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Final report

FHNW activities to consult the Cleaner Production Centre Vietnam

University of Applied Sciences
Northwestern Switzerland

Final report

FHNW activities to consult the Cleaner Production Centre Vietnam

(former FHBB changed its name to FHNW by 1/1/2006)

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Muttenz, September 2006

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Content

1 Summary

According to the Terms of Reference and the contract No. 2005/122, US/VIE/04/064 the main activities of the support program for the VNCPC from October 2005 to September 2006 (12 months) were the following:

- A detailed curriculum for the CP-training in the food and beverage industry was developed and the course conducted from 24 October until 5 November 2005 in Switzerland. The course was elaborated in close co-operation with industrial partners and technology suppliers in Europe.
- FHNW developed a curriculum for a plating course. This course was carried out from 28 November to 2 December 2005 at the VNCPC in Hanoi for technical staff of metal finishing companies. The final evaluation of the training was rated good-excellent.
- FHNW elaborated a technical research report for the VNCPC with information on cocoa bean drying and drying technologies in August 2006. The document facilitates the transfer of technology to the Vietnamese client company.
- FHNW up-dated its electronic CP-library and handed over one electronic copy to the VNCPC as well as to the CPC in Cambodia and Laos. This library contains approx. 4'000 CP-related documents.
- During the contract period FHNW organized training and coaching for two students from the Hanoi University of Technology at the Swiss academic Institution University of Applied Science Northwestern Switzerland (FHNW, former FHBB). They elaborated a Master of Science thesis as partial fulfillment of the requirements for the degree in Environmental Technology from February to August 2006. In addition one PhD student has been supported.
- A course on basic laboratory skills was developed and conducted on-site at INEST laboratory in Hanoi from 17 to 21 April 2006. The goal of the training for laboratory staff was to teach them basic laboratory skills and to prepare them for the upcoming laboratory certification according to ISO 17'025.
- FHNW carried out a technology gap assessment at the metal finishing company Xuan Hoa in Vinh Phuc on behalf of the VNCPC in December 2005. The assessment resulted in a re-engineering report, a draft proposal for a new plating plant and the optimization of the existing phosphating and powder coating plant. These documents were elaborated from February 2006 until August 2006.
- FHNW organized a study tour for two representatives from INEST/HUT on quality assurance in laboratories and ISO 17'025 in Switzerland from 7 to 11 November 2005.

The present report is a summary of the activities realized under the contract and encompasses all annual activities as no interim report was elaborated. For particulars on the subjects please refer to the respective mission reports.

2 Student exchange program

FHNW invited again two Vietnamese students during the contract period who were nominated by the Hanoi University of Technology in Vietnam for conducting their Master theses in Switzerland. Altogether FHNW hosted eight students during the last four years who elaborated their Master theses in environmental technology during six months each. The theses were practically oriented final modules of a Master study in environmental technology and were reviewed by the Vietnamese partner University.

The two students in the period 2006 have successfully finalized their studies and reached the goals within the time allocated. The students defined first the scope of the theses and elaborated an exact time schedule afterwards. During planning and execution of the works the students were closely supported by the FHNW research associates Mr. Jürg Walder, Ms. Antje Langbein and Mr. Christof Jeiziner. In addition external experts were contacted for specific support e.g. Mr. Mirza of the membrane supplier SOMICON Ltd. Furthermore FHNW organised accommodation and provided all administrative services like visa, insurance, English language courses etc.

A considerable amount of time was spent on scholarship search as the contract No. 2005/122, US/VIE/04/064 with UNIDO only covered FHNW's expenses and only part of the students' living costs. FHNW could get grants from the Swiss organization Swisscontact/SDC twice for the students' support. However, the application at and accounting for this organization were again time-consuming activities.

The Master theses finalized in 2006 are the following:

- Treatment of textile dyeing baths with membrane technology for reuse of water and chemicals (Ms. Vu Minh Trang).
- Recycling of electronic scrap: recovery of valuable metals from printed circuit boards (Ms. Ngo Thi Ngoc Thuy).

It is expected that the students will transfer the knowledge to the VNCPC and the Hanoi University of Technology where projects are carried out in textile wet processing and electronic scrap treatment. It is furthermore foreseen to foster the technology transfer especially in textile processing via the VNCPC. The Master thesis helped to find the limits of a respective technology development and transfer.

In addition FHNW organized the stay of one PhD-student at its premises. Mr. Vu Duc Toan is elaborating one part of his laboratory work on PCB-analysis at FHNW to achieve his PhD-degree at Hanoi University of Technology. FHNW organised accommodation and provided all administrative services like visa, insurance etc. In addition a scholarship was organized for the period of stay in Switzerland.

The study that is being done on PCB-analysis is regarded as foundation for the building of an instrumental analysis laboratory for the measurement of PCB at the University. If these services can be offered by the VNCPC to companies the all over attractiveness and credibility of the centre will be strengthened for longer periods.

The cooperation with VNCPC and the Hanoi University of Technology (HUT) and the support of the students was a success and contributed to the technical strengths of the center. For the students' certificates please refer to Annex 6.

3 Training

3.1 CP training in food and beverage production, Switzerland

Based on detailed curriculum description FHNW realized one industry specific CP training in Switzerland with two weeks duration for technical NCPC staff from 24 October until 5 November 2005. The subject was selected by the VNCPC and the other participants invited from various different NCPC. Eventually food and beverage processing were chosen. FHNW intended to offer the training based on the real demand at the VNCPC and was in close contact with the Vietnamese responsible during curriculum elaboration. The overall feedback of the participants was very good.

In specific the content of the training encompassed following subjects:

- Snack Food production
- LCA in food production
- Brewing processes
- Meat processing
- Personal safety and health
- Energy efficiency and process control
- Food analysis
- Biological waste management
- Food packaging
- Dairy processes

These practically oriented courses seem to be a real need not only at the VNCPC but also at other cleaner production centres worldwide. At the beginning of the curriculum elaboration it was doubted that the practical training part would be appreciated by the participants. However, it was experienced that just this part with excursions consolidates the theoretical know-how. In the present course 5 company visits were organized. FHNW was informed that many courses offered on CP-methodology and CP-related topics are too academic or only informative and do not directly guide implementation. As the present training was partly carried out by sector expert and technology suppliers the participants may directly contact key players in the area and were informed about international representatives.

The training was rather expensive even though the number of participants was increased to 14 and some lecturers waived their fees. FHNW adjusted the accommodation (apartment instead of hotel) in order to lower the burden of cost for all participants and their NCPC. However, it was still not possible to conduct the trainings without any

financial support from additional subsidies. This fact has to be taken into consideration for the organization of future trainings.

For the year 2007 FHNW will define a new course based on the requirements of the VNCPC and other CP-centres. It is intended to maintain the two week duration as this allows the combination of theory and practical exercises/excursion. First evaluations at CPC showed the need of technical training in industrial water management.

It is to say that the curriculum of this food and beverage course was also sent to VNCPC and discussed. It might be used in adjusted form for the training of company staff in Vietnam. This issue will further be described in the next mission to Vietnam.

A list of participants as well as the training evaluation is attached to this report in Annex 1 and 2.

3.2 CP-training for technical staff of Vietnamese electroplating companies

FHNW elaborated a curriculum for a CP-training especially for technical staff of electroplating companies in Vietnam. The training was organized by VNCPC and FHNW and conducted by the VNCPC, Hanoi University of Technology, Kistler engineering and FHNW itself. The target group of this training lacks of basic technical know-how and best practices and is mainly responsible for the considerable environmental impact of the plating sector. Apprenticeships or advanced technical training hardly exist in Vietnam. Therefore such courses have a real potential in industry and may be offered to companies in the future for full cost. With this training effort again the credibility of the VNCPC in the area of metal finishing could be increased. It is foreseen that the VNCPC will offer this course independently in the future.

The specific topics of the training were as follows:

- Workpiece preparation: grinding, polishing and buffing
- Degreasing, cleaning
- Pickling
- Cu-plating
- Ni-plating
- Zn-plating
- Decorative/hard Cr-plating
- Passivation, chromating, phosphating
- Energy efficiency
- Rinse
- Water conditioning / water treatment
- Removal of metal deposits
- Analytical measurement / quality control
- Occupational health / operational safety
- Cleaner Production self-assessment

FHNW financed two missions (10 days) to Vietnam and the preparation of two lectures of the Swiss plating expert Mr. Robert Kistler (Kistler engineering) and FHNW (Mr. Jürg Walder). These missions were combined with the re-engineering activities at Xuan Hoa company.

