practice to involve interested customers and affected parted parties. The food quality and safety issue is broken down into the smaller bio-analytical science as in HACCP analysis and management.

In the past, the evolution of regulation has been reactive whereby the regulation only came about following recognition of the hazards in food supply. Examples of this are food poisoning or disease related events. For the future, the basis for good regulatory framework has to be broad enough and have guidelines and principles to capture all future and unknown events. There are six steps:

- ⥣ identify the issue and its content. Here, the appropriate measures such as policy, standards, regulation, GAP, GMP, GDP and code of practice are brought in to control the issue. From the facts (based on scientific and system information) and values (based on socio-economic, political and ethical), questions and answers are formulated. When framing the problem, the context must be relevant to the nature of the system it operates in (is it regulatory, inspection, industry, organization). The interests of the stakeholders (industry, consumers, government) are considered in terms of the impact the issue will have on them. The questions framed will be put forward to experts and the answers obtained.

⥣ assess risk and benefits. This second step is a risk/benefit analysis. Using biological, chemical and physical data from scientific studies, it integrates information related to the risk factors (social, cultural ethical and economic considerations) and risk perception. Benefits are likewise assessed in a similar manner. One of the most important decisions that will be made is whether the risk assessment puts the risk as either unknown, suspected, proven or realized.

⥣ identify and analyse the options. If the risk is known, then knowledge of the professional practices should be used to overcome the risk.

⥣ select a strategy. This is dependent on the risk that has been identified.

⥣ implement a strategy. The measures to be applied would be dependent on the capacity of the system to respond once the risk is assessed.

⥣ monitor and evaluate result. It is for the decision-maker to monitor the risk management and abatement of the risk as the measures are implemented.

Legislation in food safety. For the players along the supply chain, it must be stated at the onset that legislation and regulation is a big area. It covers global multilateral conventions, national laws and individual company regulations For example, looking at the global legislation, there are 20 multilateral environmental agreements with the Ministry of Science, Technology and Innovation as the focal point. They are listed in *Table 3*.

From *Table 3,* it can be seen that to protect human health and the environment from hazardous materials and their transboundary movement, the various conventions are to control and regulate the transboundary movements of these hazardous materials and their disposal. For

TABLE 3. MULTILATERAL ENVIRONMENTAL AGREEMENTS WITH MOSTI AS THE FOCAL POINT

No.	Title	Year
1	Convention on Wetlands of International Importance especially as Waterfowl Habitat	1971
2	Convention on International Trade in Endangered Species of Wild Fauna and Flora	1973
3	Protocol to Amend the Convention of International Importance especially as Waterfowl Habitat	1982
4	Vienna Convention for the Protection of the Ozone Layer	1985
5	ASEAN Agreement on the Conservation of Nature and Natural Resources	1985
6	Montreal Protocol of Substances that deplete the Ozone Layer	1987
7	Basel Convention on control of Transboundary Movements of Hazardous Wastes and their Disposal	1989
8	London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	1992
9	United Nations Framework Convention on Climate Change (UNFCCC)	1992
10	Convention of Biological Diversity	1992
11	Copenhagen Amendment to the Montreal Protocol	1992
12	Ban Amendment to the Basel Convention	1995
13	Kyoto Protocol to the UNFCCC	1997
14	Montreal Amendment to Montreal Protocol	1997
15	Rotterdam Convention on Prior Informed Consent	1998
16	Beijing Amendment to the Montreal Protocol	1999
17	Basel Protocol on Liability and Compensation	1999
18	Cartagena Protocol on Biosafety	2000
19	Stockholm Convention on Persistent Organic Pollutants (POPs)	2001
20	ASEAN Agreement on Transboundary Haze Pollution	2002

example:

⥣ the Stockholm Convention eliminates production of persistent organic pollutants (POPs) and the transport of these materials across international boundaries by taking into account other international rules, standards and guidelines, Basel Convention together with their various amendments; and

⥣ for the POPs, parties to the convention must not go against the conventional wisdom of recycle and reuse as for the POPs recovered, may cause pollution to food due to their unintentional production and use, *e.g.,* by burning.

Another two international standards may be applicable to the HACCP and food safety issues. They are shown in *Table 4*.

