Preparation of an SPS Action Plan for Cambodia

(FAO Project MTF/CMB/032/STF)

Evaluation of
Laboratory Capacities in Cambodia

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Foreword

Over the past ten years, several attempts were made to progressively build up laboratory capacity in ASEAN countries. While efforts have obviously fruited in China, Vietnam or Thailand, the development in Cambodia has been behind.

During the years 2007 / 2008 a review of Cambodia's SPS related capacity building activities concluded that while there had been a number of useful donor-funded interventions, there was no national strategy for SPS capacity building with an associated Action Plan. As a follow-up the FAO/STDF project 246 was initiated to guide and support Cambodia in creating an SPS Action Plan for the country.

The project started in May 2009 involving two major streams of work, a strategic and policy approach, and a sector approach.

A national task force featuring members from the main line ministries of agriculture (MAFF), commerce (MoC), industry (MIME) and health (MoH) had been formed and several sub-sector studies and been commissioned to both international and national consultants.

The following document deals with the assessment and evaluation of food safety related laboratory capacity in Cambodia considering a food chain approach, including agricultural inputs such as fertilizers, pesticides and veterinary drugs.

Executive Summary

Visits to local laboratories and a questionnaire survey as well as assessments performed by national consultancies revealed that the testing capacities in the field of food safety analysis are still very limited in Cambodia. There are several laboratories organized and mandated under different ministries performing food safety related analyses, yet they are not able to provide timely and adequate analytical services to respond to the ever increasing demand and complexity of food analysis.

None of the laboratories have so far managed to achieve international accreditation under ISO 17025 so far, and important food safety parameters such as pesticide or veterinary drug residues, and mycotoxins are not monitored. Laboratories have neither the necessary equipment nor the staff with the required basic qualification and the specialized skills to undertake such analyses. Furthermore, the environmental conditions of most laboratories are not adequate to support such highly sophisticated techniques such as GC-MS/MS or LC-MS/MS required to determine residues at levels, certainty and accuracy demanded for instance by importing countries such as for instance the EU, Japan or Australia.

Finally evidence presented on the budgetary situation of the various institutions visited underlined the shortage of resources; there was no continuity in the work of the laboratories, activities were isolated and mostly depended either on donor-supported projects, or on some request by (private sector) customers to analyze certain samples.

While chemical analyses for the purpose of getting export certificates are being more and more commercialized, public funding for food safety and SPS related activities is often insufficient and rather neglected. No regular, risk-based sampling programmes could be seen as part, for instance, of overall residue monitoring schemes. In addition to certification of product consignments, most importing countries like to see regular surveillance and monitoring for diseases or food contaminants in place as an indication that a producing country can manage their food safety system and that Good Agricultural Practice (GAP) is observed.

Significant investments in facilities, equipment and supplies as well as human resources are required, requiring a significant period of catalytic support from development partners, to upgrade Cambodia’s food safety system, **and** make it operational. This effort, however, needs to be accompanied by improving the legislative framework and providing sufficient public funding to maintain operational surveillance and monitoring activities.

Figures are presented for a model ‘Government Laboratory’ performing a minimum of food safety analyses, with the costs estimated at 640.000 USD per year on top of capital investment of up to 2 million USD.

In Cambodia, three scenarios are envisaged – (i) no change over the current situation; (ii) an attempt to develop capacity at two (or even more) laboratories, but with a degree of specialization and sharing of capacity; and (iii) the upgrading of one of the existing laboratories for capital-intensive testing, to serve the needs of all ministries involved, while retaining existing capacity for less capital-intensive work. The latter is recommended.

Acronyms and abbreviations

Note: A specific glossary on modern analytical techniques is provided in the annex ( )[1]

AAS	atomic absorption spectroscopy
AI	avian influenza
AOAC	Association of Analytical Communities or AOAC International
ASEAN	Association of Southeast Asian Nations
CamControl	Cambodia Import Export Inspection and Fraud Repression
ECD	Electron Capture Detector
ELISA	enzyme-linked immunosorbent assay
FAO	Food and Agriculture Organization
FPD	Flame Photometric Detector
GC	gas chromatography
GC-MS	gas chromatography-mass spectrometry
HPLC	high performance liquid chromatography
ICP	inductive coupled plasma (for simultaneous multi-element detection)
ILCC	Industrial Laboratory Center of Cambodia
ISO	International Organization for Standardization
LC-MS	liquid chromatography-mass spectrometry
MAFF	Ministry of Agriculture, Forestry & Fishery
MOA	Ministry of Agriculture
MOH	Ministry of Health
MS	Mass spectrometry
NAL	National Agriculture Laboratory
NAVRI	National Veterinary Research Institute
NPD	Nitrogen Phosphorous Detector
OIE	World Organization for Animal Health
PCR	polymerase chain reaction
QuECHERS	Quick Easy Cheap Effective Rugged and Safe
RT-PCR	real time polymerase chain reaction
SOP	Standard Operating Procedure
SPS	Sanitary and Phytosanitary
STDF	Standards and Trade Development Facility
UNIDO	United Nations Industrial Development Organization
WHO	World Health Organization
WTO	World Trade Organization

Introduction

During the years 2007/ 2008 a review of Cambodia's SPS related capacity building activities concluded that while there had been a number of useful donor-funded interventions, there was no national strategy for SPS capacity building with an associated Action Plan. As a follow-up the FAO/STDF project 246 was initiated to guide and support Cambodia in creating an SPS Action Plan for the country.

Several sub-sectoral studies were commissioned with the aim of obtaining qualitative and quantitative information on constraints to market access for selected products, specifically where access is linked to levels of contamination. The selection of products is defined by the 2007 Diagnostic Trade Integration Study for Cambodia, which identified products with medium or high export potential. This principally listed rice, cashew and cassava, plus fruit and vegetables and fisheries products.

Objectives and approach of the study

This study examines both technical capacity (equipment / facilities / services) and institutional capacity (trained individuals, sample collection and handling, laboratory procedures, etc). The study reviews institutional mandates, examines cases where critical volume of tests is not reached, and makes suggestions for options to improve arrangements for testing.

Supported by a national consultant the study also looks at the costing of laboratory analyses within the frame of food control and import/export certification as well as present public funding and commercial activities.

In addition, in collaboration with a consultant economist (who will conduct an assessment of the market potential of each of the selected products), a costing exercise for required strengthening of laboratory capacity is undertaken.

Approach

After intensive document study and a briefing, a mission to Cambodia took place to meet with the main counterparts of the project as well as with the Team Leader and the National Project Coordinator.

Concentrating on understanding and assessing the present food safety related laboratory infrastructure of the country, nine laboratories were visited and discussions were held with respective responsible officers or representatives to identify present problems and constraints. In order to obtain additional information in a structured way from all laboratories concerned, a laboratory questionnaire was designed for a survey to be conducted following the visits.

In addition to the laboratories and institutions visited, contacts were made to several donors to brief them on the present status of the project and discuss some of their planned contributions.

The very preliminary findings on the laboratory issues were also briefly presented in a National Task Force Meeting with the stakeholders of the project.

Briefing and debriefing meetings were held both in FAO-HQ and with the FAO-R in Cambodia.

Coverage of the assessment

Among the nine laboratories visited were the four focal governmental laboratories involved in food control and belonging to four different ministries or departments (considered in the study); apart from those, 4 other governmental laboratories (not directly considered by the study) and one non-governmental laboratory (partly considered in the study) were visited.

Those laboratories are:

- CamControl (Ministry of Commerce)
- Industrial Laboratory Center of Cambodia (ILCC)
- National Agriculture Laboratory (NAL)
- National Health Products Quality Control Center
- Feed quality Control Laboratory
- National Veterinary Research Institute
- Metrology Laboratory
- Environmental Laboratory (Ministry of Environment)
- Pasteur Institute (non governmental)

All of the above laboratories are located in the capital Phnom Penh.