During the course various comments and questions from the participants were included and answered. The contributions especially from Kistler engineering were practically oriented, interactive and based on experience. Some of the participants spontaneously mentioned they will optimize their processes right after the course.

The lecturers prepared several questions for a final participant test. The result of this test is attached to this report in Annex 3.

Due to the positive results and to assist the VNCPC in formulating its own plating course the same training session is foreseen in 2006 at the new VNCPC-branch in HoChiMinh City.

3.3 Optimization of the environmental laboratory measurement capacity through lab training

During a first mission of FHNW to Hanoi University of Technology in 2003 an audit of the environmental laboratory (INEST) was undertaken by Mr. Jürg Walder. The laboratory plays an important role as supporting organization of the VNCPC. The lab services are frequently used by the centre and shall therefore be reliable. The audit showed several inadequacies at the lab infrastructure, best practices and instrument handling. It was therefore decided to carry out a first training for laboratory staff on laboratory basics/best practices. Moreover the environmental laboratory will be certified according to the international standard ISO 17'025 and for that the lab has to rely on proper working procedures.

INEST runs an analytical laboratory with modern equipment for a wide range of environmental analysis, which is not yet used optimally for different reasons. Partly the instruments have not completely been installed. The results of the analyses are in some cases not reliable since there are differences in the determination of one parameter using different methods. The INEST laboratory offers analytical measurements in a wide range of environmental analytics, including soil, water and air analysis. The laboratory staff is also equipped for certain on-site measurements in the industry by using portable testing kits and sampling.

Within a relative short time it is planned to establish an own quality assurance system and to realise the certification according to ISO 17025 to strengthen the position of the laboratory as a competent partner in the field of environmental analysis in Vietnam.

The target of the present mission was the improvement of basic working skills of the lab personnel. Ms. Antje Langbein, laboratory responsible at FHNW conducted a one-week training from 17 to 21 April 2006 on following topics:

Materials used in the laboratory/resistance

- Laboratory equipment

- Chemicals in the laboratory
- Waste and waste disposal
- Good laboratory practices
- Safety at work
- Quality assurance

This basic training shall be continued in the future with specific courses on analytical instruments. It was experienced that the different lab technicians have not received proper training on e.g. AAS, GC-MS, HPLC etc. and work mainly according to the equipment handbook only. However, the participants of the basic course appreciated very much the contribution and new information.

In order to achieve the ISO 17'025 certification it is important not only to describe the relevant processes of the laboratory but also in parallel establish a proper training scheme for the staff. The basic lab training could be the first module of such a training scheme and could be offered in the future by a competent lab responsible of INEST/HUT.

For further information on the mission and its content please refer to the mission report in Enclosure 1 of Ms. Antje Langbein.

3.4 Study tour on Quality Assurance in Switzerland

FHNW organized a study tour in Switzerland from 7-11 November 2005 for the head of the laboratory for environmental engineering and deputy director of INEST, Mr. Huynh Trung Hai as well as for the quality management responsible Mr. Ha Vinh Hung of the laboratory. The study tour was prepared to show the two participants ISO 17025 certified laboratories in Switzerland and the procedure to adopt this standard. The environmental laboratory at INEST would like to be certified according to this standard soon. The services offered by this lab are important for the VNCPC in the future. FHNW elaborated the tour programme and organized the company visits as well as the presentations. Latter were also financed by FHNW although the study tour was not budgeted in the present contract. FHNW also organised accommodation and provided all administrative services like visa, insurance etc. for the two persons.

For the study tour program and the reports of the two participants please refer to Annex 4.

4 Technical support and information

4.1 Re-engineering of industrial processes

From 5 to 9 December 2005 an international expert team together with the Vietnamese Cleaner Production Centre (VNCPC) conducted a technology gap assessment at Xuan

Hoa company, factory No. 2 in Vinh Phuc, Vietnam. The mission was organized by FHNW and attended by Mr. Jürg Walder and the Swiss plating expert Mr. Robert Kistler (Kistler engineering).

Xuan Hoa company is a growing metal mechanic enterprise located close to Hanoi, Vietnam. It is one of the Vietnamese factories that supplies intermediates or final products for the international furniture corporation IKEA. The financial situation allows Xuan Hoa to invest in certain production plants at present. A first investment was announced for a powder coating line in the year 2006. Xuan Hoa Company is running two factories at the moment and intends to concentrate the activities at one place (e.g. powder coating lines). Further investments for plating lines are expected for the year 2007.

During the technology gap assessment all relevant data were measured or estimated at the plant-site. The team concentrated on following areas: one plating line, phoshating and powder coating lines and water preparation. All single sequences were checked and the process parameters taken up.

The analysis of the existing Ni-Cr-plating plant No. 3 and the product quality showed some significant deviations from European standards. The existing situation concerning running costs, product quality, environmental impact and working conditions is inefficient and not satisfying.

First analysis and calculations of annual savings in water and chemicals by using adequate new process- and rinse technologies show big advantages. The total of the annual savings were initially calculated with US$ 409'000.

The replacement of the existing inadequate Nickel-Chromium-Plating plant No. 3 with a state-of-the-art plating system and rinse technique is recommended by the international experts. First estimations based on experience resulted in approx. 1 Mio USD investment. A first draft proposal of technology suppliers in Germany however, showed cost of 1.5 Mio USD (without secondary equipment) and 1.9 Mio USD for a turnkey plant. Considering the enormous advantages, the simple pay back time of 5 years is reasonable. The expected lifetime of standard European plating plants is at least double than the lifetime of the installed Taiwanese plant.

FHNW elaborated together with Kistler engineering an interim report on the technology gap assessment with all measured process steps, conclusions and recommendations. In addition to this interim report a report on the powder coating and phosphating lines was handed in later. As the interim report only stated rough investment costs a draft proposal for a new plating plant was elaborated based on supplier information. All three documents were handed over to the VNCPC. Furthermore a specific follow-up scheme for the technology transfer project was included. After receipt of Xuan Hoa's commitment that is expected in the second half of the year 2006 the VNCPC and the international expert team will organize and enable the transfer of the plating plant to Vietnam.

Green credit lines offered by the Swiss State Secretariat for Economic Affairs (SECO) could further enable Xuan Hoa's investment at favourable conditions. FHNW will assist in financial engineering upon request.

The assistance in the re-engineering and technology transfer project is an important element in a broader realization of preventive measures. The idea is to focus primarily on supply chain companies of international corporations and to disseminate the findings. This approach might influence other suppliers when backed by the international corporation and multiply the effort done by the cleaner production experts.

For further detailed information on the re-engineering interim report, the supplementation on phosphating and powder coating as well as the draft proposal for a plating plant please refer to Enclosure 2.

4.2 Information on environmentally sound technology

FHNW was asked by the VNCPC about assistance in technology selection. The VNCPC is conducting a Cleaner Production Assessment at a cocoa processing company. As drying of cocoa beans is done inefficiently at present a new drying technology shall be evaluated and a possible technology transfer prepared..

FHNW therefore elaborated a technical research report for the VNCPC with information on cocoa bean drying and drying technologies in August 2006. Based on this document stating specifications and cost the VNCPC/company can select a specific dryer. For further information on the document please refer to Annex 5. FHNW will assist the technology transfer process upon request.

In addition FHNW up-dated its electronic CP-library and handed over one electronic copy to the VNCPC as well as to the CPC in Cambodia and Laos. This library contains approx. 4'000 CP-related documents and helps the centers to prepare technical assessments in various industry sectors.

5 Lessons learnt

The present staff of the VNCPC is familiar with the overall cleaner production methodology and has proved its success by using it in various industries. FHNW would like to further contribute to these skills by offering tailor made CP trainings. However, as these trainings are rather expensive a regional or even global approach shall be made. As shown for instance with regional trainings offered for the NCPC in Central America the cost can significantly be reduced. Classic CP-services are still important for the VNCPC although it might change its role to facilitating other environmental projects. CP-assessments still contribute necessary income for the centre. Thus, the centre needs competent staff that is trained on relevant technical aspects.