There are also Malaysian laws legislated and they are shown in *Table 5*.

From *Tables 4* and *5*, there are enough laws and regulations, especially one Malaysian Standard (MS 1480) and the four Malaysian Certification Schemes for HACCP (2003 a, b, c and d) from the Ministry of Health Malaysia together with company policies to safeguard and ensure food safety regarding palm oil. The standards that are described in the food act and food regulations must be harmonized. Whenever the standards applied, the measurements must be validated and certified by independent assessors and verifiers who are accredited by internationally recognized bodies. There should also be a greater harmonization of criteria like setting clear MRLs-based on food safety. There must be reciprocal recognization of international standards, and plantations should go for harmonization of legislations and criteria.

The point to note here is traceability. There is a need to integrate a *Life Cycle Approach* through controls from production, processing, manufacturing, storage, transport, treatment, reuse, recycle, recovery and final disposal of the waste material that may contaminate the safety of palm oil as food. This would mean that while practices are in place, there are new record keeping, new tests and therefore new costs to incur by the industry. Obviously the producers and the players along the supply chain would like to know the following:

⥣ what attributes of a product are to be traced?;

⥣ what methods of a product will be used to measure the

TABLE 4. INTERNATIONAL STANDARDS RELATED TO HACCP AND FOOD SAFETY

No.	Standard	Year
1	Codex Alimentarius Commission: Guidelines for Application of Hazard Analysis Critical Control Point (HACCP)	1993
2	International Commission on Microbiological specification for Foods: Microorganisms in Foods. 4. Application of Hazard Analysis Critical Control Point (HACCP) System to Ensure Microbiological Safety and Quality	1988

TABLE 5. MALAYSIAN NATIONAL LEGISLATIONS IN THE FOOD SAFETY

No.	Title	Year
1	Pesticides Act	1974
2	Food Act	1983
3	Palm Oil Industry (Quality Control) Regulations	1983
4	Food Regulations	1985
5	MS 1480 Food Safety According to Hazard Analysis and Critical Control Point (HACCP) System	1999
6	Malaysian Certification Scheme (MCS 1) for Hazard Analysis and Critical Control Point - Guidelines for HACCP Certification	2003
7	Malaysian Certification Scheme (MCS 2) for Hazard Analysis and Critical Control Point - Guideline for HACCP Compliance Audit	2003
8	Malaysian Certification Scheme (MCS 3) for Hazard Analysis and Critical Control Point - Guideline for Certification of HACCP Compliance Auditor	2003
9	Malaysian Certification Scheme (MCS 4) for Hazard Analysis and Critical Control Point - Guideline for HACCP Surveillance Audit	2003

attributes?;

- what records must be kept of the traceability measures?; and
- what verification is required by the government, buyers and others along the value chain that the right attributes have been properly measured, correctly recorded and promptly communicated along the supply chain?

For each of the steps mentioned, there are costs involved. Yet the benefits are not easily measured.

Long-Term Thinking Behind the R&D Strategies into Food Safety

This is an important area of R&D direction and the requirements are further broken down into food science studies, food/consumer interaction and nutrition and health studies. Here, MPOB has a role to play.

