Research Workshop on Valorisation of Traditional Processing of Indigenous Fruit

Sunway Hotel, Phnom Penh, Cambodia.
14-16 January, 2013

A three day (14-16 January 2013) research planning workshop was organised by the Department of Food Technology and Chemical Engineering at the Institute of Technology of Cambodia, Phnom Penh, Cambodia and the Centre of Underutilised Crops (CUC) at the University of Southampton funded by the Leverhulme Trust, UK. The theme of the workshop was Valorisation of traditional processing of indigenous and underutilised fruits. The workshop was focused on promoting cutting edge research and innovation with the following specific objectives:

- Review cases (from our partner countries) of traditional processing of indigenous or underutilised fruit which may provide the basis for innovative ways of contributing to improvements in local health and nutrition;
- Present final results of mini-research projects and conclusions as to what kind of further research is justified;
- Highlight the particular research interests and expertise of the Cambodian partner in relation to processing of indigenous fruits;
- Identify fundable research gaps that are of interest to two or more network partners and can build on their expertise;
- Draw up an outline of one or more research projects relating to the valorisation of indigenous fruit processing and assign responsibilities for proposal development.

The workshop was attended by 21 participants including researchers, academics and entrepreneurs from the SME sector of Cambodia as well as network project partners from Bangladesh, India, Vietnam, Sri Lanka, France and the UK (see Appendix 1 for the full list of participants).

The workshop programme (see Appendix 2) consisted of a first day of presentations and discussions on valorisation of traditional fruits processing, a second day discussing the results of the partners' mini-research projects and development of outline research ideas, and a third day comprising a field trip to a food processing enterprise in Phnom Penh followed by further presentations and a discussion about the next workshop in Sri Lanka.

Day 1: Monday, 14th January, 2013

Opening session

The opening session started with registration, the national anthem and introduction of participants followed by a welcome address given by Dr Hul Seingheng of the Institute of Technology of Cambodia.

Dr Kate Schreckenberg Coordinator, Centre for Underutilised Crops (CUC), University of Southampton reminded the participants of the network's aims and outlined the objectives of the current workshop, emphasising the need for developing a good research proposal.

Dr Chunhieng Thavarith, Deputy Director General, Institute of Technology of Cambodia (ITC), Phnom Penh welcomed the participants to the workshop and expressed his hope that this workshop would be a platform for good discussion and exchange of research results and ideas among the network partners. He highlighted the fact that the Cambodian economy is based on agriculture and that there

is a need for much greater capacity in this field. Although demand within Cambodia is increasing, most fruit and fruit products have to be imported from neighbouring countries. The SME sector in Cambodia is still in its infancy and there is no proper support from the Government. This is an area that ITC is working on to improve technology on food processing, post-harvest technology and food preservation in the public and private sector. He thanked the international and local participants for attending in the workshop.

Session 1 (Chair: Dr Hul Seingheng)

Overview of fruit processing in Cambodia: Current status and future prospects by Dr In Sokneang, Institute of Technology of Cambodia (ITC), Phnom Penh.

Dr In provided an overview of food consumption and dietary habits in Cambodia, highlighting the fact that fruit consumption is higher in urban areas due to its relatively high price. Fruit is generally eaten when in season and there is no large-scale fruit processing. She highlighted the nutritive value and utilisation of some of the important indigenous and underutilised fruits in Cambodia. These are banana (*Musa* spp.), jackfruit (*Artocarpus heterophyllus*), mango (*Mangifera indica*), tamarind (*Tamarindus indica*), noni (*Morinda citrifolia*), aonla (*Phyllanthus emblica*) and jamun (*Syzygium cuminii*). There has been relatively little research on indigenous fruits in Cambodia but ITC is beginning to work in this area, with new projects coming on line to study the nutritional and therapeutic values of fruit such as banana, pineapple and mango. This remains a challenging area for development as there is no national policy on fruit or indigenous fruit and there is concern that development of SMEs may be constrained by competition from other ASEAN countries.

The discussion highlighted the lack of a national inventory of indigenous fruits or data on production volumes. The Ministries of Agriculture, Industry and Health might all be interested in this area but there is currently no coordinated approach. Collaboration with the International Society for Noni Science in India was suggested.

Value addition to Jackfruit (Artocarpus *heterophyllus* Lam) through integrated processing and preservation by Dr M.A. Jalil Bhuyan, Dr. Madan Gopal Saha and Dr. Md. Atiqur Rahman**,** HRC, Bangladesh Agricultural Research Institute, Bangladesh.

Dr Atiq explained that jackfruit (*Artocarpus heterophyllus* Lam) is a very popular fruit and also a national fruit in Bangladesh .This fruit is rich in minerals and vitamins. Although production levels are high, post-harvest losses are estimated at over 25%, in part due to lack of processing. The only way to overcome this is value addition and preservation. The Bangladesh Agricultural Research Institute (BARI) and Bangladesh Council for Scientific and Industrial Research (BCSIR) have developed protocols for preparing a large range of jackfruit products from biscuits to butter, pickles and seed powder. However, there is still a need for further standardisation of products and validation of the technologies as well as work to disseminate them to SMEs. Key constraints are that most processing equipment is imported from overseas and the 5-month seasonality of the fruit limits year-round activities.

Discussion points included the fact that there is little precise information on yields per hectare (which are about 30-40 tons) as there are few orchards or plantations, with most information being extrapolated from household data. Although the agro-based sector has been declared an emerging priority in the industrial policy, there is no national policy on jackfruit and its research and development suffers from a lack of coordination among the ministries (Agriculture and Industry), research bodies and the private sector. The fact that jackfruit is highly cross-pollinated was mentioned, meaning that vegetative propagation is needed to ensure consistent quality. The

government has been working hard to ensure food security in terms of self-sufficiency in cereal crops but has paid less attention to nutritional security, for which fruit would be an important factor. There is some export of whole jackfruit to the Middle East and the ethnic markets of Europe and America but as yet there is no processing industry based on jackfruit. Given that 30-40% of the fruit consists of peel, consideration is needed for how to use this 'waste' product.