Industries are part of a network and help the VNCPC to extend its role as centre of excellence for environmental services. One limiting factor for the technical work of the centre is the lack of engineering know-how. For the promotion of technology-transfer, technology gap-assessments are a pre-requisite and proper engineering support a real asset. That is why FHNW will focus more on this service in 2007 and try to cooperate with professional engineering companies in Europe. It is very important to have at least one demonstration project on technology transfer to show the benefits of the methodology to international clients. The idea of clean technology implementation could then be disseminated more widely and the overall effect will increase. In that context it is essential to keep track of all follow-up activities and milestones arranged with industries as companies have strict investment plans. A certain technology proposal for instance must be elaborated on time. Furthermore the establishment of the Swiss green credit lines for investment facilitation is important.

The student exchange program proved to be successful during the last years. Some of the Master students were selected for PhD courses right after their stay at FHNW. Also the chosen subjects for the theses could further be developed at the VNCPC as e.g. plating technology. Nevertheless, it is very important to select students with sufficient knowledge of the English language in the future. It was experienced that proper assistance can only be provided when a minimum level of communication is possible. FHNW is thinking of an entry test like the TOEFL (test of English as a foreign language) for students entering the exchange program.

FHNW could contribute again to a successful programme in the framework of development cooperation. For this experience and UNIDO's support during the past months all involved staff of FHNW would like to express again their gratitude. FHNW is looking forward to cooperating further with the VNCPC.

6 Enclosures

- **Enclosure 1**: Laboratory support for VNCPC and Hanoi University of Technology (Ms. Antje Langbein)
- **Enclosure 2**: Re-engineering at Xuan Hoa company (Mr. Robert Kistler, Mr. Jürg Walder).

Annex 1 List of participants food and beverage training, Switzerland

P Course on Food+Beverage production, FHNW Switzerland
articipant list

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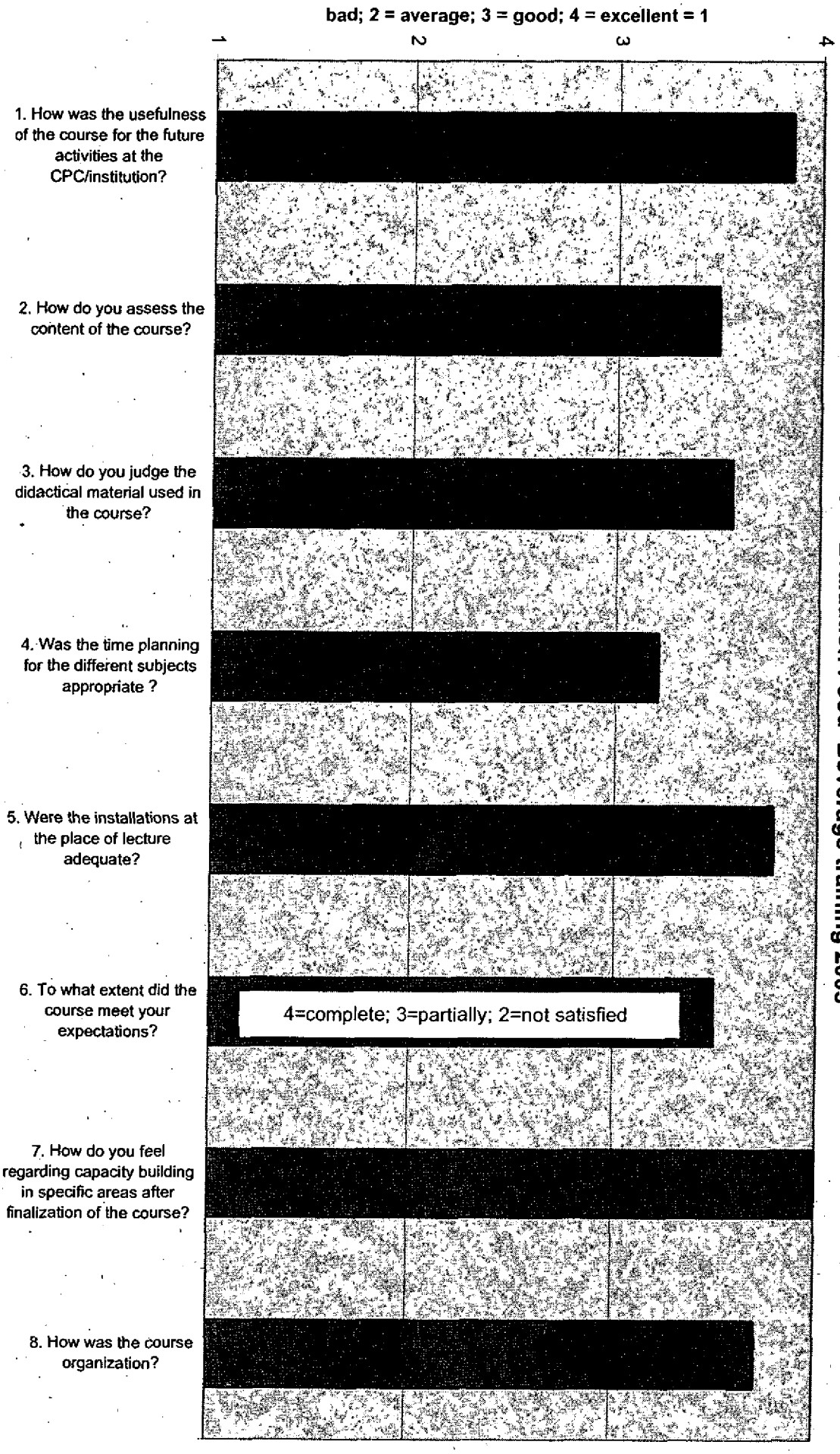
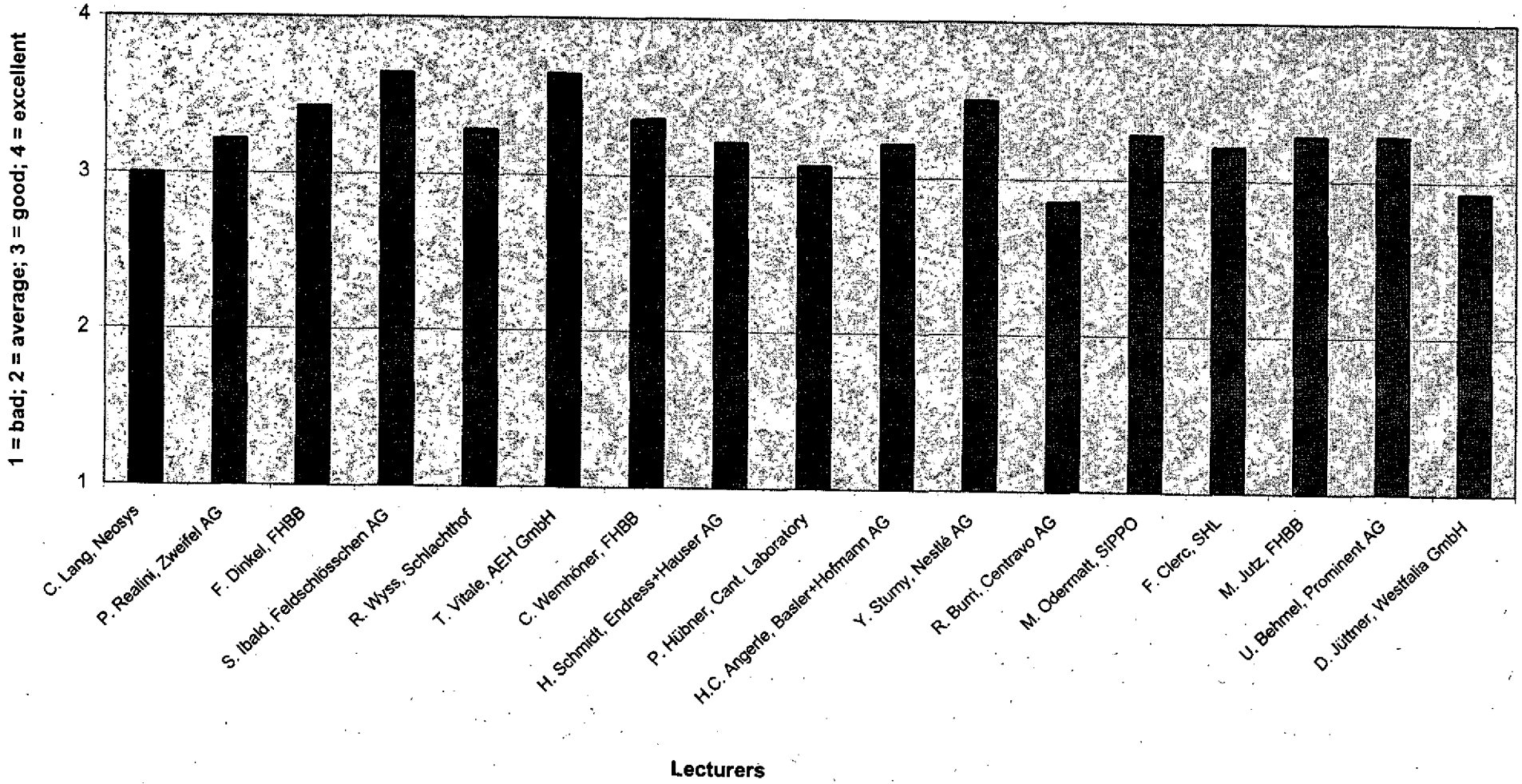
and Collignon	Mr.	Vietnam	Vietnam Cleaner Production Centre (VNCPC)	Hanoi University of Technology, Institute for Env. Science and Technology, 4th floor, C10 Bldg., DHBKHN, Dai Co Viet Road, Hanoi, Vietnam	bertrand.collignon@vncpc.org	Tel +84-4-868 16 86 Fax +84-4-868 16 18
Le Nguyen	Mrs.	Vietnam	Vietnam Cleaner Production Centre (VNCPC)	Hanoi University of Technology, Institute for Env. Science and Technology, 4th floor, C10 Bldg., DHBKHN, Dai Co Viet Road, Hanoi, Vietnam	hang.nl@vncpc.org	Tel +84-4-868 16 86 Fax +84-4-868 16 18
g Manh Dinh	Mr.	Vietnam	Vietnam Cleaner Production Centre (VNCPC)	Hanoi University of Technology, Institute for Env. Science and Technology, 4th floor, C10 Bldg., DHBKHN, Dai Co Viet Road, Hanoi, Vietnam	thang.dm@vncpc.org	Tel +84-4-868 16 86 Fax +84-4-868 16 18