Related border inspection posts or related harbor or airport facilities were not visited. In view of suitable sampling strategies and their proper implementation, however, this may be necessary in future. Sampling is to be considered as an important part of the process of analysis, which if not done properly, can invalidate the whole process and the results.

Mandates of different laboratories

The following paragraphs briefly describe the mandates of the different laboratories as conceived and reported by the institutions. It should be mentioned, however, that a separate national consultancy[1] *has independently collated information on the current mandates within the Government of Cambodia relating to the SPS activities in the country.*

Camcontrol Testing Laboratory (CTL)

The Camcontrol Testing laboratory (CTL) under Directorate-General for Import Export Inspection and Fraud Repression (CAMCONTROL), Ministry of Commerce, is responsible for testing of food samples for physical, chemical and microbiological contaminants to support the food inspection activities of CAMCONTROL at the border inspection posts and at the local markets.

Industrial Laboratory Center of Cambodia (ILCC)

The ILCC under the Ministry of Industry, Mines and Energy (MIME) has the main objective of providing testing services for food analysis in support of the regulatory departments of MIME, food product safety and quality control systems, standard activities, and other Non-Government customers (private sectors, NGO and community) for researching and improving their food product quality and safety.

National Agriculture Laboratory (NAL)

The National Agriculture Laboratory (NAL) is the reference laboratory of the Ministry of Agriculture, Forestry and Fisheries (MAFF) mainly for testing pesticide products and fertilizers as well as elements in soil and water.

National Health Products Quality Control Centre

This laboratory under the Ministry of Health mainly performs drug quality control using instrumental analysis. To some extent it is also involved in analyzing samples from poisoning outbreaks.

Feed quality control laboratory

This laboratory also under the Ministry of Agriculture, Forestry and Fisheries was still under construction. Details of its organization and planned operation were not known.

National Veterinary Research Institute (MAFF)

The National Veterinary Research Institute under the Ministry of Agriculture, Forestry and Fisheries is primarily monitoring the animal health by doing serological, histological and bacteriological analyses. Food analyses as performed in the past are discontinued. The laboratory is therefore not directly considered under this study.

[1] Interim Mission Report, Mr. Khlauk Chuon, January 2010 (FAO)

Metrology laboratory

Although metrology is an important element for laboratory operation and accreditation[2], this laboratory, which presently operates under the Central Metrology Department of the Ministry of Industry, Mines and Energy is not covered by this study.

Environmental Laboratory

The Department of Environmental Pollution Control under the Ministry of Environment has an analytical laboratory since 1996 supported by UNDP and EU. Although the laboratory has been visited it is not be considered to be part of the present food safety system.

The Pasteur Institute

The Pasteur Institute as an international NGO maintains a large and wider laboratory complex in Phnom Penh with a number of specialized laboratories, among them a food microbiology and water laboratory.

The Food Microbiology & Water Analysis Laboratory of the “Institute Pasteur du Cambodge” (IPC) was created since 1996. The laboratory carries out routine services in three subjects:

- Water microbiology;
- Food microbiology and samples from environment (e.g. food preparation surfaces, air, water etc…);
- Chemical parameters of water;

As the collaborative laboratory of the Ministry of Health with other IPC laboratories, this laboratory participated as stakeholder in investigations of food borne diseases with local and international partners.

[2] Laboratory accreditation according to ISO 17025 requires among others that all measurements and calibrations are traceable to the international standards; for our type of laboratories, measuring equipment involving parameters like mass, volume and density, or in some cases for instance temperature are important to be calibrated.

Development, distribution and evaluation of a laboratory questionnaire

The visits to the above governmental and non-governmental laboratories in Cambodia revealed a great variability of facilities, staff, equipment, budgets and activities; therefore it was decided to additionally organize a questionnaire based survey amongst the laboratories dealing with SPS related issues and food safety.

The questionnaire included key laboratory issues such as mandates and legislative backup, general laboratory facilities, qualification and experience of staff, availability and condition of equipment, sampling programmes and strategies, and sample capacities, budgets and ability to sustain laboratory operations.

A sample of the questionnaire is attached as annex ( )[2].

The questionnaire was distributed to the main governmental laboratories dealing with food safety, and to the Pasteur Institute[3]. Feed back was received from CAMCONTROL, ILCC, MOH, NAL and the Pasteur Institute.

Unfortunately, no response has been received from the Feed Laboratory. Considering, however, that feed is an important agricultural input in the food chain, which can greatly influence the quality of the final products of animal origin, it should be important to give special attention and consideration to that aspect.

Collection and evaluation of specific data and information on local laboratory operating costs

As part of a national consultancy[4], data and information on laboratory organization and management as well as particular operating cost and environment were collected and analyzed.

The scope of the work included collecting information on major analytical techniques used in the country, availability of laboratory support services (major equipment suppliers, local service capacity) related to the analytical techniques used in the country, costs of major chemicals and reagents as well as specialty gases commonly used in the food laboratories (chemical and microbiological), cost estimates for major standard analyses, as well as identification of bottlenecks in sample preparation. It also included collecting information the system of recruitment of new laboratory personnel, laboratory organization, the practice in collecting fees in return for performing analyses, and whether fees could be retained by the laboratory or whether they have to be channeled back to the central finance of the government.

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[3] Among the wide range of analyses for health sector, the Pasteur Institute maintains also one food and water laboratory; the questionnaire was only given to that laboratory unit.

[4] Annex: summary report on Laboratory Organization and Costing, based on consultancy by Mr Dim Theng, January 2010

Key findings

The key findings cover the national laboratory capacity to analyze contamination in food products intended for exports, including contamination by mycotoxins, pesticides and other residues, heavy metals, microbial contamination and others.

Principal export markets

The main exported agricultural products are: rice, rubber, fish, timber, cassava, cashew nuts, soybeans and livestock. According to various sources in the country it is very difficult to have reliable data about exports because great quantities of products are traded informally across the border and tools in support of data collection are weak[5].

The DTIS study 2007[6] identified an initial basket of 19 export potentials which have been further examined, among them beer, cashew nuts, cassava, corn, soybeans, fruits and vegetables and rice, including organic rice. Exports are mainly directed to three continents: Asia, America and Europe.

It should be noted, however, that a large share of food exports passes across the border to Thailand and Vietnam, or by sea through exchange of goods between Cambodian and Thai boats, without certification. This is particularly evident for fisheries products as well as for other food products such as cashew nuts or rice. These products may then be further exported from those countries and are neither known as ‘Cambodian origin’ products nor shown in Cambodian statistics.

Exporting countries and/or exporters have to be aware of the various food quality and safety requirements of the importing countries. Although international standards exist or are being elaborated, such as Codex[7] standards, those do not cover all foods and/or contaminants. In addition to international standards, many countries or regions have their own standards and/or requirements that need to be followed.

While food safety issues have become more and more pressing to politicians, many countries have revised their food safety systems, shifting responsibilities to producers and decreasing the maximum allowable residue limits (MRLs) for contaminants along with the introduction of new tools such as risk analysis. Particularly the EU is known for strict implementation of these MRLs. Examples with comparison of Maximum Residue Limits in some countries are shown in annex ( )[3].

Maximum Residue Limits (MRLs) are legal limits determined by, and enacted in different countries; thus it is always best practice to check or verify those MRLs through respective sources, for instance through gazettes published, or up-to-date databases maintained by the Competent Authority (CA) in the that country; some references are shown in annex ( )[4].

[5] FAO internal assessment, L.Valenti, November 2009

[6] Cambodia’s 2007 Trade Integration Strategy, Phnom Penh, December 2007

[7] Codex Alimentarius: www.**codex**alimentarius.net

National laboratory capacity

The findings presented below refer only to the nine laboratories (both governmental and non-governmental) related to food analyses visited during the short mission end of September 2009; all laboratories were located in Phnom Penh. Initial findings were already presented in the Progress Note of October 2009 to the National Task Force, some are further elaborated below:

Laboratory facilities

1. The facilities available to the laboratories are not uniformly good, or always appropriate for running laboratory activities. To illustrate with some examples:

   - one active laboratory operates in cramped conditions following a move of building (space is a constraint to the extent that certain equipment has not been re-commissioned since the move, and an area of testing has been allowed to lapse).