Evaluation of some innovative process for extraction of functional extract from cashew apple waste (*Anacardium occidentale*, L.) by Fernando Antonio Pinto De Abreu (PhD research work), Embrapa Brazil and Manuel Dornier, Claudie Dhuique, Fabrice Vaillant, Max Reynes.

Dr Max explained how carotenoids can be extracted from cashew apple using membrane technology. Cashew apple has a great socio-economic importance in the supply chain especially in Brazil. The cashew juice is a by-product that results from pressing the nut's hypertrophied peduncle, known as cashew apple, a juicy pseudo fruit. Peduncle processing generates large volumes of industrial solid waste that are usually discarded or sometimes used as animal feed. This study aimed to evaluate a new process for providing an added value to this industrial by-product, extracting carotenoids without the use of solvents or heat. The process comprised several steps: extraction by pressing, followed by enzymatic maceration, a cold concentration of the extract by cross flow microfiltration and purification by diafiltration. The purified extract has a strong potential for use in the formulation of foods and beverages as a natural dye. Depending on which molecules are desired, the treatment can be changed, but the whole system is appropriate for developing countries as the processing technology is easily obtainable. The process could be tried out for other fruits to extract colorant molecules with high market potential as dyes (particularly red and green colours). It is more costly and difficult to do the functional analysis to determine the health properties of the molecules extracted. Market research is also needed to establish demand for the product and the volume of raw material required to meet demand.

Discussion points included the fact that carotenoid composition will vary according to variety. One of the problems with cashew apples is the level of phenols (causing bitterness) in the juice, for which there is no farmer-appropriate technology. Health screening is a costly process and needs to be done by more than one lab – this could be the focus of a new research project.

Session 2 (Chair: Dr Pham Huu Yen Phuong)

Valorisation of the vegetal biodiversity for food safety: Characterisation of antimicrobial plant extracts by Samira Sarter, H.V. Nguyen and S. Chu-Ky, CIRAD-Hanoi University of Science and Technology, Vietnam.

This presentation outlined the food safety concern posed by antibiotic resistance among foodborne pathogens in South-East Asian countries highlighting the need for efficient alternatives to reduce antibiotic use in food production systems. A case study was presented on the exploration of antimicrobial essential oils (from *Cinnamosma fragrans*) as alternatives to antibiotics in shrimp aquaculture. Preliminary screening of essential oils from various Vietnamese plants is now being undertaken in Hanoi and they will be participating in the Bio-Asia project (2013-15) on ethnobotany for sustainable therapy in aquaculture and food safety.

Discussion points included the possibility of testing different methods of extracting essential oils (beyond the current focus on steam distillation) to see which ones are more appropriate for different oils and different producer contexts. Another issue relates to whether to go for blind screening of a large range of plants to find biological activity (tends to have a 0.5% success rate) or whether to base screening on traditional knowledge of farmers (this ethnobotanical approach can

have a 20% success rate). It is also necessary to establish which part of the plant has the highest content of essential oil.

Preservation and quality aspects of selected Sri Lankan fruits by Prof DAN Dharmasena, Faculty of Agriculture, University of Peradeniya , Sri Lanka.

Prof Dharmasena highlighted that the changes occurring in processing can either be desirable or undesirable and can affect the sensory and functional properties, and nutritive value. Development of toxic substances, changes to the texture, flavour, colour and nutritive value are some of the undesirable changes. Development of pleasing odours, flavours and textures, inactivation of enzymes and nutritional substances, improvement of the functionality in food ingredients are possible desirable properties. *Garcinia cambogia* (Garcinia), *Citrus aurantifolia* (Lime) and *Tamarindus indica* (Tamarind) are some of the seasonal fruits in Sri Lanka and the preservation is mainly done by indigenous methods to make them usable throughout the year. The products obtained from indigenous preservation methods lead to poor quality end products and therefore, they are still considered as underutilised crops in Sri Lanka. The common preservation methods currently used are heating, cooling (chilling and freezing), reduction of water activity by salting, concentration, dehydration and fermentation. The compositional changes after traditional processing have not been studied sufficiently and only few experimental data have been published.

Discussion points included the need to deal with insect contamination of tamarind – this is often tackled using salt but a high concentration of salt is bad for health. Although the government promotes healthy food, research is mostly in the hand of the private sector which prefers not to collaborate with government labs in order to obtain patents on their results. The SME sector still relies on government research institutes to provide appropriate research technologies. Lime juice can be stored for a long period without bitterness if it is extracted without crushing the peel and filtered well. Dried 'black lime' is not used locally, but exported to the Middle East to provide aroma when cooking rice.

Stability evaluation of anthocyanins obtained from wild Jamun (*Syzygium cumini* Skeels) fruits and their utilisation as a food supplement by Shailendra K. Dwivedi and Vigya Mishra, Amity International Centre for Post-Harvest Technology & Cold Chain Management, India.

Dr Dwivedi presented a proposal to extract and evaluate the stability of wild *Jamun* anthocyanins and to utilise them as a food supplement to improve the colour as well as nutritional quality of processed food products. He discussed the properties of anthocyanins, how they could be extracted from wild *Jamun* fruits, and evaluation of their stability to light, temperature and pH, etc. The extract would be dried and prepared into a uniform powder or could be microencapsulated in standardised food grade capsulation material. These capsules could be incorporated in different food items like confectionary, dairy products, beverages, etc., as a nutrient supplement. Ripe fruits are deep purple in colour and have been used in traditional medicine systems for curing many chronic problems primarily *Diabetes mellitus* but proper health screening is needed.