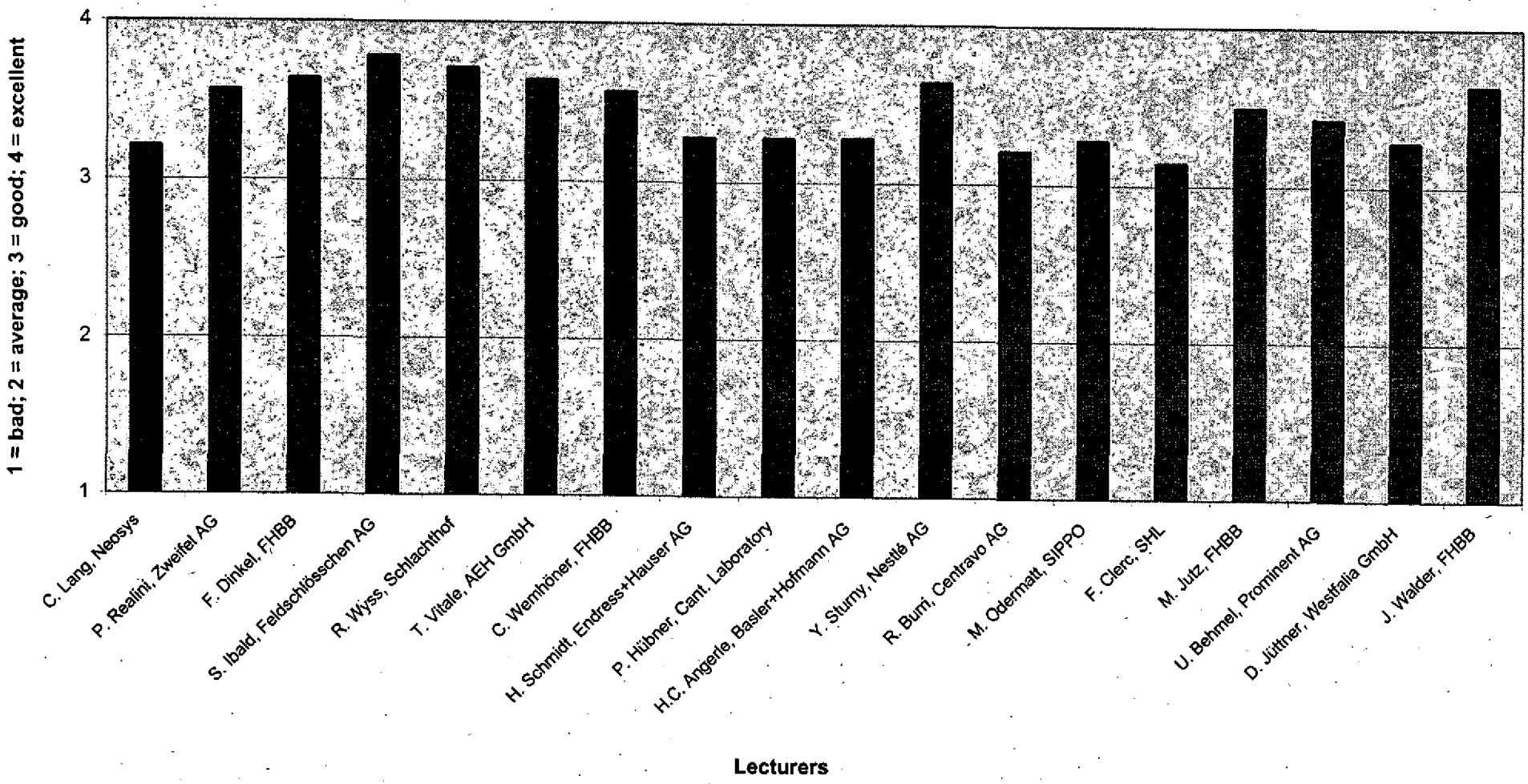
Annex 2 Evaluation of food and beverage training, Switzerland (average)


bad; 2 = average; 3 = good; 4 = excellent = 1
1
2
3
4
1. How was the usefulness of the course for the future activities at the CPC/institution?
2. How do you assess the content of the course?
3. How do you judge the didactical material used in the course?
4. Was the time planning for the different subjects appropriate ?
5. Were the installations at the place of lecture adequate?
6. To what extent did the course meet your expectations?
4=complete; 3=partially; 2=not satisfied
7. How do you feel regarding capacity building in specific areas after finalization of the course?
8. How was the course organization?
General Evaluation Food+Beverage training 2005