   - a second laboratory operates in older buildings which are not purpose-built and where the layout precludes efficient operation of a laboratory service.

   - a third laboratory is purpose-built but some aspects of laboratory design are not really appropriate and will need modification

2. Each of the five public sector laboratories seen would have to make some improvements to layout or use of infrastructure/facilities in order to be upgraded. International accreditation according to ISO 17025 requires that laboratories ensure that their environmental conditions do not invalidate the results or adversely affect the required quality of any measurement.

3. Out of the five laboratories, the ILCC lab has a large building space of about 1100 sqm (three times more than CamControl); the laboratory building was constructed in 2006 and is equipped with air conditioning. Apart from some unused space within the building, there is a reasonably large amount of land available around the laboratory for expansion. Modifications and improvements would however be necessary to achieve a suitable air exchange rate for the laboratory working environment, including the installation of additional fume cupboards and other extraction facilities.

4. Laboratory safety devices are lacking in many places and should therefore be uniformly introduced to, or increased in all laboratories.

5. HVAC systems appear to be neglected; proper air exchange according to the type of laboratory is not guaranteed and not integrated into their design.

6. Another week point is that not all laboratories have a waste management plan and related facilities; with upgrading the laboratories, this should be an integral part of each laboratory design and management procedure.

Equipment and supplies

7. Equipment – of varying levels of sophistication – has been provided by development partners over a number of years. Some is in use; some is no longer in use; some has not yet been used. This range is seen most notably in both Camcontrol and NAL, but applies to a lesser extent also elsewhere.

8. High tech equipment such as GC-MS or HPLC-MS or any MS/MS has not been found in any of the food laboratories; the EU and many other countries, however, assume the use of such specific equipment in their accredited laboratories to determine the very low levels of some contaminants such as pesticides or veterinary drugs, and for confirmation of positive results obtained in many cases through screening tests.

9. All laboratory managers interviewed commented on the difficulty of obtaining supplies (reagents, gases, glassware, etc) as one of the constraints they are currently facing.

Types of testing

10. Several of the laboratories are equipped in similar fashion to undertake a similar range of tests. This is being justified by the different mandates claimed by the different laboratories. For instance.

    - CamControl and ILCC both undertake determination of heavy metal (mercury, cadmium, etc) contamination using a technique known as Atomic Absorption Spectrometry (A.A.S.)

    - CamControl, ILCC and Ministry of Health (as well as the Institute Pasteur) have facilities for microbiological analysis of food and water samples

Volumes of activity

11. The visits and the evaluation of the questionnaire showed that the total number of samples analyzed over one year was below or even well below 2000 samples in all laboratories.

12. In visiting the laboratories, it is clear that much of the laboratory activity is driven on a project or issue basis (eg 3-MCPD in soy sauce). When a particular problem results in a sampling programme for a particular product being set up, samples are collected, supplies procured, and tests carried out. In the absence of such stimuli, activity levels are not high, depending on occasional private sector requests, requests for testing from NGOs, etc.

13. Furthermore, considering the requirements and procedures for procurement of chemicals as described by most institutions, the laboratories are not able to respond quickly to emerging issues as they usually have to plan their demands well ahead of time and apply for, or find the required financial resources.

14. No evidence was seen of sampling being designed on risk-based considerations. The issue of risk analysis and risk based sampling and monitoring programmes has actually been raised also by separate FAO exercise during a training workshop in October 2009.

15. As a general rule, without specifying a benchmark level of activity (which varies depending on the nature of tests undertaken), if laboratories do not operate to a regular programme of work, the quality (accuracy) of testing results will suffer. It seems likely that most of the public sector laboratories visited would be prone to this.

16. As could be seen also, there is no practice to regularly participate in inter laboratory testing rounds, or national and international proficiency testing schemes. The regular and successful participation in such schemes, however, is another requirement for obtaining accreditation according to ISO 17025.

17. Allied to this, current staffing levels are adequate only for the current relatively low levels of activity and sophistication. If a regular monitoring programme for food safety in Cambodia (imports, exports and domestic production) is to be put in place, more and better trained staff with appropriate formal basic qualifications will be needed.

Laboratory supplies, administrative "red tape" and budget issues

The process for purchasing and receiving laboratory supplies and consumables such as chemicals, reagents or media for chemical or microbiological testing is cumbersome; the laboratory typically prepares the proposal request for one year funding (which already limits the flexibility of the laboratory to respond to immediate needs). In addition, the budgets for purchasing laboratory items are usually quite limited and laboratories have no right to receive or keep that budget for directly purchasing the items needed.

All items are to be purchased through the government procurement (bidding) committees which are composed from different organizations such as ministry of economics and finance, and the agencies involved.

The procurement process is long and complex, starting from identifying the needs and preparing the specifications through various approval steps up to the level of the Minister, invitation for bidding, pre-qualification evaluations, identification and selection of suppliers, award of the order followed by the requirements for the supplier to provide certain bank statements and guarantees as well as other documentation.

There is little flexibility left to respond to any modified or additional needs, unexpected events or emergencies. This has also been observed in many cases, when for instance an instrument broke down or a lab run out of certain supplies which effectively halts laboratory operation.

Cost of analyses

As experienced elsewhere, there has been little awareness among the institutions and the politicians about the real cost of analysis in Cambodia. In other countries, the use of models for business management and cost control in public institutions has begun to lead to a need for laboratories to know the real cost of the different services they offer.

The cost of analysis is ultimately determined by a wide range of factors, and not only the equipment, the chemical or the reagent that is required to perform an analysis. For a comprehensive cost analysis many elements have to be considered, such as for instance:

- A suitable laboratory building and its facilities
- The proper maintenance of such facilities
- The range of more or less sophisticated instruments and equipment
- The service and maintenance of such equipment
- The depreciation and replacement of such equipment
- The properly qualified and skilled staff for the various tasks in the laboratory
- Access to related information and validated methods of analysis
- The chemicals, reagents and solvents needed to perform the analyses
- Certified internal and reference standards where necessary
- The general and suitable working environment including HVAC
- The calibration and recalibration of instruments and equipment
- The IT infrastructure that is usually necessary for highly sophisticated equipment
- The participation in inter laboratory ring analyses and proficiency testing schemes
- The time and efforts preparing for accreditation and the cost of accreditation itself
- The general inputs for administration and management of the laboratory
- General costs for utilities (gas, water, electricity etc.)

All of the above elements imply a certain cost that reflects on the total and real cost for establishing and running a laboratory.

Viewing the knowledge about the direct and indirect costs of laboratory operations as one of the basic prerequisites for investment and sustainability, the project chose some key examples to analyze the costs involved in chemical and microbiological analyses. For this reason, a catalogue of chemical and microbiological products was prepared by the national consultant referring to internationally-recognized analytical methods and using local prices for inputs and services required.

At the same time, a second and different approach was chosen by the international consultant to develop a generic cost model considering as much as possible the basic costs for establishing and operating a modern food laboratory that would be able to deal with a wider range of food safety parameters such as contamination with heavy metals, mycotoxins, pesticides or veterinary drugs, additives or other toxic products that may have been added or migrated into the food. This model including some minimum capacity assumptions is presented further down together with the conclusions and recommendations.

The tables below are a summary tabulation of some results of an initial exercise carried out by the national consultant in the country; the costs shown for each group are based on selected methods and include chemicals, materials and equipment involved. The exercise assumed a fixed number of samples and different investment costs for the various work areas (e.g. microbiology, screening by ELISA, or for instance trace analysis) as indicated below each table. Further details are available through the respective study[8].