Discussion points included the fact that there is little published data on jamun anthocyanins and antioxidants although they possess antimicrobial properties against different microorganisms like: Salmonella, Bacillus, E. coli, Aspergillus, etc. Jamun seed power is often used by diabetic patients but there is little known about any potential side-effects. Most of the anthocyanins appear to be available in the peel but, in the case of wild jamun, the fruit flesh is also a good source. The fruit is only available for a few weeks in June – a serious constraint for SME development.

Session 3 (Chair: Prof DAN Dharmasena)

Integrated processing of *Jamun* (*Syzygium cumini* Skeels) fruit for value addition and assessment of its impact on health and nutrition by Dr Susanta K. Roy, Dr Sunil Saran and Dr Vigya Mishra, Amity International Centre for Post-Harvest Technology & Cold Chain Management, India.

Dr Roy explained that Jamun is rich in mineral contents especially iron, potassium, sodium and calcium. Jamun seeds are used in traditional medicine. They are reported to be rich in flavonoids and phenolics which halt the diastatic conversion of starch into sugar. They are not suitable for the table purpose and are best suited for processing as they contain high amounts of acidity, tannins and anthocyanins. He described a standardised method of juice extraction from wild jamun by crushing and pressing the whole fruit that can be used to make various delicious beverages. The pomace which is left over after the juice is extracted consists of seed and peel and is very rich in anthocyanins and various other phytochemicals. These can be isolated and used in traditional medicines, thereby adding to its value.

Discussion points included the fact that jamun powder is typically packaged in polyethylene or aluminium laminated pouches, while PET bottles and glass bottles (coloured) are generally used for processed products. Although jamun only fruits for a few weeks, its availability for processing can be extended from May to July if fruit are harvested from different geographical regions of India.

Reduction of tannins in compressed cashew apple juice by Ms Duong Thi Ngoc Diep, Faculty of Food Science and Technology, Nong Lam University, Vietnam

Ms Duong presented a proposal to undertake research on cashew apples in Vietnam to make use of the large waste by-product of cashew nut production. The main aims of this research would be to characterise the raw cashew apple juice, trial techniques to remove the tannins/astringency of the juice to make it more acceptable to consumers and investigate methods for removal of microorganisms to improve shelf-life.

Discussion points included the need to change harvesting methods if apples (which have a very short shelf-life) are to be used as they are currently allowed to fall and left in the field when the nuts are harvested. Other points included the need to consider methanol, which evaporates off but is potentially dangerous to workers, the possibilities for drying the apples, and the use of membrane technology to extract tannins.

Purification of anthocyanin by polymeric adsorbent resins by Justine Y. Phuong P. H. Boffo, Faculty of Food Science and Technology, Nong Lam University, Vietnam.

Dr Boffo started by highlighting the high demand from industry for anthocyanins and other polyphenol extracts. At the same time there is a need for better extraction processes which do not rely on high temperature (leading to loss of colour) or organic solvents (which can lead to pseudo-allergenic reactions in humans). As an alternative, she suggested the utilisation of polymeric adsorbents (resins) like styrene-divinylbenzene copolymerisate polymer, which have been used for purification of anthocyanins from acai and blackberry fruits. She proposed research on whether these processes could work for the extraction and purification of monomeric phenols from cashew apple waste and of betalains from pitaya (dragon fruit) by-products.

Discussion points included the fact that there is varietal variation in the polyphenol and carotenoid content of cashew apples from BRAZIL, India and Africa (Cote d'ivore and Benin). The shelf life of the resin can be more than 10 years if the resins are stored properly but the recommended shelf life depends on the type of resin and the containers used. The resin is exhausted when impurities are no

longer captured by it and low levels of anthocyanins can be detected in the extract that has passed through the column.

Wine production from Cambodian indigenous fruits: The case of Jamun, Mango and Tamarind by Borarin Buntong, Faculty of Agro-Industry, Royal University of Agriculture, Cambodia.

The presentation outlined the work undertaken through a JICA-funded project to increase income-generating activities for rural households in Cambodia. Specifically, the production and processing flow chart of wine production from Jamun and Mango were presented, as was the production of Ampel Meas, a rice liqueur flavoured with tamarind (which is increasingly popular).

Discussion points included that the production will be licensed by Ministry of Industry, Mine and Energy and Ministry of Agriculture, Forestry and Fisheries in addition to commercial market which is licensed by the Ministry of Commerce. Three kinds of yeast were used: *Saccharomyces cerevisiae*, *Saccharomyces ellipsoideus*, and dry yeast (*Saccharomyces* spp.). Several different mango varieties were used for the mango wine: Keo Romeat, Keo Sary and Keo Moung (need to be careful as some are high in pectins which can produce methanol). For both mango and jamun, only pulp was used for fermentation (i.e. the seeds were removed, although – in the case of jamun – these might be a good source of anthocyanins). The shelf life of the wine is potentially unlimited if the wine is filtered properly before bottling.

Session 4: Discussion on 2-3 themes to develop into research proposals (Chair: Dr Kate Schreckenberg)

Kate emphasised consideration of the following points when developing a research proposal:

- National research and funding priorities in relation to species, production systems, SME support, food and nutrition
- Building on traditional knowledge about fruit properties to select fruit and varieties
- Characterisation of indigenous fruit
- Integrated processing (i.e. use of all parts of the fruit – producing no waste)
- Technological capacity of SMEs
- Emphasis on some 'innovative' aspect of the research
- Food and nutritional security
- Involve more partners from SMEs, company, research bodies and universities

Discussion points included:

Choice of fruit: We should choose up to three fruit which are common across all/many of the partner countries for collaborative work. Jamun, cashew and jackfruit are available in all three countries

Funding: There are currently no large calls for funding open in this area. Network partner need to explore some of the opportunities available in their own countries as donors are increasingly providing funding on a regional basis. The Indian partners said they have received funding from the Bill and Melinda Gates Foundation. In France, the Agropolis Foundation funds research in the agricultural sector. In Bangladesh funding generally comes from the World Bank, Asian Development Bank and USAID. Cambodia has previously been successful in obtaining funds from AUS Aid, JICA, and Belgium Development Fund (BDP). Vietnam is getting funding from UK – DFID.