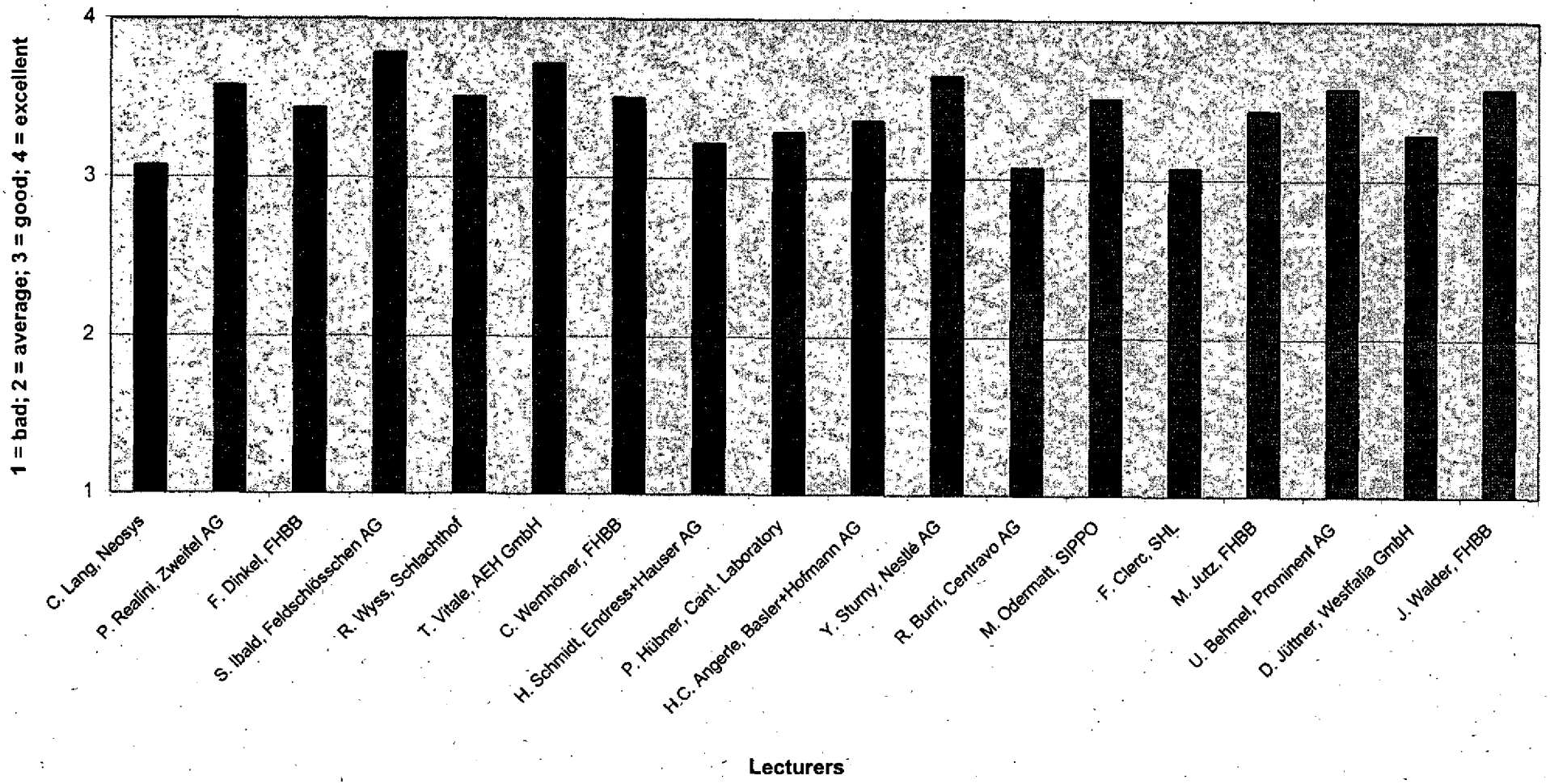
Specific Evaluation Food+Beverage training 2005 / Teaching method



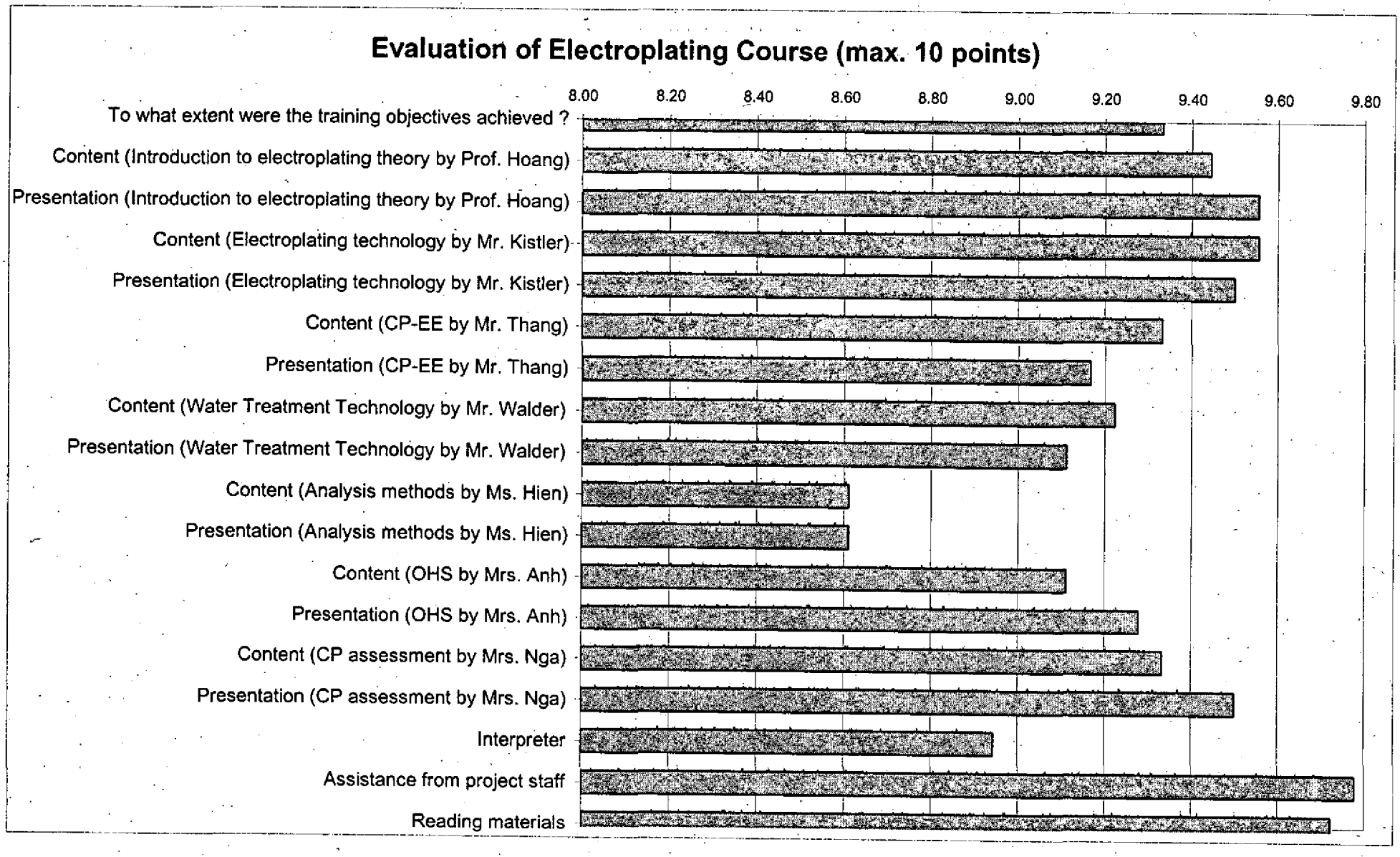
Specific Evaluation Food+Beverage training 2005 / Competence



Specific Evaluation Food+Beverage training 2005 / Clearness



Annex 3 Evaluation of training on metal plating, Vietnam


Evaluation of Electroplating Course (max. 10 points)
8.00
8.20
8.40
8.60
8.80
9.00
9.20
9.40
9.60
9.80
To what extent were the training objectives achieved ?
Content (Introduction to electroplating theory by Prof. Hoang)
Presentation (Introduction to electroplating theory by Prof. Hoang)
Content (Electroplating technology by Mr. Kistler)
Presentation (Electroplating technology by Mr. Kistler)
Content (CP-EE by Mr. Thang)
Presentation (CP-EE by Mr. Thang)
Content (Water Treatment Technology by Mr. Walder)
Presentation (Water Treatment Technology by Mr. Walder)
Content (Analysis methods by Ms. Hien)
Presentation (Analysis methods by Ms. Hien)
Content (OHS by Mrs. Anh)
Presentation (OHS by Mrs. Anh)
Content (CP assessment by Mrs. Nga)
Presentation (CP assessment by Mrs. Nga)
Interpreter
Assistance from project staff
Reading materials

Annex 4 QA study tour program and short participants' reports

Study tour "QA in analytical laboratories"