Table 1: Price for some Microbiological Parameters

No	Description of Test and material used	Estimated Cost , USD
1	**ISO-4833: Total Plate Count at 30 deg.C**	
1.1	Media	5.81
1.2	Consumable including water, electricity and other disposable materials	1.5
1.3	Equipment utilized [9]	6.10
1.4	Labor Cost per sample	5.0
	TOTAL	**18.41**
2	**ISO-9308-1: E. Coli and Coliform Bacteria in Water by Membrane Filtration**	
2.1	Media	20.18
2.2	Consumable	1.5
2.3	Equipment utilized	6.10
2.4	Labor Cost per sample	5.0
	TOTAL	**32.78**
4	**ISO-21527-1: Yeast and Molds**	
4.1	Media	8.55
4.2	Consumable	1.5
4.3	Equipment utilized	6.10
4.4	Labor Cost	5.0
	TOTAL	**21.15**
5	**ISO-7932:Bacillus cereus- Colony-count technique at 30 deg.C**	
5.1	Media	15.06
5.2	Consumable	1.5
5.3	Equipment utilized	6.10
5.4	Labor Cost	5.0
	TOTAL	**27.66**

[8] Study prepared by national consultant, Mr Dim Theng, January 2010

[9] For the estimation of equipment use, the following assumptions were made:

total investment: 112.000 USD

utilization: 10 years

yearly maintenance cost: 1.000 USD

total number of test per year: 2.000

7	**ISO-6579: Detection of Salmonella**	
7.1	Media and reference culture	31.17
7.2	Consumable	1.5
7.3	Equipment utilized	6.10
7.4	Labor Cost	5
	TOTAL	**43.77**

Table 2: Price for some Chemical Water Testing:

No	Description of Test and material used	Estimated Cost , USD
1	**AOAC-973.57: Sulphate analysis in water, Turbidimetric method by spectrophotometer at 420nm.**	
1.1	Reagent and standard	3.82
1.2	Consumable	0.5
1.3	Equipment	2.0
1.4	Labor Cost	3.0
	TOTAL	**9.32**
2	APHA-3114B: Arsenic in Water by hydride generation/AAS	
2.1	Reagent and standard	20.15
2.2	Consumable	1.5
2.3	Equipment [10]	12.82
2.4	Labor Cost	3.00
	TOTAL	**35.97**
3	APHA-4500-NO3-E: Nitrate Determination by Cadmium Reduction/Spectrometric method	
3.1	Reagent and standard	6.31
3.2	Consumable	1.5
3.3	Equipment	2.0
3.4	Labor Cost	3.0
	TOTAL	**12.82**
4	APHA-3500-Fe-B: Total Iron by Phenanthroline/ Spectrophotometer method	
4.1	Reagent and standard	11.16
4.2	Consumable	1.5
4.3	Equipment	2.0
4.4	Labor Cost	3.0
	TOTAL	**17.66**

[10] For the estimation of equipment use, the following assumptions were made:

total investment: 85.000 USD

utilization: 15 years

yearly maintenance cost: 2.000 USD

total number of test per year: 600

Table 3: Price for some Chemical Food Safety Testing:

1	AOAC- 2007.01: Determination of Multi-Residue Pesticide in Food by Acetonitrile Extraction and Partitioning with magnesium sulfate by GC/MS [QuEChERS Method]	
1.1	Reagent and standard	37.60
1.2	Consumable	4.0
1.3	Equipment [11]	22.00
1.4	Labor Cost	5
	TOTAL	**68.61** ***[12]
2	LC/MS/MS Analysis of Chloramphenicol in Shrimp	
2.1	Reagent and standard	52.35
2.2	Consumable	4.0
2.3	Equipment	26.0
2.4	Labor Cost	5.0
	TOTAL	87.35
3	AOAC 999.11:Determination of Heavy Metals in grains by Atomic Absorption Spectrophotometry after dry Ashing	
3.1	Reagent and standard	28.00
3.2	Consumable	5.0
3.3	Equipment	46.25
3.4	Labor Cost	7.50
	TOTAL, USD	86.75
8	AOAC 990.32: Determination of Aflatoxin in Grain by ELISA	
8.1	Reagent and standard	11.81
8.2	Consumable	2.0
8.3	Equipment	3.0
8.4	Labor Cost	3.75
	TOTAL, USD	20.56
9	AOAC 990.32: Determination of Aflatoxin in Grain by HPLC	
9.1	Reagent and standard	21.45
9.2	Consumable	3.0
9.3	Equipment	12.00
9.4	Labor Cost	3.75
	TOTAL, USD	40.20

[11] For the estimation of equipment use, the following assumptions were made:
total investment: 340.000 USD
utilization: 10 years
yearly maintenance cost: 10.000 USD

[12] This example will be subjected to a detailed analysis and verification; actual costs for this specific type of analysis are reported much lower in international literature.

Although this exercise still needs to be refined further within a process of continuous monitoring and evaluation, it becomes clear that a significant heterogeneity exists in the costs of the different tests, especially also when positive results are obtained (e.g. for mycotoxins or pesticide and veterinary drug residues) that need to be reconfirmed.[13]

Cambodian salaries for analytical chemists and other laboratory specialists are low but are hard to calculate. They need to be well calculated with direct and indirect costs, and incorporated into the overall estimation of the budgets required; particularly when highly sophisticated instrumentation is involved, the availability and sustainability of specially qualified staff to ensure optimum running of equipment can become a bottleneck and a high risk to the system.

Volumes and types of test performed

The volumes and types of tests performed are important from different points of view:

1. Each type of test may require a different way in sample preparation and different procedures for testing or measurement. Proficiency in analytical work is normally only achieved if the work is regularly done according to Standard Operating Procedures and integrating the relevant quality assurance measures.

2. As the basic (general) equipment and facilities overhead operating costs should be passed on to the actual material cost per analysis, operations become more economic the more analyses can be done (per day or per month) with the equipment and staff available.

3. Monitoring and surveillance activities would require a certain number of samples to be included in a survey in order to achieve a certain confidence level for the survey to be representative. This, however, can be difficult to determine as the number of samples depends very much on the homogeneity of the pool of samples.

The general food safety monitoring in terms of a ‘National Residue Plan’ would have to be worked out based on more concrete data of the agricultural environment, which are not available at this time; it should also be clearly stated that this can be quite a complex task that needs to involve additional specialists and requires a set of basic data on the agricultural production and trading environment.

In the EU for instance, the National Residue Control Plan (NRCP) is determined by a Commission Decision laying down detailed rules on official sampling. For the year 2006, for instance, the EU analyzed about 65.000 samples (corresponding to approximately one sample per 7.700 inhabitants) for pesticide residues in fruits, vegetables and cereals. By comparison, the US analysed 13,000 samples in 2008 (or one per 20,000 inhabitants). In both of these jurisdictions, food control systems have been in place for a number of years

[13] It is also important not to create any disincentives for finding positive results – if finding higher than permitted contamination results in further work and cost, laboratory workers must not be penalized by this finding

and the variability of samples is expected to be low. This is unlikely to be the case in Cambodia

Applying this sort of ratio (of samples per inhabitant) to Cambodia, the country would have to plan for about 1000 samples per year for pesticide residues; in addition to that, risk based monitoring plans would have to be defined for food products of animal origin. Thus one may assume an initial figure of around 2000 samples for a food safety monitoring programme for Cambodia.

It should be noted that there is a fundamental difference between general food safety monitoring - which requires statistically sufficiently high number of samples and aims at identifying food safety problems and/or problems with adherence to Good Agricultural Practice (GAP) - and the certification of a certain consignments for export, where one single sample may be sufficient provided this one sample is representative for the whole consignment.

While surveillance and monitoring should be considered as a public responsibility, certification of export consignments is basically a commercial activity that may be done by both, public and/or private sector, provided the relevant laboratories are accredited for that purpose.

Qualification, experience and skills of staff

Food safety monitoring, and the use of the required highly sophisticated analytical instrumentation for the laboratories, needs permanent, motivated, highly-qualified and specialized analytical chemists, food chemists and microbiologists. The education and training of such people is costly, and salaries would tend to reflect this. As the survey has shown, however, remuneration for staff employed in governmental laboratories is quite low and there are few incentives for performance.