Innovation: The innovative element of our research is likely to be its focus on health and nutrition, rather than simply promoting food security through higher production levels.

Role of SMEs: They dominate in all countries, but should we focus on extension of existing technology or develop new technologies? To convince SMEs to come on board, it is essential to include an economic aspect (rates of return and economic feasibility).

Day 2: Tuesday, 15th January, 2013

Confirel Co Ltd. Presentation by HYM Piseth, CONFIREL Plant Manager.

This company produces a range of products from sugar palm (*Borassus flabellifer*), the national tree of Cambodia. The company was established in 2001 to produce new products based on local knowledge of the trees and with fair benefits to all involved. They exploit about 1 million trees, working with 20,000 families. Their products include crystallised fruit, fermented wine and vinegar, organic palm sugar, a distilled whisky-like palm spirit, a sparkling champagne-style wine, chocolate and candy. They are developing eco-packaging from the leaves and have obtained EC, JAS and USDA organic certificates for their palm sugar ('palmyrah'). They are being supported by the EU to produce babyfood ('Nutrikhmer') and have obtained geographic indication for their Kiry Kampot pepper. A number of other products are in preparation.

Session 5: Reports on mini-research projects undertaken by partners

Bangladesh: Maturity Indices and Quality Criteria of Jackfruit by Dr M. G. Saha, Dr M. N. Islam and M. M. Molla, Bangladesh Agricultural Research Institute, Bangladesh.

The research found that the ideal time for harvesting jackfruit ('Gala' type cultivars) for use as vegetables was 60-70 days after fruit set (DAF) while harvesting for use as a fruit is best at about 100 DAF. Farmers' knowledge about when to harvest fruit for dessert consumption is similar to that determined by researchers. However, their knowledge in relation to harvesting the fruit for use as a vegetable is less reliable. A number of visual features such as density and shape of spines, sound when tapped and shape of fruit stalk were found to be good indicators of maturity. Discussion focused on how the results could be disseminated to farmers through training workshops. The issue of how to deal with the 'waste' of the seeds and stalks was also discussed, including the fact that the seeds may be a good source for resistant starches.

India: To standardize the technique of preparing a fruit leather by blending two indigenous fruits viz Bael and Aonla pulp by Dr Susanta K Roy, Dr Shailendra K Dwivedi, Dr Vigya Mishra & Dr Neeru Dubey, Amity International Centre for Post-Harvest Technology & Cold Chain Management, Noida, India.

The research found that a blend of 2 parts bael to 1 part aonla plus 10% sugar produced a fruit leather with the highest sensory evaluation, although it suffered from considerable non-enzymatic (Maillard) browning. The latter could be counteracted by use of 2000ppm of KMS (Potassium metabisulphite) which is below the permitted limit in existing Indian food laws. Laminated pouches performed better than polyethylene packaging in terms of preventing browning, retaining ascorbic acid content and maintaining a high sensory score. Processing was considered simple enough for small rural entrepreneurs with good potential for the fruit leather to be used as a nutritious sweet lunch item for children. More research is needed to determine the nutritional and antioxidant properties of the leather and the possibility of fortifying the leather with soy flour.

Cambodia: Market demand study on fresh products and derived products of banana **(*Musa* spp.)**, jackfruit **(*Artocarpus heterophyllus*)** and cashew nut (***Anacardium occidentale*)** in Phnom Penh market by Mr TY Piseth and Dr Hul Seingheng, Institute of Technology of Cambodia.

This study sought to fill a gap in the information available on production of banana, jackfruit and cashew nut in Cambodia. Production for all three fruits was found to be relatively small-scale (2-5ha for cashew and banana, and family-scale for jackfruit). Establishment costs were highest for jackfruit as was time until first harvest (3-4 years) but it also provided the highest returns per year per hectare. Although banana production is sufficient to meet the demands of the domestic market, most jackfruit is imported from neighbouring countries as are processed cashew nuts (although the fresh product is exported, suggesting a lack of processing capacity in-country). Consumers in Phnom Penh typically bought fruits at the market twice a week and generally prefer fresh banana and jackfruit to processed derivatives.

Vietnam: Added-value for cashew industry by producing reduced-fat cashew apple chips by Dr Justine Y. Phuong Boffo and Ms. Diep Thi Ngoc Duong, Nong Lam University, Vietnam, and Dr Max, Reynes and Dr Adrien Servent, CIRAD, France.

The study found that it is economically viable to produce chips as a value-added product from cashew apples. Conventional deep-fat frying was compared with vacuum-frying coupled with vacuum de-oiling. The latter produced less oily chips with better sensory attributes. An economic feasibility analysis suggests that the payback period for a factory producing 80kg of chips per day would be 2.3 years. Cashew apple chips were found to be as acceptable to consumers as potato chips.

Session 6: Group work to develop research proposals

Group 1 – Characterisation of indigenous and underutilised fruit

The group identified the following issues which might form part of a proposal on fruit characterisation:

1. Ethnobotany of indigenous fruit: In some countries, e.g. Cambodia and Vietnam, there has been little emphasis on indigenous fruit, so the first need is to compile existing information. This would include a list of all indigenous fruit (and, where possible, information on specific varieties) and any information available in the literature on the botanical characteristics and uses of these fruit. Even where a basic list is available, it could be useful to collect more ethnobotanical information on the species we are interested in to discover their local characteristics/uses and how these vary between sites.