FHBB/ IfU , 7 - 11 November 2005

Detailed programme

Date	Time	Subject	Content of the lesson	Form of the lesson	Responsible / lecturer	Remarks	Contact
Getting started (1 day)							
7 November, Monday							
	9:00 - 10:30	Introduction	>Introduction of participants and IfU staff >Presentation of organisation and procedure of the study tour >Introduction of involved partners	plenum (meeting room at 2nd floor/ IfU)	J. Walder, A. Langbein		
	10:45-12:00	First steps	>Review of the situation at INEST (current status of certification, current problems) >Exchange of experiences in lab management and Quality Assurance in the lab	plenum (meeting room at 2nd floor/ IfU)	J. Walder, A. Langbein	Status at INEST laboratory, discussion of specific problems, implementation of recommendations (see mission reports 11/2003 + 4/2005)	
	13:30 - 15:30		>presentation of the IfU laboratory handbook >content and structure of the lab handbook >the lab folder on the IfU server	presentation/ discussion (meeting room at 1st floor, IfU)	A. Langbein		
	16:30 - 18:00	Quality Management in general	>Structure, maintenance of management systems >Requirements for the QM system >Standards	presentation/ discussion (meeting room at 1st floor, IfU)	P. Schönenberger, consultant	Introduction into Quality management	SAQQualicon Kirchberg, Switzerland email: ps.schoenenberger@swissonline.ch
Waste disposal, health and safety (0.5 day)							
8 November, Tuesday morning							
	8:30 - 11:30	health + safety in the laboratory, waste management	>survey of professional education at APRENTAS >waste minimisation measures >alternatives for toxic or harmful substances >waste separation and collection >waste disposal (organisation, costs) >personal measures >organisational measures >responsibilities	visit of a training institution for lab professions (APRENTAS, Muttenz)	(Remo Borer), laboratory responsibles		Contact Aprentas: Remo Borer remo.borer@aprentas.com +41 61 468 39 10
Studies in analytical chemistry at FHBB/ QA (0.5 day)							
8 November, Tuesday afternoon							
	13:30 - 14:30	theory/ lectures	>Outline of Chemical Dept. FHBB, studies in analytical chemistry	lecture (at Ch. Dpt.)	H.-R. Schmutz, lecturer of Ch. Dpt.	overview, special lectures in analytical QA, statistics, QMS e.g.	Dept. Chemie: Hans-Rudi Schmutz Tel. 061 467 43 53
	14:45 - 16:00	practical courses in the labs of Ch. Dpt. At FHBB	>organisation of practical training >responsibilities >issue of chemicals and materials >health and safety measures >training of personnel >maintenance of equipment	lecture (at Ch. Dpt.)	H.-R. Schmutz, lecturer of Ch. Dpt.		Dept. Chemie: Hans-Rudi Schmutz Tel. 061 467 43 54
	16:00 - 17:00	laboratories at FHBB	>visit of the laboratory at FHBB >visit of storage of chemicals and wastes	visit on-site	H.-R. Schmutz, lecturer of Ch. Dpt.	waste management health and safety measures	Dept. Chemie: Hans-Rudi Schmutz Tel. 061 467 43 55
ISO 17025 (2 days)							
9 November, Wednesday							
	8:30 - 10:30	basic principles	>organisation, structure of ISO 17025 >benefits of implementing ISO 17025 >maintenance of the system >effort in time demand and costs	lecture at IfU (meeting room at 2nd floor/ IfU)	Mr. Heinz Peter, consultant	about the definite programme team will be informed on Monday, 7/11	Heinz Peter, Dagmersellen Tel. 062 756 0958 hp@hp-management.ch
	10:45 - 12:30	documents	>development and content of binding documents (e.g. SOP's)	lecture at IfU (meeting room at 2nd floor/ IfU)	Mr. Heinz Peter, consultant		Heinz Peter, Dagmersellen Tel. 062 756 0958 hp@hp-management.ch
	13:30 - 14:00	staff training	>staff training: basic education and further training regarding ISO 17025	lecture at IfU (meeting room at 2nd floor/ IfU)	Mr. Heinz Peter, consultant		Heinz Peter, Dagmersellen Tel. 062 756 0958 hp@hp-management.ch
	14:00 - 15:30	certification	>certification institutions in CH and Vietnam >responsibilities within the lab. (management and staff) >steps in the implementation process >internal and external audits	lecture at IfU (meeting room at 2nd floor/ IfU)	Mr. Heinz Peter, consultant		Heinz Peter, Dagmersellen Tel. 062 756 0958 hp@hp-management.ch
	14:00 - 17:00	QA in analytical chemistry	statistical and QA - typical advanced measures	lecture at IfU (meeting room at 2nd floor/ IfU)	Mr. Heinz Peter, consultant		Heinz Peter, Dagmersellen Tel. 062 756 0958 hp@hp-management.ch
10 November, Thursday							
	10:00 - 12:00	visit of a certified commercial analytical lab	>theoretical part/ introduction >visit of the sample preparation and storage in the lab	excursion (lab visit)	BACHEMA AG, Schlieren	between 12:00 - 14:00 lunch in Schlieren	Felix Schuppisser (GL) Tel. 044 738 39 20 schuppisser@bachema.ch
	14:00 - 16:00	visit of a certificated commercial analytical lab	>visit of the instrumentation and the analytical work >final discussion	excursion (lab visit)	BACHEMA AG, Schlieren		Felix Schuppisser (GL) Tel. 044 738 39 20 schuppisser@bachema.ch
Environmental analysis in Switzerland							
11 November, Friday morning							
	9:00 - 12:00	visit of a governmental lab for environmental analysis	>process of the analytical work from receiving the sample to the measuring result >method validation procedure	laboratory visit	AUE / BL (Marcel Beck)	duration: 2 up to 3 hours	AUE/ BL (Liestal) Umweltanalytik/ Teamleiter Rainer Bachmann Tel. 061 925 5541 oder Stellvertreter Marcel Beck Tel. 061 925 5507)
Wrap-up							
11 November, Friday afternoon							
	13:00 - 14:30	presentation of literature	>recommended websites and literature (list) >other material (collection of electronic files)	discussion/ plenum (meeting room at 2nd floor, IfU)	J. Walder, A. Langbein		
	14:45 - 17:00	review	>next steps in implementation of ISO 17025 at INEST >final discussion	discussion/ plenum (meeting room at 2nd floor, IfU)	J. Walder, A. Langbein		

Study tour "Quality Assurance in analytical laboratories"

Time: from 7 to 11 November 2005

Institution: Institute of Environmental Technology (IfU)-FHBB

Content:

Day 1: General

Mr. Jürg Walder introduced IfU and time table of the study tour. Mrs. Antje Langbein introduced a handbook of IfU, its contents and the way to store data on computer.

The system of quality management and Quality Assurance in an analytical laboratory was presented by Mr. Peter Schonenberger from SAQ Qualicon.

Day 2: Waste disposal, health and safety in the laboratory

Visiting the laboratory of Vocational School for Chemical and Pharmaceutical Industry in Aprentas

Mr. Remo Borer introduced an overview of Aprentas, organizing structure and fields of activities as well as development orientation of Aprentas. Mr. Remo Borer pointed out training plan, current number of students and where students of Aprentas can work after graduation. Then, he took the visitors go to visit the Aprentas laboratories. At that time, students were carrying out experiments of organic substance synthesizing.

Ms. F. Caviezer, an instructor, introduced laboratories, work and the existing equipment in the laboratory to the visitors. He also showed the principles for classifying, collecting and temporarily storing laboratorial waste such as used paper, broken glass, organic solvent and waste water.

Laboratorial wastes were classified at sources. Used waste, broken glass, organic solvents were collected and contained separately depending on their properties and then stored temporarily at the store. These wastes had been taken away regularly by functional companies.

Fire prevention and control systems: fire alarms were positioned at every inflammable and explosive place such as the area of containing waste solvent, chemical stores etc... remote fire control system was equipped in chemical store area. Along the corridor of each floor, fire extinguisher and fire control instruments were available.

In order to ensure the safety of laboratory, staff and people working in the laboratory had to wear white blouses, gauze masks, and glasses. Gas cylinders were put on firm holders to avoid them falling out, causing danger.

Visiting the chemical faculty of FHBB:

Research and education activities of the chemical faculty were decribed by Prof. Dr. Hans-Rudolf Schmutz. After a short discussion, the visitors were took to visit laboratories of the faculty. In there, equipment came with directions for use beside.

When they were used, staff must take notes in diaries. Scales are equipment easy to be affected by vibration so all scales of this faculty were put on thick and heavy stone table with anti-vibration system.

Gas cylinders were kept safely by holders and put separately. Gas was led through pipeline to working area.

All doors of lab were attached to warning boards with contents: "no eating in lab", "wearing gauze mask in lab", "danger", etc,.