Well-qualified specialists may easily be attracted to better paid jobs in the food industry or other parts of the private sector. In some organizations in Cambodia, the internal staff rotation policy has a direct and negative effects on the performance of the work. Two examples will explain this further:

- Camcontrol, for instance, regularly rotates laboratory staff and sends them to border inspection posts where they would do other work; this in a way is a promotion and incentive to the persons themselves as they will receive an additional allowances; the laboratory, however, will suffer from this practice as it will receive in return staff that does not necessarily have the qualification or experience required. Unfortunately the implications of such policies for the sustainability of the work and the system are not always well understood.

- Pasteur Institute, for instance, has a different staff rotation policy: they promote their staff by assigning them different work within the same laboratory to acquire additional technical expertise. In this way, they keep the staff in the team and broaden their experience, which makes them then also interchangeable, in case one turns sick or would leave the institution. This kind of policy clearly has a positive effect on the performance of the institution.

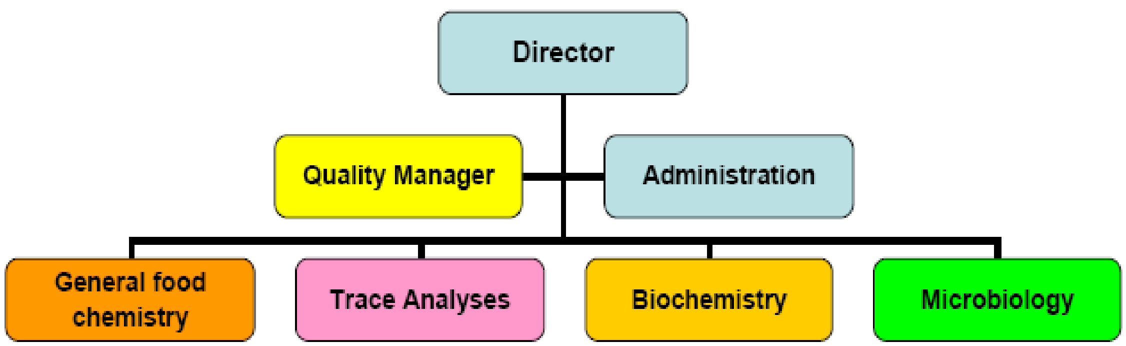
Model for a modern Central Food Safety Laboratory for Cambodia

Cambodia presently has limited capacity to perform highly sophisticated analytical tests such as for pesticide residues or veterinary drug residues in food products. At the same time it has been stated by various donor assessments that the country needs to upgrade it's laboratory network in order to cope with SPS requirements, both for domestic and export purposes.

The purpose of this model is to illustrate the order of magnitude of potential costs and the relationship between cost categories. Even if the initial values used as assumptions need to be adjusted. the model still stands.

It is also known that these types of analyses require a special working environment with special laboratory facilities and highly qualified and skilled staff; while it is also know that such analyses can be very costly, the true cost is often underestimated. For the purpose of cost estimation, a simple cost calculation model is presented below.

Model organigram used for a basic food safety laboratory



The laboratory is assumed to have 24 staff members as follows: 1 director, 3 food chemists, 2 biochemists, 2 microbiologists, 2 specialists for trace analyses, 7 laboratory technicians, 1 laboratory engineer, 1 IT specialist, 2 logistics/driver, 1 accountant, 1 administrative assistant and 1 cleaning staff.

Each position will have a clearly defined job description and the related basic qualifications, experience and skills required to perform these duties satisfactorily. In filling these positions, it is assumed that only fully qualified staff will be recruited.

The salaries should be attractive enough to recruit and retain the necessary specialists for the laboratory; for the present model, a salary range up to 500 USD per month has been applied for professionals with a ‘end of year gratification’ for all staff. The total cost of personnel is estimated at around 90.000 USD per year.

Such a laboratory should be able to carry out general food chemistry analyses such as basic composition of the products, including for instance sugars, alcohols or additives. The trace analysis department will be able to monitor heavy metals, mycotoxins, pesticides or veterinary drug residues, but also residues of other contaminants as may appear incidentally or after manipulation of the food. The microbiology department would be able to perform basic hygiene tests as well as also antibiotics residue monitoring based on microbial growth inhibition tests, and together with the biochemistry use also advanced techniques such as PCR. Furthermore, the biochemistry department would take care of general screening tests based on ELISA.

All departments would be fitted with the basic analytical equipment that is required to perform the type of tests using modern analytical techniques that are specific and accurate with the sensitivity required to cope with the strict Maximum Residue Levels (MRLs) presently in place in most developed countries.

The equipment, particularly for trace analyses, would include (apart from the basic laboratory equipment required) the following more sophisticated items:

- GC-ECD
- GC-FPD or NPD
- GC-MS system, with automatic sampler, PC hard- and software
- GC-MS-MS (instead of GC-MS)
- Online GC gas generators (nitrogen, hydrogen, zero air)

- HPLC-UV / DAD / FD
- HPLC-FD including post-column derivatisation unit for vet drug, carbamates and others
- HPLC-MS/MS system (strongly recommended for Vet Drug analysis)

- AAS
- GF-AAS
- ICP-MS (optional or for a later phase)

The total amount of the above equipment including accessories will be of the order of 1,900,000 USD; in addition to that we need the basic equipment and instruments for the other laboratories as can be seen further down (500,000 USD).

The cost of maintenance for the equipment has been assumed as a percentage to the total investment costs for the laboratory equipment; a relatively low figure of 5% is used assuming that labor costs in the ASEAN countries are lower than in European countries. Nevertheless, an amount of nearly 89.000 USD per year has to be considered.

Basic services and utilities include electricity, water, gas, telecommunication & internet as well as the use of one or two vehicles. The main determining factors here are the cost of electricity and the use of cars. A rough estimated of these costs leads to almost 52.000 USD per year.

Furthermore, administrative costs have to be assumed also for certain items such as licenses, insurances, advertising, etc. or for instance maintaining laboratory accreditation. For this purpose about 43.000 USD are allocated.

Finally also laboratory staff needs to update their knowledge or get additional training, or are required to participate in some symposium or other type of regional meeting. For this purpose a total of 39.000 USD is calculated.

Summarizing the operational costs with the above assumptions, the following table reflects the present model:

Model Food & Feed Laboratory
(Phnom Penh, Cambodia)

Estimate of operational costs (per year)

POS	ITEM	UNIT	P.A.
1	Cost of personnel	USD	$89.225
2	Cost of depreciation of equipment (*)	USD	$246.250
3	Cost of maintenance (**)	USD	$88.650
4	Basic services/utilities	USD	$51.955
5	Cost of analyses	USD	$82 500
6	Other costs	USD	$43.000
7	Training courses	USD	$39.000
	Total estimated costs:	**USD**	**$640,580**

(*) assuming straight line depreciation over 8 years
(**) as 5% of investment costs

Note: Item number 5 in the above table refers to direct costs of analyses (such as solvents, reagents and chemicals or other materials used for the specific analysis); it does not include general operating and maintenance costs. The following assumptions have been made:

1500 bacteriological analyses	@ 10 USD	= 15.000 USD
500 composition analyses	@ 15 USD	= 7.500 USD
2000 trace analyses	@ 30 USD	= 60.000 USD

These direct material costs could be further refined through a more detailed evaluation of the work and the actual costs; in many cases the real cost may be lower than indicated above.

As can be derived from the above table, the actual direct cost of the analyses is minor compared to the total indirect operational costs for such a laboratory; even when the number of samples is doubled from 4000 to 8000 samples per year, the total operational costs would only increase by around 12,9 %, provided instrument und staff capacity allows.

Thus, there are three important factors to consider:

1. the instrument capacity (how many samples can be handled for a certain test by any one instrument?)
2. the staff capacity (how many samples can be handled by one person, and how does this number match the capacity of the instruments available?)
3. the actual direct costs of the test (what are the cost of the solvents, reagents and chemicals, etc under most economic conditions in the country?)