2. Basic fruit characterisation: All partners have the equipment and are able to carry out basic fruit characterisation. This includes, for example, physical characteristics, mineral and vitamin content, Total Soluble Solids (TSS). Note that it is useful to do this for different varieties as their properties may differ.

3. Bioactive compounds: These are potentially of more commercial interest but can also require more specialised equipment and capacity to characterise. Starting with extracts of the fruit or essential oils, a large number of bioactive compounds could be assessed: anthocyanins, carotenoids, antimicrobial activity, phenolics, tannins, alkaloids, vitamins (riboflavins, ascorbic acid, etc), enzymes (e.g. proteases, pectins). Depending on the research focus, bioactive compounds could be split into two categories:

(i) Those that make a direct contribution to human health, including both functional foods (e.g. vitamins, antioxidants) and those with more medicinal properties (e.g. reducing blood pressure or helping to control diabetes). The latter set would require collaboration with specialised medical researchers.

(ii) Those that make an indirect contribution, e.g. antimicrobials that are used in agro-industry to substitute for chemical inputs.

4. Market characterisation: This would include both an assessment of the potential supply of the product (quality and quantity, seasons, locations) and the market demand (quality and quantity, substitutes, consumers, price).

5. Other issues: We discussed that it might be useful to look not only at the fruit but also at other parts of the plant, particularly those parts that can be harvested non-destructively. Use of waste by products for ethanol production could also be useful.

Group 2 – Innovative technology for safety and hygiene

The group focused on technologies appropriate for SMEs to produce products that are attractive, nutritious, marketable, well-packaged, and have a good shelf-life. They considered both primary and secondary technology, as well as considering the need for low-energy 'green' technology.

- What products? Need to study the whole system (product life cycle): from genetics, production, processing and packing to transport and distribution.
- Which technology? Aim to take existing technologies and apply them to new problems and make small innovative breakthroughs. Could separate technologies into those producing direct products for consumers (e.g. juice, wine, jellies) and more 'indirect' technologies which produce bioactive products for intermediary users.
- What target audience? Small and medium-size enterprises (SMEs).
- What objectives? (1) searching for the technologically easiest, most cost-effective solutions, and environmental friendly applications, (2) evaluating several technological alternatives to reach the same objective and choose the easiest from the implementation and financial standpoint, (3) study the financial aspects of the investment/ economically viable technology.

The discussion illustrates the potential of unleashing innovation to address food technological challenges in respect of the desired products from Cambodia, Bangladesh, India, Vietnam and Sri Lanka as shown in the table below:

Summary of discussion on innovation technology

No	Fruit	Products		Discussed Technologies
1	**Jackfruit**	Intermediate products Bioactive compound	NA	
		End products	Seed powder	Solar drying
			Chips	Vacuum frying,
2	**Cashew apple**	Intermediate products Bioactive compound	Carotenoids, Other antioxidants	Membrane Supercritical CO2, Microwave extraction
		End products	Juice	Membrane
			Chips	Vacuum frying,

3	**Tamarind**	Intermediate products Bioactive compound	NA	
		End products	Juice, Paste, Concentrated juice,	Grinding, Concentration Traditional Extraction,
			seed powder	Solar drying
4	**Dragon fruit**	Intermediate products Bioactive compound	Betaline, Anthocyanins	Membrane Supercritical CO2, Microwave extraction
		End products	Chips,	Vacuum frying,
			Juice	Membrane
5	**Jamun**	Intermediate products Bioactive compound	Anthocyanin	Membrane
		End products	Juice, Wine, Vinegar	Traditional Extraction, pressing, pulping
6	**Aonla**	Intermediate products Bioactive compound	NA	
		End products	Juice, Pulp, Fruit leather	Traditional Extraction, pressing, pulping
7	**Bael**	Intermediate products Bioactive compound	NA	
		End products	Pulp, nectar juice	Traditional Extraction, pressing, pulping

Session 7: Potential funders for proposals

Roundup of existing funding partners

Sri Lanka: Some funding from ITDG (UK) on small-scale industries; Wageningen University; Japanese universities on environmental engineering; Sri Lankan government (rather unpredictable) mostly through the Council for Agricultural Research Projects (CARP).

India: Quite a lot of national funding is available through the government (Dept of Science and Technology) but mainly for in-country work. Amity has had a project with Bill and Melinda Gates Foundation (for this it is necessary to have a US partner).

France: The Agence Francais de Developpement (AFD) has a foundation for Cambodia but funds development rather than research. Some PhD funding can be obtained through French embassies. The FAO regional office in Bangkok might be interested in providing complementary funding. Agropolis is another potential source of funding in response to specific calls as well as for providing PhD funding.

Vietnam: The French Ministry for Foreign Affairs has an annual call on natural substances which one could apply to for up to 20,000 euros per year to cover PhDs, mobility, meetings but no direct lab research costs (i.e. it is good complementary funding for a network). The Association Union Francophonie (AUF) also provides small amounts, e.g. to strengthen South-South cooperation, but not for research itself. National funding is available for lecturers to apply to at regional and government level.

Bangladesh: There is not a great deal of government support for research. The central government applies for projects from the World Bank and the ADB and then this gets allocated to different departments. USAID, ADB and WB have been funding the Horticultural Research Centre for the past 10 years. One can apply to the National Agricultural Technology Projects (WB funds) but it is hard to get funds for work on fruit crops as they are so long-lived.

Cambodia: The AUF used to provide some funding. The WB provides funding to the government which passes it on to academic institutions, including some allocated to ITC. JICA are present in Cambodia (focus on engineering) as is AUSAID but the latter is focused on water and sanitation. The EU has provided funds through the SwitchAsia programme and Belgian CUD is also a possibility.