All the laboratories of the faculty were not big but tidy and well arranged.

Day 3: ISO 17025

Basic principles of ISO 17205 were provided by Mr. Heinz Peter. The processing of setting up Quality system of an analytical laboratory and the method to set up materials of Quality system was discussed.

Contents of discussion included: quality policy, technical management and quality management, standard of operation procedures (SOPs), equipment maintenance and management, training staff and job description, management review especially audit

Day 4: Visit of a certified commercial analytical laboratory

Mr. Felix Schuppisser welcomed the crew to visit Bachema AG analytical lab. He introduced size, capacity and development orientation of the laboratory. After that, he took people to visit sample preparation area, sample store and analytic lab.

Samples of stone, ore were ground to fine size, bottled and stored in cabinet. Analytic lab was divided into 3 sections: basic analysis, instrument and microorganism analysis. Scales in these labs were checked everyday following the standard objects of laboratory.

Day 5-Environmental analysis in Switzerland

Visiting Kanton environmental analytic laboratory:

The manager presented about the quality handbook of the laboratory, procedures of analysis from receiving samples to analytical results: procedures of equipment control, chemical management, sample delivering and receiving, analyzing samples, approving measuring methods, measuring result security…

Then, he took the crew to visit the lab.

In the lab, gas cylinders were gathered according to using purposes with pipeline connected to equipment. Each room had direction board for fire incident, there were high pressure taps attached with basins.

Everyday, temperature of fridges for storing samples were checked on.

Experience lesson

The activities of a laboratory could cause a number of hazardous wastes that must be classified, collected, stored and treated under the right technique to minimize their severe effects on staff's health and the environment.

In addition, staff working in a laboratory often got in touch with harmful chemicals, so they must be fully equipped with personal safety utensils.

There were high risks of fire and explosion in laboratory, so it is necessary to pay attention to fire prevention and control to minimize the risk of fire and explosion.

Scales are equipment easy to be affected by vibration so all scales of this faculty were put on thick and heavy stone table with anti-vibration system.

It was necessary to have notebooks to take notes status of equipment in order to find out erroneous and repair timely. Staffs working in lab had to be educated and trained regularly as well as upgrade their certificates.

We would like to thank Mr. Jurg Walder and Ms. Antje Langbein who organised the study tour and Institute of Environmental Technology (IfU) – FHBB as well as UNIDO for what they did for a success of the tour. Experience lessons from the tour about activities of environmental laboratories are valuable for us to develop our laboratories in Vietnam.

Exchanging information and learning experience in laboratory management

1: Institution: Vocational School for Chemical and Pharmaceutical Industry

Aprentas, Muttenz

2. Date: November 8th, 2005

3. Membership:

- Mr. Jürg Walder - Institute of Environmental Technology - FHBB
- Ms. Antje Langbein - Institute of Environmental Technology - FHBB
- Dr. Huynh Trung Hai - Institute for Environmental Science and Technology - HUT
- MSc. Ha Vinh Hung - Institute for Environmental Science and Technology - HUT

4. Picked up by:

Mr. Remo Borer

5. Contents of the visit

Mr. Remo Borer introduced an overview of Aprentas, organizing structure and fields of activities as well as development orientation of Aprentas. Mr. Remo Borer pointed out training plan, current number of students and where students of Aprentas can work after graduation. Then, he took the visitors go to visit the Aprentas laboratories. At that time, students were carrying out experiments of organic substance synthesizing.

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In order to ensure the safety of laboratory, staff and people working in the laboratory had to wear white blouses, gauze masks, and glasses. Gas cylinders were put on firm holders to avoid them falling out, causing danger.

6. Experience lesson:

The Aprentas la aboratories were always clean and tidy. Mr. R. Borer and Ms. F. Caviezer were kindness, they provided us a lot of helpful information as well as lessons, some of them can be applied in our daily activities.

The activities of a laboratoty could cause a number of hazardous wastes that must be classified, collected, stored and treated under the right technique to minimize their severe effects on staff's health and the environment.

In addition, staff working in a laboratory often got in touch with harmful chemicals, so they must be fully equipped with personal safety utensils.

There were high risks of fire and explosion in laboratory, so it was necessary to pay attention to fire prevention and control to minimize the risk of fire and explosion.

Annex 5 drying of cocoa beans – technical research report

CP - research report

Drying of cocoa beans

Artificial drying of cocoa beans in Dong Nai, Vietnam

For: Vietnam Cleaner Production Centre (VNCPC)

Author: Eng. Reto Steiner

Basel, August 2006

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Abstract

Traditionally in Vietnam cocoa beans are dried in the sun. Today the cocoa is harvested also during rainy season because of higher prices. For that reason this report takes a look at the possibilities of artificial drying on an industrial level.

With the drying the water content in the beans is reduced from up to 50% to 5-7 %. There are a few quality requirements for the bean and criteria for the drying process which are explained in this document.

Mechanical dryers are only profitable if a large volume of cocoa is to be dried. We have to distinguish different types of driers which could be appropriate for drying cocoa beans like: Simple dryers (cement oven), Hot-air dryer (SAMOA or BROOKS), Static dryer with ventilation, Movable tray dryers (Tunnel dryer), Rotary dryer, Conveyor belt dryer and Vertical type grain dryer. There are many companies manufacturing dryers, but only few are experienced with cocoa beans. On the other hand the expected quantity of beans is too little and often not in the range of available dryers.

A financial calculation with all details should be made and there should be analyzed if the use of wood or dried shells in the furnace or other alternative combustible is ecologically and economically feasible.

In any case it is recommended if possible to carry out at least a solar pre-drying of the cocoa beans with solar panels or with a system with rain protection (cover, plastic tarp...).

University of Applied Sciences Northwestern Switzerland
Drying of cocoa beans

Content

List of figures

List of tables

1 Cocoa (cacao)

1.1 Cocoa beans

Cocoa beans (raw cocoa) are the seeds of the fruit of the cacao tree. The fruit, of similar appearance to cucumbers, is filled with sweet, slimy pulp and contains 30 to 50 large almond-like seeds (beans). (Wikipedia 2006)

Cocoa has a high nutritional value because of its high content of fat (cocoa butter), protein and carbohydrates. Substances of content of the cacao bean are (Chocoland 2006):

- Cocoa butter 54.0 %
- Protein 11.5 %
- Cellulose 9.0 %
- Starch 7.5 %
- Tanning substance and chromophor component 6.0 %
- Water 5.0 %
- Mineral aggregate and salts 2.6 %
- Theobromine (Alkaloid) 1.2 %
- Different sugars 1.0 %
- Caffeine 0.2 %

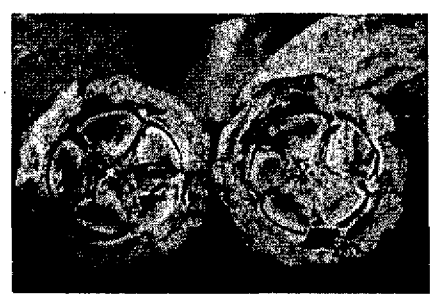


Figure 1: Cocoa Fruit with Beans (seeds) inside

Cocoa beans are grown by farmers in West Africa, Southeast Asia and Latin America, more than 85 % of them are small-scale family farmers. (Ehponline 2006)

Main harvesting season in Vietnam takes place from November to April. In August is the sub-season where there is harvested less. However, cacao is harvested every time during the year because of higher prices. The rainy season in Dong Nai starts in May and ends in October. (VNCPC 2006)

1.2 Post harvest processing and storage

1.2.1 Processing

The cocoa seeds present initially a high content of bitter substances because of the presence of highly bitter tannins. It is necessary to treat the seeds of the cacao tree in several steps:

- **Fermentation process:** In the fermentation process in concrete pits or fermenting tanks the seeds are killed, the tannins are oxidized; aromatic substances (chocolate flavor) and the development of the typical brown to deep red-brown color of cocoa is formed. The process of fermentation lasts up to10 days.
- **Drying process:** The beans are dried in the sun or with the use of an artificial dryer.

Figure 2: Cocoa Beans (TIS 2006).