Known bottlenecks in trace analyses are for instance sample preparation and/or the minimum chromatography time required for each run.

Assuming a total of 4000 or even 8000 samples per year for trace / residue analysis leads at average to 20 respectively 40 samples per day considering 200 working days per year (allowing for equipment down time, holidays, etc). With the given number of staff and good laboratory organization and management, these numbers of samples could be handled with the existing or proposed high-tech equipment. In addition to these numbers of instrumental analyses, screening tests could be performed for instance using ELISA or for instance growth inhibition tests for antibiotics, keeping in mind, however, that positive samples would have to be confirmed by instrumental analysis.

Cost recovery mechanisms

As can be deduced from the above, roughly 640.000 USD are needed to operate and maintain this model of a central food safety laboratory (building and furniture not included). Considering that food safety is generally considered a public good, it would typically be a government requirement to provide a proper legal framework and regular budget for these activities.

Conclusions and Recommendations

The results of the visits, of the surveys and of the various discussions held show that Cambodia's food safety laboratory network is not performing well and cannot cope with the demands of modern food safety systems support and SPS requirements without major change. While several laboratories exist more or less in parallel, they partly duplicate work and compete with each other, but none of them is in a position to offer the range of required services at the expected level of quality and quantity, and none of them has actually reached international accreditation.

Mandates are not always clear and also seem to overlap, and above all, there appears to be little recognition of the difference between public and commercial interest. Any country, while being concerned about their food exports being fit for human health (to ensure market access), should extend the same concern to the imported and locally produced food.

Looking at regular budgets allocated to food laboratories in Cambodia, it becomes clear that these laboratories will have difficulties to fulfill their tasks within a food safety system. Consequently, consumer protection suffers.

The same, however, applies also to export control and certification: although some institutions may perform analyses against a fee, the volume of such samples is too low, and the laboratories are not usually able to retain these fees to organize and manage their operations. Without having a regular budget to maintain a minimum level of activities, it is virtually impossible to have a functioning and sustainable system of food control.

Such a minimum level of activities is not only described by the number of samples handled per year, but also determined through a number of other requirements and factors, such as for instance a certain redundancy in staff and equipment to ensure that highly-sophisticated equipment runs optimally; laboratory accreditation demands for validation of analytical methods used, continuous training of staff according to their duties performed, participation in proficiency testing schemes, and many more. All in all, there is a great challenge also to each laboratory by the required documentation and quality management.

The development of the laboratory infrastructure and environment in Cambodia is still behind and not yet favorable to highly sophisticated analytical laboratory operation. The various technical cooperation efforts and donations of the past years have not fruited and not shown the desired results. And this will not change, if not both the Government of Cambodia and the donors will change their understanding, path and strategy.

Several scenarios can be visualized at this point:

Scenario 1: with no change in Government efforts, priorities and policies there will be little change from the present situation; money put from both sides (Government and Donors) will not be used effectively, equipment supplied will not bring the expected results, and money put into running costs will have little effect.

Scenario 2: Cambodia maintains and continues with the two main labs as follows:

ILCC: increasingly taking care of food industry related issues including export-related
analyses and confirmations with distinct support from the food industry

CAMCONTROL: taking care of imports and local markets (in coordination and cooperation with ministry of health and the customs department) and running a food sampling and public food control system

The National Agriculture Laboratory would need to test agricultural inputs such as fertilizers and pesticides.

The National Veterinary Research Institute will focus on animal health issues.

The situation and mandate of the Feed Laboratory of the Ministry of Agriculture would still have to be discussed.

The National Laboratory for Drug Quality Control would continue with its present activities related to drug quality control.

[It should be noted that this scenario requires the two main laboratories to be significantly upgraded, and that the number of samples to be tested may not justify such investment]

Scenario 3: Cambodia decides to establish a single laboratory along the lines of the model set out above, specifically for sophisticated analyses (those requiring costly equipment), while retaining current laboratories for simpler (lower capital cost) tests. This would be achieved by upgrading one of the two main existing laboratories

This laboratory will need to have a modern working environment and be equipped with all sophisticated instruments as required. The laboratory will then not only be able to respond to food safety issues, but could for instance at the same time handle criminological investigations that require sophisticated analytical procedures.

This laboratory will have a special status and independent management directly responsible to a higher authority (e.g. an interministerial food safety committee, or for instance the cabinet of ministers).

The laboratory would need to have a clear commitment from Government with a regular budget at a level considerably higher than present levels and at an amount that guarantees proper and sustainable operation and further development.

At the same time, the donor community will consolidate their efforts and support the laboratory not only by delivering the necessary equipment but also provide management of the laboratory at different levels, from laboratory organization and management down to the technician level over at least a three to five year period.

In all three scenarios the agricultural inputs will have to be handled separately as described under scenario (2) for NAL and NAVRI. The situation regarding the feed laboratory remains to be clarified, while the human health drug control lab may continue their present activities.

Scenario (3) actually does not necessarily mean to eliminate the other laboratories, but rather to leave them with lower level activities, partly also with probably slightly different mandates and the need to collaborate with the central laboratory for the trace analyses. Furthermore, as future growth would bring in more demands in analytical capacities, those laboratories may be upgraded as well as long as the economic situation would justify that. The central laboratory would then more and more take over the role of a reference laboratory, which would have to help upgrade other laboratories, build new capacities and transfer technical know-how acquired.

The establishment of a single upgraded laboratory would have a number of advantages:

- a clear mandate with reduction of overlaps
- less rivalry and competition stress due to overlaps
- concentration of high tech equipment in a single place
- only one high-tech laboratory with complicated environment
- higher number of samples and throughput giving better use of equipment
- increase of number of equipment where justified (positive redundancy)
- reduction of service and maintenance costs for this equipment
- concentration of high level specialists with required skills
- the possibility of internal exchange, bridging of gaps
- higher flexibility due to own operational standards
- quick response to newly emerging issues
- less administrative red tape

The upgraded laboratory should have a modern analytical laboratory environment but should also have its own technical unit that will be trained to perform the basic maintenance and calibration of most equipment in house, which in turn will again save high expenditures for frequent technical service coming in from abroad.

Economic considerations

While scenario (1) would not be a solution at all, scenario (2) leads to duplication of the high-tech structure, increasing drastically the investments costs (app 1 million USD per lab - without investment in building and furniture) and basic operation costs (app 500.000 USD per lab assuming above described activities); furthermore, it also increases the risk of not being able to achieve the objective under local conditions.

All in all, the scenario (3) is presently seen as the most meaningful and sensible solution under the conditions observed, provided that it find the full support by the Cambodian Government and the development partners.

Potential risks, assumptions and key requisites

Cambodia is a relatively small country with very limited financial resources and it cannot afford to have parallel capacities. The establishment of modern analytical laboratories is very costly and can be a complex and demanding undertaking. Investment costs both in building facilities and analytical equipment are high, and experience in other countries has shown that the risk of failure is likewise high if not certain minimum requirements and pre-requisites are fulfilled.

Orientation solely towards commercials activities requires a steady minimum demand in terms of export analyses and does not necessarily provide a correct picture of the food safety situation in the country itself. With food safety being a public good, the costs for food safety related activities should be born by the public sector at a level that guarantees flexibility and sustainability of the system.

Key requisites for the system to function are not only that the institutional framework is in place but also that the legislative framework is conclusive and supportive to the mandated activities. In this regard there are still many efforts needed by the Cambodian government. One of the important issues apart from having clear mandates and corresponding budget lines is the fact that these institutions need to have much better flexibility to manage their operations and activities within the given mandate.

It is assumed that with a regular and sufficiently high budget the laboratory will be able to plan and implement a surveillance and monitoring programme adapted to the needs of the country.

It is also assumed that the international donor community will support the establishment of a Central Government Laboratory by providing long term assistance for organization, operation and management of the laboratory for several years, so that the necessary skills can be transferred to the local counterparts.

For that to be successful, the laboratory requires staff with the necessary higher basic qualification and skills, and of course a more attractive salary scale to avoid that staff migrates to better paid jobs after receiving additional training.