Group 1: Brainstorm on potential funding proposal on 'Technology transfer to rural producer groups'

1. Possible proposal title: 'Utilisation of underutilised fruit for improved (rural) livelihoods and nutrition'

We agreed to use 'underutilised' instead of 'indigenous' as the former is a larger category and would include such fruit as cashew apple, for example. We decided to leave 'rural' in brackets as a project like this could also be usefully targeted at a peri-urban environment, where SMEs have access to the resource as well as to the market. In terms of scale, a project of this kind would be focused on smaller SMEs (less than 10 employees), including women's groups.

2. There are several types of products a project like this could focus on:

(i) Powders, slices and teas: various different types of equipment are available for this kind of processing. The least complicated are solar dryers; challenges include less consistent quality and browning of products unless you add additives. Drum dryers are used in many places. Spray dryers (pilot size version made in Vietnam costs about $20,000) can make powders from juice. Challenges for all systems are packaging and storage (against rodents, humidity, oxygen) and embedding food safety standards in the process.

(ii) Juices and pulps: The main challenge here is stability during storage with many juices losing their sensory appeal through colour change or the juice separating, reduced nutrient content over time and food safety issues. Any project looking at these products should aim to minimise preservatives and other additives as well as prioritising low energy processes.

(iii) Chutney pickles (and jams where there are large tourist markets): These suffer from similar challenges to the juices.

(iv) Fermented products, e.g. vinegars.

3. Appropriate packaging:

This is a generic issue for all products and partner countries, e.g. Cambodia has great difficulty obtaining glass containers. Packaging needs to be available, cost-effective, good for food safety, have high market acceptability and be as environmentally friendly as possible.

4. Food safety and good management practices (GMP):

These issues also cut across all products. Resolving them requires a focus on (i) education and awareness-raising (e.g. on sanitation and hygiene, health and safety of producers); (ii) regulation and/or market incentives to force or encourage producers and processors to implement the best possible practices; (iii) 'greening' the food processing industry, i.e. reducing waste and energy consumption.

5. Proposals could be put together in a number of ways:

(i) Targeting the same products or processing challenges

(ii) Targeting the same kinds of producer or processor groups (e.g. women's groups)

(iii) Targeting the same species. Table 1 indicates the approximate presence of the species we have discussed in the different partner countries.

Table 1. Availability of different species in partner countries. (XXX indicates a significant presence, while X indicates a minor presence.)

Fruit	**Scientific name**	**Vietnam**	**Cambodia**	**India**	**Bangladesh**	**Sri Lanka**
Jackfruit	*Artocarpus heterophyllus*	XXX	XXX	XXX	XXX	XX
Cashew apple	*Anacardium occidentale*	XXX	XXX	XXX		XX
Jamun	*Syzygium cumini*	X	XXX	XXX	XXX	XX
Tamarind	*Tamarindus indica*	X	XXX	XXX	X	XX
Bael	*Aegle marmelos*	X	X	XXX	XX	X
Aonla	*Emblica officinalis*	X	X	XXX	X	X
Dragon fruit	*Hylocereus undatus*	XXX	X			X

Group 2: Brainstorm on potential funding for a proposal on 'Innovative research technology for safety and hygiene product'

To ensure healthy and safe food, a production system which retains the fruit colour, taste and texture is very important. The group explained the innovation technologies of (1) **safe** food (non-chemical contamination/applications from harvest to consumers' tables including processing, packaging and transport), and (2) **healthy** food (determine the impact pulses have on weight loss, lowering cholesterol and improving immunity system). The project focus would be on the application of novel technologies to improve microbial safety and shelf life of fresh fruits, and processed fruits while maintaining overall high taste and nutritional quality. During discussions the group considered use of the following technologies:

Hurdle technology: Factors used for food preservation are called '*hurdles*'. Potential hurdles for use in the preservation of foods can be divided into physical, physicochemical, microbial derived and miscellaneous hurdles including high temperature, low temperature, water activity, acidity, redox potential (Eh), competitive microorganisms (e.g. lactic acid bacteria) and preservatives (e.g. nitrite, sorbate, sulphite). To ensure the stability and safety of foods, each hurdle should be applied in the proper manner as each product may require a different combination of hurdles, depending on a range of factors including: (i) the initial microbial load of the product requiring preservation, (ii) how favourable conditions are within the product for microbial growth, (iii) target shelf-life (Sun et al., 2004).

Membrane technology for the processing of fruit juices mainly applied for clarification using ultrafiltration (UF) and microfiltration (MF), and for concentration using reverse osmosis (RO, as a concentration technique to remove water from fruit juices). The effects of product preparation, membrane selection, and operating parameters are important factors influencing filtration rate and product quality. Recent significant progress on membrane processes for concentrating fruit juices, including the use of reverse osmosis, direct osmosis concentration, membrane and osmotic distillation, and integrated membrane processes.

PEF involves the application of high voltage electrical fields for microseconds to liquid foods. It is suitable for preserving liquid and semi-liquid foods, removing micro-organisms and producing

functional constituents. PEF has not yet been used in Europe on industrial scale although it has been used in the US for orange juice, and it has considerable potential for improving quality and taste of pasteurised foods compared with traditional preservation techniques. The process variables affect also the food microstructure and the interaction between food ingredients.