- Firstly, expanding R&D in food science by the industry. The physical performance optimization of palm oil products may be illustrated by the basic research on empirical understanding of the crystallization of palm and kernel oils. The nucleation, growth rate of the crystals, fractal analysis and compatibility of the blends will eventually lead to better blends of margarine. The mechanical stability, food component interaction and process optimizing are to achieve desired consumer benefits.
- Secondly, widening nutritional and health food arena. Here the big opportunities for the future revolves around offering something different that the consumers are earnestly seeking, *i.e.* foods that offer and deliver real health benefits. This includes foods containing physiologically active components that will deliver potential benefits in terms of health maintenance and disease prevention. For this, the bioactive molecules and micro-organisms, bioavailability and uptake and health effects in terms of energy management, gut protection, healthy ageing, mental performance, mobility and physical appearance are important nutritional and health attributes of new R&D.
- Thirdly, food with the most consumer concern being the *trans* fatty acids. There have been various attempts to impose regulations in the EU on *trans* fatty acids in food. In Denmark, the legislation in March 2004 decreed that industrially produced *trans* fatty acids acceptable in food shall not be more than 2%. Many food processors are already calling for the products to include less than 1% *trans* fatty acids. This legislation on *trans* fatty acids threatens those refiners that have hydrogenation facilities. They might need to invest in other production techniques, *e.g.* interesterification which could be expensive. Palm oil with its natural solid fraction of palm stearin does not need hydrogenation. This provides a further opportunity for palm oil.
- Fourthly, food for cardiovascular health through balanced fat to help cholesterol. Plant sterols in reduced fats are efficacious in reducing cholesterol absorption, serum cholesterol and LDL cholesterol without changing HDL cholesterol. Everyone benefits from reducing the blood cholesterol. The benefits are proportional to the starting baseline level. The science of a right balance of saturated, mono and polyunsaturated helps to control blood cholesterol and maintain cardiovascular health.
- Fifthly, food for skin health through nutrition. This is another important issue for those interested in beauty. The goal is to maintain the skin elasticity to stop wrinkles. Lycopene from palm oil prevents collagen degradation at the cellular level. Lycopene absorption prevents skin ageing. Lycopene with vitamin C slows down skin oxidation. The benefit is to maintain skin quality, firmness and elasticity and delay and reverse skin wrinkling due to ageing.
- Sixthly, food/consumer interaction. The preference and impact of palm oil food products on the consumers will require R&D into the physics and chemistry of aroma, taste and texture. Further to be investigated are chemoreception, neurobiology and psychological and sensory perception. This type of R&D looks at satisfaction and appetite control. Food aromas are being visualized. This is done through sophisticated mathematical transformation of complex analytical data into sensory diagrams. This will enhance pleasure for biscuits made

from palm oil bakery fats by revealing the fascinating science of bakery aroma analysis.

⥣ Seventhly, food quality and safety. Here the results of the HACCP analysis on the chemical, microbiological and contaminant effects on safety are to be put into a national database for future understanding of contamination and risk reduction. The consistency of quality and effect of packaging on off-flavours will be investigated.

We must not be lulled into complacency but continue to pursue the vital role of R&D strategies in today's food research to meet the future global challenge for general health and general well-being of humans. There are five simultaneous areas to look into. They are:

- ⥣ palm oil as food - looking at nutritional effects;
- ⥣ growth-foods with general health claims;
- ⥣ maintenance - foods with specific health claims;
- ⥣ prevention - clinical foods; and
- ⥣ cure - foods with medical nutrition.

The culture of R&D has always make the oil palm industry profitable by coming up with ever more innovations. This will now be directed to meet the new requirements on nutrition, health and food for human well-being. This key success factor that comes to our minds is to consistently review how market information can be used to drive the R&D.

DISCUSSION

In discussing the preparedness of the industry to take on the EUREPGAP protocol, it must put into a proper perspective. In the future, a host of other factors will take prominence in the palm oil trade as the review showed that the GAP, GMP and GDP are already in place and that it is only a matter of repackaging the good practices to minimize the hazards that are likely to come about through the supply chain. Amongst them are changes in legislation, preference for vegetable oils over animal fats, concerns over GMO food on health, concern over cocoa butter substitutes, and pressure from retailers and consumers when oilseed oils are drawn away for biodiesel.

This paper certainly has drawn the attention of all the players to focus on the key elements for food safety standards that must now be benchmarked. There will be efforts made to encourage cooperation between the players in the supply chain and the worldwide palm oil producing countries, their governments and the consumers for which awareness and education must be communicated.

Firstly, there is stricter legislation to content with. Among the major markets, many of them are beginning to introduce stricter laws on food safety and proof of origin. The other smaller importing countries are also beginning to follow the trend to request for evidence of better food safety measures undertaken on the food production and import. As the custodian of the palm oil industry, the MPOB is encouraging producers and the other players along the value chain to conform to the importing countries' requirements. One such area is the requirements of EUREPGAP. All along, through R&D efforts, MPOB have been helping the players to identify and isolate any hazards throughout the whole supply chain. This has also benefited end user and consumer and they like it because it promises ever-safer food.