There is undoubtedly a significant risk that the investment into a modern Central Government Laboratory fails, if some of the above conditions are not met – but it is even higher, if the investment is made in several laboratories at the same time.

Annex (1)

GLOSSARY ON SPECIAL ANALYTICAL TECHNIQUES

AAS	**Atomic Absorption Spectroscopy**: used for qualitative and quantitative determination of (heavy) metals; the technique can be used to analyze the concentration of over 70 different metals in a solution. Although developed in the mid 1950s, it is still widely used but also often be replaced by the more recent ICP-MS (see below)
ELISA	**Enzyme-linked immunosorbent assay:** a biochemical technique used mainly in immunology to detect the presence of an antibody or an antigen in a sample. The ELISA has been used as a diagnostic tool both in medicine and plant pathology, as well as a quality control check in various industries. ELISA test kits can be extremely sensitive (e.g. detect very low levels of pesticide or veterinary drug residues) and handle dozens of samples at the same time (sample screening); in some cases, however, ‘false positive’ results are a problem and must be reconfirmed by using another analytical technique.
GC or GLC	**Gas-liquid chromatography (GLC)**, or simply **gas chromatography (GC)**, is a common type of chromatography used in analytical chemistry for separating and analyzing compounds that can be vaporized without decomposition. Typical uses of GC include testing the purity of a particular substance (e.g. pesticide quality control), or separating the different components of a mixture (e.g. when analyzing food for pesticide residues).
GC-MS	**Gas chromatography-mass spectrometry** (**GC-MS**) is a method that combines the features of gas chromatography and mass spectrometry to identify different substances within a test sample. Substances are first separated and then determined based on their molecular structure. Applications of GC-MS include drug detection, environmental analysis, or for instance investigation, and identification of unknown samples; it can positively identify trace elements in materials that were previously thought to have disintegrated beyond identification.
HPLC	**High performance liquid chromatography** (or **high pressure liquid chromatography**, **HPLC**) is a form of column chromatography used frequently in biochemistry and analytical chemistry to separate, identify, and quantify compounds based on their idiosyncratic <structural or behavioral> polarities and interactions with the column's stationary phase. Instead of GLC it is used for substances that cannot be vaporized or that decompose when vaporized. It has a wide range of application such as the detection of pesticides, veterinary drugs or for instance mycotoxins.
ICP-MS	**Inductively coupled plasma-mass spectrometry** is unique among the flame and plasma spectroscopy techniques for simultaneous multi-element detection and in the ability to discriminate even between the mass of the various isotopes of an element. In many cases it replaces the common AAS.

LC-MS	**Liquid chromatography-mass spectrometry** (L**C-MS**) is a method that combines the features of high performance liquid chromatography and mass spectrometry to identify different substances within a test sample. Substances are first separated (not in gas but in liquid phase on the HPLC column) and then determined based on their molecular structure. Applications of LC-MS include drug detection, environmental analysis, a wide range of biochemical analytes, or for instance investigation, and identification of unknown samples; it can positively identify trace elements in materials that were previously thought to have disintegrated beyond identification.
MS	**Mass spectrometry** (MS) is an analytical technique for the determination of the elemental composition of a sample or molecule. It is also used for elucidating the chemical structures of molecules. The technique has both qualitative and quantitative uses. These include identifying unknown compounds, determining the isotopic composition of elements in a molecule, and determining the structure of a compound by observing its fragmentation. Other uses include quantifying the amount of a compound in a sample MS is now in very common use in analytical laboratories that study physical, chemical, or biological properties of a great variety of compounds.
PCR	**Polymerase chain reaction** (**PCR**) is a technique to amplify a single or few copies of a piece of DNA across several orders of magnitude, generating thousands to millions of copies of a particular DNA sequence. The method relies on thermal cycling, consisting of cycles of repeated heating and cooling of the reaction for DNA melting and enzymatic replication of the DNA. PCR is now a common and often indispensable technique used in medical and biological research labs for a variety of applications, such as diagnosis of diseases, identification of genetic fingerprints (used in forensic sciences and paternity testing); in food chemistry it can be used for instance to prove species specificity or to detect genetically modified organisms.
QuECHERS	**QuECHERS** stands for **Q**uick **E**asy **C**heap **E**ffective **R**ugged and **S**afe: is a streamlined approach in sample preparation that makes it easier and less expensive for analytical chemists to examine pesticide residues in food. The introduction of this method became very popular in countries with labor costs as it significantly cuts down the sample preparation time and cost; it requires, however, the use of MS techniques to identify and confirm the traces of residues.
RT-PCR	**Real-time PCR** is a further developed form of PCR and so named because it detects and measures the amplification of target nucleic acids as they are produced. It uses a probe labeled with fluorescent dyes or alternative fluorescent detection chemistry, and a thermocycler equipped with the ability to measure fluorescence. Widely used in biochemistry and food chemistry, it is less critical than the conventional PCR, where there is a much higher risk of cross contamination.

Annex (2)

Laboratory Questionnaire

Laboratory (official name)			
Ministry		**Department**	

Role of the laboratory related to testing to food & agricultural products: **Indicate reference to source of this mandate in legislation (e.g. Prakas, Sub-Decree, etc):**
Address of the laboratory: **Contact person:** **Phone numbers:** **E-mail:**
Official working hours:
Please add an organigram (organizational chart) of your institution. **attached: [ ]**
Describe current activities in the laboratory:
Do you have any regular / routine sampling programme in place? **[ ] YES [ ] NO**
Is your sampling: [ ] statistical [ ] random [ ] occasional || risk based [ ] Y [ ] NO
Where do you get your samples from (indicate approximate percentage and whether the sample is analyzed free of charge or against a fee?

	TYPE OF SMP	GOV	NON-GOV	FREE	PAY	% cost coverage[14]
[ ]	**regulatory samples**					
[ ]	**voluntary samples**					
[ ]	**complaints**					
[ ]	**other**					

Who is delivering your samples ?

[ ] own sampling officers [ ] other sampling officers [ ] customer

Do you regularly perform any of the following food chemical tests:

- food composition [ ] YES [ ] NO
- food additives [ ] YES [ ] NO
- heavy metals [ ] YES [ ] NO
- pesticide residues [ ] YES [ ] NO
- veterinary drug residues [ ] YES [ ] NO
- mycotoxins [ ] YES [ ] NO
- other contaminants [ ] YES [ ] NO
- fertilizer quality [ ] YES [ ] NO
- pesticide quality [ ] YES [ ] NO
- veterinary drug quality [ ] YES [ ] NO
- others please specify: ____

What are your major matrices to analyze (indicate approximate percentage):

Matrix (sample types)	*app %*	*microbio*	*chemical*	*Other*

Main equipment (e.g. AAS, GC, HPLC; UV/VIS):

- HPLC with UV detector
- GC with ECD, FID and NPD detectors; GC with ECD detector

Capacity	**2006**	**2007**	**2008**	**2009 (anticipated)**
Number of samples for microbiology tests				
Number of samples for chemicals tests				
Number of samples for other tests				

[14] If you are able to estimate to which extent the fees you are charging do recover the costs of performing the analysis, please indicate a percentage according to your experience – otherwise indicate "NP"

Budget: Does your laboratory have a regular budget or other source of income?				
- Government US$				
- other sources US$				
- Fees / revenues from testing US$				
Were you able to keep those fees for direct use by the laboratory, or for refilling your budget?				

Staff remuneration (*indicate average salary for each of the categories*)

	initial	after 5yr		benefits
Microbiologist				
Analytical chemist				
Laboratory technician				
Laboratory auxiliary staff				
Head of a laboratory unit or department				
Director general of the whole laboratory				

What is the average job rotation period in your laboratory? (*you may describe in more detail***)**

Staff incentives: what incentives do you actually offer your staff ?