The discussion pictured the innovation research project outline as shown as below:

Summary of discussion on innovation research project

No	Axes	Products		Discussed Technologies
1	Safety	Fresh products	Dragon fruit, Tamarind	Lactoperoxidase (LPS) Near-Infrared spectroscopy (NIR) Ozone
		Processed products	Jamun juice, Cahew apples juice. Dragon fruit juice	Membrane technology, Pulse Electric Field (PEF) Microwave
2	Healthy	Fresh products	Jackfruit, dragon fruit, Jamun	Essential oil/ Bioactive
		Processed products	Juice (cashew, apple, bael, aonla)	Membrane technology Hurdle technology
			Chip (jack fruit, dragon fruit)	Vacuum frying-de-oiling

Day 3: Wednesday, 16th January, 2013

Field visit to Confirel Company

Confirel is one of the largest processed food industries in Cambodia. It was established in 2001 to preserve the rare resources of the palm trees and to participate in the development of the economy of Cambodia, by Dr Hay Ly Eang with the technical support from the group of Khmer technicians, Institute of Technology of Cambodia, CIRAD (International Cooperation centre for Agronomic Research and Development in France) and CRITT-IDF. Its products include:

- Organic Palm Sugar: Rich in minerals, oligo-elements and polyphenols (anti-oxidant, 400mg/ 100g)
- Jaya Palm Spirit (500ml), Jaya Palm Spirit (187ml), Mekong Palm Sparkling, Kirel Palm Wine Original 500ml, Kirel Palm Wine Original 750ml, Kirel Palm Wine Pineapple 500ml, Kirel Palm Wine Ginger 500ml
- Kirum Organic Palm Vinegar, Kirum Kampot Black Pepper Vinegar
- Kampot Pepper: Kampot Pepper (Black), Kampot Pepper (White), Kampot Pepper (Red)
- Palm Candies/Choco: Palma Palm Candy Original, Palma Chocopalm Mango, Palma Chocopalm Banana, Palma Mix 7
- Bobor Rong Roeung: Bobor Rong Roeung/Sachet 35g, Bobor Rong Roeung/Box 35g×7

By involving farmers at all stages of the production process, the company provides them with the necessary resources to carry on their activities. Confirel also contributes to the preservation of this unique heritage by using only the fruit and leaves of the sugar palm tree. Confirel is based on a widely recognized gastronomic know-how, which is appreciated in many Western countries for its originality and authenticity.

Session 8: Discussion on next workshop in Sri Lanka

Dates for the workshop were agreed: 13-15th May 2013. The venue, accommodations and the local logistic support will be organised by our Sri Lankan host. One of the things we discussed was how we should use the workshop in Sri Lanka. The participants agreed that it would be useful to try to do a few different things at the workshop.

1. The main two days would be a training workshop focused on 'Initiatives and tools to facilitate uptake by SMEs of new processing technologies for fruits and their derivatives'. All partners seem interested in how best to achieve transfer of technology, thinking both of transfer to smaller rural producers as well as to companies at the larger end of the SME category. In addition to our partners, it would be good to include some SMEs in this part of the workshop to ensure that we get some realistic discussion/experience of how technology transfer can take place. Max offered to provide some insights into his experience from the PAVUC project in Latin America, where he worked with private sector companies throughout but found that the results were not necessarily used by the research partners but turned out to be more appropriate for other private sector actors. Phuong also mentioned that she could talk about her interaction with the cashew nut industry in Vietnam.

2. The final day of the workshop would be just for the partners and would consist of two half-days:

(i) Training in how to write large research proposals. Max, Nazmul and Kate can run this. For this the previous EU proposals will be circulated in advance so that partners can use it as a model to write sections that are relevant to their interests.

(ii) Some time on dissemination of our results. We will look into a possible review paper but also how we could go about compiling the information we have so far in some form of hard copy publication.

Closing session

Certificates of attendance were distributed among the participants. Kate expressed her gratitude and thanks to Dr HUL and his colleagues for their excellent organisation of this workshop that brought with a lot of positive outcome. She also thanked all the participants for their contributions to making the workshop an overall success.

Appendix 1. List of participants

Country	Name of Participant	Institute	Email
Bangladesh	Dr Madan Gopal Saha	Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh.	mgs_60@yahoo.com
	Dr Md Atiqur Rahman		atiqur_2004@yahoo.com
	Dr Md Abdul Jalil Bhuyan		Dir.ss@bari.gov.bd
Cambodia	Dr Seingheng HUL	Institute of Technology of Cambodia, Phnom Penh, Cambodia	hul@itc.edu.kh
	Dr In Sokneang		insokneang@yahoo.com
	Mr Luon Vireak		vireak.luon@gmail.com
	Ms. Seng Kong		seng_kongoo7@ymail.com
	Mr. Ty Pisith		typiseth76@yahoo.com
	Mr. Hym Piseth	Confirel Company	hpiseth@confirel.com
	Mr. Sin Sokdavin	Department of Agriculture, K. Cham	
	Mr. Buntong Borarin	Royal University of Agriculture	borarin@yahoo.com
India	Prof Susanta Kumar Roy	Amity international centre for post-harvest Technology and Cold Chain Management**,** Amity University, India.	roysusanta2002@yahoo.co.in
	Dr Shailendra Dwivedi		shailendra.pht@gmail.com
France	Dr Max Reynes	CIRAD, France	max.reynes@corad.fr
	Dr Samira Sarter	Hanoi University of Science and Technology, Vietnam	samira.sarter@cirad.fr
Sri Lanka	Prof D A N Dharmasena	University of Peradeniya, Sri Lanka	dand@pdn.ac.lk
Vietnam	Dr Pham Huu Yen Phuong		Phyenphuong05@yahoo.com
	Ms Duong Thi Ngoc Diep	Nong Lam University, Vietnam	diepngocduong@yahoo.com
UK	Dr Kate Schreckenberg	University of Southampton, UK	k.schreckenberg@soton.ac.uk
	Dr Nazmul Haq		N.N.Haq@soton.ac.uk
	Mr Malik Hamid		m.a.hamid@soton.ac.uk

Appendix 2. Workshop Programme

Research Workshop on Valorisation of Traditional Processing of Indigenous fruit
14th - 16th January, 2013, Cambodia

The Department of Food Technology and Chemical Engineering at Institute of Technology of Cambodia, Phnom Penh, Cambodia and the Centre of Underutilised Crops (CUC) at the University of Southampton are jointly organising a three day (14-16 January, 2013) research planning workshop funded by the Leverhulme Trust, UK. The workshop is focused on promoting cutting edge research and innovation under the project **"International network on preserving safety and nutrition of indigenous fruits and their derivatives"**.