Secondly, concern over animal fats. Palm oil R&D by MPOB continues to have a role to play in expanding its uses as a replacement for animal fats. The future will see continuous consumer preference for vegetable oils over animal fat. This has helped increase the consumption of vegetable oils in general and palm oil in particular. For example, palm oil is the preferred raw material in margarine instead of fish oil and consumption of butter is decreasing steadily.

Thirdly, concern over GMO food. The consumer concerns against GMO will be an area that will generate great interest in the future. Results from a survey across the 15 EU countries showed that the general consumer concern about the GMO is high with 71% stating that they would not buy GMO products and 56% feeling that GMO-based foods are a danger to the environment. From the same survey, 95% of the consumers want the right to choose whether or not to eat GMO-based foods and 86% require information on labelling to enable them to make a choice. This has forced food manufacturers to avoid GMO soyabean oil. This provides an opportunity for palm oil. Thus far, all particular shipments of palm oil from Malaysia are certified to be GMO-free. This will in no way jeapordize the current research in using biotechnology to modify the composition of palm oil towards higher oleic content.

Fourthly, another food with consumer concern is cocoa butter substitute. For the past two decades, there has been a dispute among the EU member countries whether chocolate manufacturers are allowed to use vegetable oil-based ingredients called cocoa butter equivalents (CBE) instead of cocoa butter in chocolate manufacture. In August 2003, the EU Parliament accepted a level of 5% CBE in chocolate manufacturing. For this, the manufacturer needs to label the product as containing vegetable oils. This represents an opportunity for niche refining in terms of an extended market for CBE. The additional market represents an increased production from 25 000 t to 50 000 t. Malaysian owned companies like Aarhus Olie (belonging to United Plantations Berhad) and Loders Croklaan (belonging to IOI Berhad) will stand to benefit.

Fifthly, concern over health. In the near future, foods to enhance general health, natural defences, improving natural intestinal flora in infants and for gut protection with healthy fibres for daily consumption will be investigated.

Sixthly, concern over diminishing oil seeds supply due to use for biofuel. Biofuel is a related topic where the directives in EU may draw rapeseed, sunflower and soyabean oils away from food: The EU current policy on biodiesel and bioethanol dictates renewable energy at 12% of the total energy consumption by 2010. This may require an additional production of 14-18 million tonnes of biofuels by 2010. As 90% of EU biodiesel comes from rapeseed oil, the present 4 million tonnes production may exert pressure to look for land to produce the additional 10-14 million tonnes required. As rapeseed is most unlikely to meet the demand, there will be substitution by sunflower and soyabean oils and the biofuel companies are experimenting the use of other oils. This will open new opportunities for palm oil where R&D has already enabled biodiesel production from the EU. It is likely that GMO soyabean oil may be used but palm oil with its higher productivity/hectare stands a better chance to be used. It is foreseen that the development of biofuel directive will increase the demand for vegetable oils besides rapeseed oil.

Thanks to the continuous stream of technologies from MPOB R&D, the innovations are shared first with Malaysian entrepreneurs and then the world through the annual Transfer of Technology (ToT) that showcases new innovations. Central to the innovation system is the critical mass of skilled personnel in R&D to help the entrepreneurs tap the opportunities offered by the innovations. In this respect, the country leadership has acknowledged MPOB as having e*xcelled in the area of commodities by utilizing more technology and going for value adding activities* (Abdullah Ahmad Badawi, 2004). He further added that the oil palm sector is *an example of good R&D and commercial connectivity. The sector's commercialization rate of 12% is far higher than the national average of 5%.* Since then, it has been reported that of the 209 technologies developed over 25 years by MPOB, 60 have been adopted giving about a 30% commercialization rate (Yusof, 2004).

CONCLUSION

The future for palm oil is bright. The more palm oil products are subjected to tests, the more they become a better oils as R&D innovations are used to overcome the problems and issues identified. In order to gain public trust and confidence, the actual risk assessment should be carried out by accredited verifiers and certification, based on understanding the relationship between the current regulatory framework and the technical, economic, health and safety attributes of palm oil, is the real challenge facing the partners over the entire food supply chain in today's safe food production.

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