Do you cooperate with other laboratories on national or international level?
(*please give details*)

Do you participate in any proficiency testing schemes? [ ] national [ ] intern. [ ] none

Do you have international accreditation according to ISO 17025 ? [ ] YES [ ] NO

Does the laboratory publish an annual report ? [ ] YES [ ] NO [ ] copy attached

Prioritize main bottlenecks *(1= most important, 5= least important)***:**

Level of staff training
Laboratory building lacks space that could allow for further upgrading/ expansion of capacity
Staff motivation
Funding to cover operating costs
Minor equipment to optimise use of major equipment

Plans:

- Do you have an official strategic plan for your organization / laboratory?
- Do you have a sampling plan for the year 2010?
- Do you have a budget for the year 2010?
- Any other financial support for 2010?

Please list cooperation partners & programmes:

<u>Attachments</u>:

1. **Staff listing**
2. **Equipment listing**
3. **Laboratory facilities**
4. **Laboratory floor plan**
5. **Organigram (org. charts)**

Completed by:
Date:

The following questions relate to your laboratory building facilities; if you have a building layout plan (floor plan of your laboratory), please add a copy.

EXAMPLE ONLY

Total area of the building:	600	mU	
Year of construction:	2004	number of floors:	2

Who owns land & building: GOC / our institution

	[mU]		
Sub-area for microbiology:	180	number of rooms:	3
Sub-area for food chemistry:	200	number of rooms:	2
Sub-area for administration:	100	number of rooms:	7

Do you have an underground basement or cellar:	no	
Do you have any auxiliary buildings or rooms outside the lab:	yes	generator room
Do you have any air-conditioning in labs ?	yes	
In how many percent of the labs ?	20	
Do you have a central air-conditioning ?	no	split-type ACU
Do you have a continuous air exchange in the lab ?	no	only fume hood

Indicate whether you have any of the following safety devices:

Fume hoods	2 (AAS)
Fume cabinets	1 (sample prep.)
Laminar flow cabinets	2 (microbiology)
emergency shower	1
emergency eye wash	1

Does the laboratory have a waste management plan ?	no	
Does the laboratory have a waste treatment facility?	no	
Is the laboratory located near to housing areas?	yes	(20 m away)
Do you have a site location plan?	yes	attached
Do you have a floor plan ?	yes	2 attached
Do you have land around your laboratory for expansion?	yes	about 2500 mU

Any additional comments:

we have in fact a plan to upgrade our laboratory by adding another wing to the main building; the plans for the nw wing are already designed and approved by our relevant ministry.

We are presently waiting for the approval from the Ministry of Finance to provide the 1,9 million USD for the new attachment.

Name of Laboratory:

PHNOM PENH / Cambodia

EXAMPLE ONLY

STAFF LIST

(Please fill the names grouped according to work areas, e.g.: aministration, mcirobiology, chemistry)

BSc/MSc/F **Status:** 01 OCT 2009

No	NAME	FIRST NAME	TITLE	GEN	AGE	WORK AREA	POSITION	Professional education	grad.	with lab since	
1	CHAN	Theng	Dr.	M	56	administration	Director of Institution	economist	PhD/MSc	2005	
2	CHUN	Theva	Dr.	M	42	microbiology	Head of Unit	microbiologist	PhD/MSc	2007	
3	UNG	Visarto	Mr	M	38	pesticide residue	analytical chemist	food chemistry	BSc/MSc	2006	
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

Questionnaire filled by:
Date:

Name of Laboratory:

PHNOM PENH / Cambodia

EXAMPLE ONLY

MAJOR EQUIPMENT LIST

(Please fill the names grouped according to work areas, e.g.: aministration, mcirobiology, chemistry)

Status: 01 OCT 2009

No	WORK AREA	EQUIPMENT	BRAND	MODEL	AGE	Condition	S	SC		Remarks
1	pesticide residues	GLC	SHIMADZU	GC 17-A	2004	in use, regular service	OK	no		
2	pesticide residues	GLC	SHIMADZU	GC 14	1996	broken, not serviceable	NO	no		
3	pesticide residues	HPLC	SHIMADZU	LC-10	2005	no new colums, serviceable	CK	yes		
4	heavy metals	AAS								
5	heavy metals	ICP-MS								
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Remarks & explanations

S serviceability
SC service contract

Questionnaire filled by:
Date:

Choices: not installed yet
in use, serviceable
broken, needs repair
broken, not serviceable
on order
outdated
etc.

Annex (3)

Comparison of MRLs in different countries (figures in mg/kg)

	Thailand					Vietnam					CODEX					USA					EU				
Matrix > / Chemical	rice	cashew	fish	egg	pepper	rice	cashew	fish	egg	pepper	rice	cashew	fish	egg	pepper	rice	cashew	fish	egg	pepper	rice	cashew	fish	egg	pepper
Chlorpyrifos	0,1			0,01	0,5				0,01	--	0,5	n.a.		0,01*	n.a.				0,01	1	0,05	0,05*		0,01*	0,5
2,4 - D	0,1			0,01		0,1	0,2				0,1	0,2		0,01*	n.a.	0,5	0,20				0,05	0,05*		0,01*	0,05*
Carbaryl	1	1			0,5	1	1			--	1	n.a.		n.a.	0,50	15	o,1			5	1	0,05*		0,05*	0,05
Deltamethrin	--	0,02		0,02		2	--		0,02	0,2	2	(a)		0,02*	n.a.	1	o,1		0,02	0,3	2	0,05*		0,05*	0,2
Dithiocarbamates	0,05			0,05							n.a.	n.a.		0,05*	n.a.						0,05*	0,05*		0,05*	5(ft)
Fenitrothion	1			0,05							6	n.a.		0,05*	n.a.						0,5(ft	0,01*			0,01*
DDT	0,1	0,01	1(*)	0,1							0,1	n.a.		0,1	n.a.						0,05*	0,05*		0,05*	0,05*

(*) > in fat content

(a) 0,02 mg/kg in hazelnuts and walnuts

Note: The US database lists only chemicals for which an EPA MRL exists

2,4-D (sum of 2,4-D and its esters expressed as 2,4-D)

(*) indicates lower limit of analytical detection

Remarks: *Maximum Residue Levels (MRLs) are normally set for hundreds of chemicals and hundreds of commodities; it is therefore not practical to show all these MRLs in one single table. The above table is thus meant just as an example to demonstrate the principle and the complexity of locating the correct MRL for a certain chemical in a certain commodity and for the certain country or region. Also MRLs may change over time and it is therefore best to consult the respective competent authority of the country to obtain up-to-date and correct figures.*

§

MRLs for fish are not set in the new regulation although it is the Commission's intention to introduce some at a later stage.

Annex (4)

References to national MRLs

Maximum Residue Limits (MRLs) are legal limits determined by, and enacted in different countries; thus it is always best practice to check or verify those MRLs through respective sources, for instance through gazettes published, or up-to-date databases maintained by the Competent Authority (CA) in the that country; some references are shown in annex.

The following links are given for ease of reference:

A) CODEX Alimentarius

The CODEX Alimentarius is maintained and published by FAO/WHO and has a database with Maximum Residue Limits set for pesticides and veterinary drgy residues. The database is freely accessible and can be found under the following link:

http://www.codexalimentarius.net

B) EU European Union MRLs

The European Commission through the Directorate-General for Health & Consumers has laid down new rules and regulations for pesticide residues in food in 2008. The system is now more transparent and MRLs for food and feed can be located through a MRL database located at http://ec.europa.eu/sanco_pesticides/public/index.cfm

C) US MRLs

For the United States of America, USDA maintains a MRL database that can be accessed through the web under http://www.mrldatabase.com/

D) Australia

The Australian government through the Australian Pesticide and Veterinary Medicines Authority issues the official list with the MRL standard.


Australian Government
Australian Pesticides and Veterinary Medicines Authority

The MRL Standard

Maximum residue limits in food and animal feedstuff

February 2010

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List of annexes

[1] Analytical glossary
[2] Sample questionnaire distributed
[3] Examples of Maximum Residue Limits
[4] References to some lists of national MRLs