Workshop objectives:

- Review cases (from our partner countries) of traditional processing of indigenous or underutilised fruit which may provide the basis for innovative ways of contributing to improvements in local health and nutrition
- Present final results of mini-research projects and conclusions as to what kind of further research is justified
- Highlight the particular research interests and expertise of the Cambodian partner in relation to processing of indigenous fruits
- Identify fundable research gaps that are of interest to two or more network partners and can build on their expertise.
- Draw up an outline of one or more research projects relating to the valorisation of indigenous fruit processing and assign responsibilities for proposal development.

Workshop venue & accommodation for participants: Sunway Hotel Phnom Penh, No. 1, Street 92, Sangkat Wat Phnom, Phnom Penh 12202, Kingdom of Cambodia. T +855 23 430 333, F +855 23 430 339.

Research Workshop Programme

Monday (14th Jan 2013)

Time	Session	Speakers
08.30-9.00	Registration	Dr Hul/Ms Kong
9.00-9.10	National Anthem & Welcome address	Dr Hul/Ms Kong
9.10-9.20	Introduction by the participants	Participants
9.20-9.30	Introduction to the workshop	Dr Kate Schreckenberg
9.30-9.40	Opening Address	Dr Om Romny, Director General of ITC
9.40-10.10	Photo Session and Tea Break	
10.10-10.45 25 min presentation + 10 min discussion	Overview of fruit processing in Cambodia: Current status and future prospects	Dr In Sokneang, ITC, Cambodia **Suggested Discussants:** Dr Reynes and Dr Dharmasena
10.45-11.20 25 min presentation + 10 min discussion	Value Addition to Jackfruit *(Artocarpus heterophyllus* Lam.) through Integrated Processing and Preservation	Dr M G Saha and Dr Md Atiqur Rahman ,Bangladesh Agricultural Research Institute **Suggested Discussants:** Dr Haq and Dr Phuong
11.20-11.55 25 min presentation	Obtention of some carotenoids extract from cashew apple using	Dr Max Reynes, CIRAD, France **Suggested Discussants:**

+ 10 min discussion	membrane technology	Dr Schreckenberg and Prof SK Roy
11.55-12.50	Lunch break	
12.50-13.25 25 min presentation + 10 min discussion	Valorisation of the vegetal biodiversity for food safety: Characterisation of antimicrobial plant extracts	Dr Samira Sarter, Hanoi University of Science and Technology, Vietnam **Suggested Discussants:** Dr Haq and Dr Hul
13.25-14.00 25 min presentation + 10 min discussion	Preservation and quality aspects of selected Sri Lankan fruits	Prof DAN Dharmasena and Dr KH Sarananda, Sri Lanka **Suggested Discussants:** Dr Schreckenberg and Dr Dwivedi
14.00-14.35 25 min presentation + 10 min discussion	Stability evaluation of anthocyanins obtained from wild Jamun (*Syzygium cumini* Skeels) fruits and their utilization as a food supplement	Dr Shailendra Dwivedi, Amity University, India. **Suggested Discussants:** Dr Reynes and Dr Bhuyan
14.35-15.00	Tea Break	
15.00-15.35 25 min presentation + 10 min discussion	Integrated Processing of *Jamun* (*Syzygium cumini* Skeels) for value addition and assessment of its impact on health & nutrition	Prof Susanta Kumar Roy, Amity University, India. **Suggested Discussants:** Dr Schreckenberg and Dr Sarter
15.35-16.10 25 min presentation + 10 min discussion	Valorisation of fruits by product for health beneficial components	Dr Pham Huu Yen Phuong and Ms Duong Thi Ngoc Diep Vietnam **Suggested Discussants:** Dr Haq and one from Cambodia
16.10-16.45 25 min presentation + 10 min discussion	Wine production from indigenous fruit such as goose berry, jambula, tamarind and mango	Mr Buntong Borarin, Royal University of Agriculture, Cambodia **Suggested Discussants:** Dr Reynes and Dr In Sokneang
16.45-17.30	Discussion on 2-3 key themes to develop into research proposals	**Chair-** Dr Kate Schreckenberg
17.30	Closure of the first day	

Tuesday (15th Jan 2013)

Time	**Session**	**Speakers/Chair**
8.25-9.00 25 min presentation + 10 min discussion	History and product presentation	Mr Hym Piseth, Cofirel Co.Ltd, Cambodia.
9.00-10.00 15 mins for each presentation + discussion (reports to be circulated in advance)	Presentation of final reports of mini-research projects -Vietnam -India -Bangladesh -Cambodia	Chair Dr Nazmul Haq
10.00-10.30	Tea Break	
10.30- 12.00	2-3 Groups working to develop outline project proposals and report back	Group leaders to be determined
12.00-13.00	Lunch Break	
13.00-14.30	Inventory of potential funders	
14.30-15.30	Report back to plenary to obtain feedback from other participants on	

	proposal outlines	
15.30-16.00	Tea Break	
16.00	Closure of the second day	
18.00	Conference Dinner	

Wednesday (16th Jan 2013)

9.00-12.30	Field Visits to Cofirel Company (sugar palm products) and ITC food chemistry labs	
12.30-13.30	Lunch break	
13.30-14.30	Discussion on dissemination and policy briefings	
14.30-15.00	Tea break	
15.00-16.00	Finalise the next workshop (Date, venue, topics, participants, budget etc.)	Only the partners
16.00	Closure of the third day	