The production process in a factory in Dong Nai (Vietnam) produces from 25 kg fresh seeds (obtained from 100 kg fresh fruit):

- X kg seeds after fermentation (unknown)

- 10 kg cocoa beans, product (after drying)

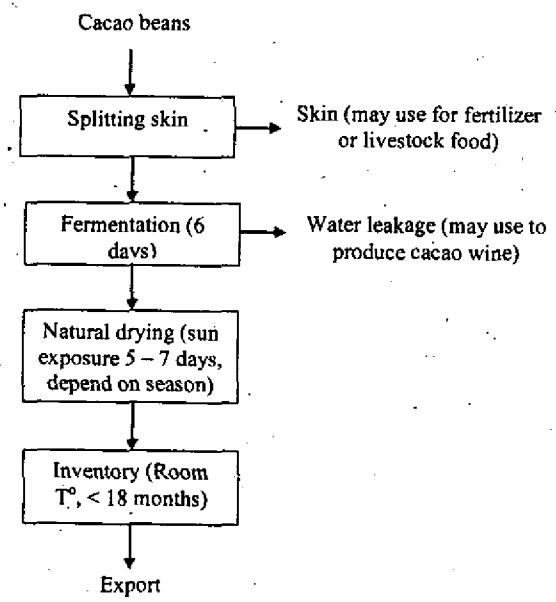


Figure 3: Production processing scheme of cocoa beans (VNCPC 2006)

The fermentation is realised in a closed tank for natural fermentation (temperature 30-400°C). Currently, leakage water is discharged and Cocoa skins are fed to cows. Productivity in Vietnam is about 2 kg beans product/tree and year (2 tons/ha). (VNCPC 2006).

1.2.2 Storage

For the transport overseas, there are a few very important requirements on storage of the cocoa bean, which can be also very important for storage before exporting:

- Cocoa beans require particular temperature conditions because rancidity and over-fermentation easily occur at temperatures higher than 25°C.
- Cocoa beans require particular humidity/moisture conditions because cocoa beans become brittle if the water content is smaller than 6 %, or there is a risk of vapour and mold damage if the water content is higher than 8%. During transport the beans could release 1-3% of the water content because they are highly hygroscopic. The water content on packing the cocoa beans should be approx. 6 – 8 %.
- Cocoa beans require particular ventilation conditions.
- Cocoa is very sensitive to other odours: it is important not to store the cocoa beans with other products like coffee beans.

Cocoa beans have a tendency to self-heating and post-fermentation because of the elevated oil content (39 – 60 %) in interaction with temperatures higher than 25°C, high relative humidity and lack of oxygen.

In Dong Nai the cocoa beans are stored at room temperature and up to a maximum duration of 18 months.

Sources: TIS (2006), VNCPC (2006)

1.2.3 Quality

For high quality grade the natural cocoa product must be well fermented (5 days minimum), well dried and has to show pleasant flavour and aroma. There are a few requirements of quality which are important for the processing of the cocoa bean:

Good quality of the cocoa bean means: loose and undamaged shell, light to dark reddish-brown colour, readily crumbled, highly fragile kernel, fully ripe, correctly fermented, firm beans of uniform size with a dry weight of no less than 1 g, ungerminated, without foreign matter or mold, not infested with insects, no wetting damage, not smelling sour, musty or smoky.

Bad qualities of the cocoa bean are: unripe and poorly fermented, overfermented (excessive heating), insect infested, flat, unripe, small and broken, germinated, ham-like odour (due to overfermentation), smoky odour (due to excessively long drying)

Extended storage over 6 months may result in losses: the beans should be shipped shortly after harvest. (TIS 2006)

2 Drying of the Cocoa bean

After the fermentation process the cocoa bean contains up to 60 % of water. With the drying the beans are loosing up to 50 % of their weight and the fermentation process is completed. The water content after drying is reduced to 5-7 %.

The goals of drying are:

- Guarantee a sufficient **stability** of the beans
- Making them **storable** and to achieve **keeping quality**
- Develop the **distinct flavour** (during the drying the bean get even more brown and develop a more distinct flavour) (Wikipedia 2006)

Requirements (quality factors) on the drying are:

- **Not too fast:** the beans turn out acidic with a bitter flavour when dried too quickly because of incomplete chemical reactions (chemical reactions started in the fermentation process are not allowed to complete their work)
- **Not too slow:** moulds and off flavours can develop if the drying is too slow
- ***Carried out carefully*** **:** to ensure that off-flavours are not developed
- **Bean temperatures:** should not exceed 55°C during the drying (FAO 2006) (65 °C corresponding information of ICCO)

There are two methods for drying of cocoa beans which are the natural sun drying and the artificial drying.

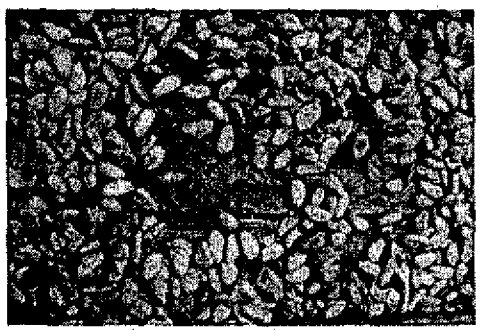


Figure 4: Fermented cacao beans out to dry (www.schweisguth.org)

After drying, the beans have a moisture content of 6 to 7 %. They can now be conditioned to be stored. The specific weight of the beans at this moisture is 520 to 530 kg/m³ and they become fragile. It is important to control the moisture with measurements. (FAO 2006)

University of Applied Sciences
Northwestern Switzerland
Drying of cocoa beans

2.1 Sun drying

The method of natural sun drying is used in countries in West Africa and the West Indies, where the harvest takes place in a dry period. The beans are dried slowly within a week or more, depending if the weather is sunny or rainy. They are placed in the sun on mats, trays or on concrete floors and need to be covered in rainy weather conditions. In some countries in the West Indies and South America, drying is realized on wooden drying floors *with moveable roofs. Other protection from rain is possible* with the sliding tray drier: the boards can be slid under a shelter. During the drying, the beans have to be frequently turned. (ICCO 2006) (FAO 2006)

Solar driers can be divided into two categories:

- Driers with direct use of the sunlight (warmth absorption by the product)
  - Traditional drying racks in the open air
  - Covered racks (protecting against dust and insects)
  - Drying boxes provided with insulation and absorptive material
- Driers with indirect use of the sunlight (product is not exposed to direct sunlight, drying air is warmed separately from the beans) (WOT 2006)

The duration time for natural drying (sun exposure) in Vietnam is about 5 – 7 days with a drying density of about 250 kg seeds per 20-25 m^2. The duration depends on the season (light intensity and air temperature). (VNCPC 2006)

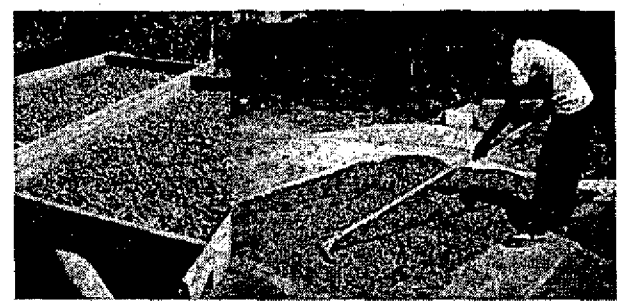


Figure 5:(left) Direct Sun drying of cocoa beans (www.schweisguth.org)

Figure 6:(right) Direct Sun drying (www.bpl-beverages.com)

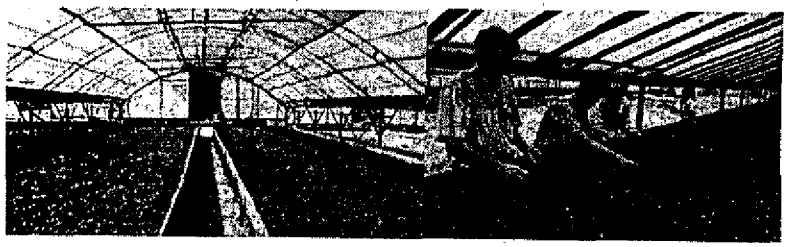


Figure 7: (left) Dryer with plastic tarp, Dom. Rep. (www.ethiquable.com)

Figure 8: (right) Solar dryer with plastic tarp, Sao Tome and Principe (www.ruralpovertyportal.org)

Figure 9: Dryer in Cooperative EL CEIBO, Bolivia

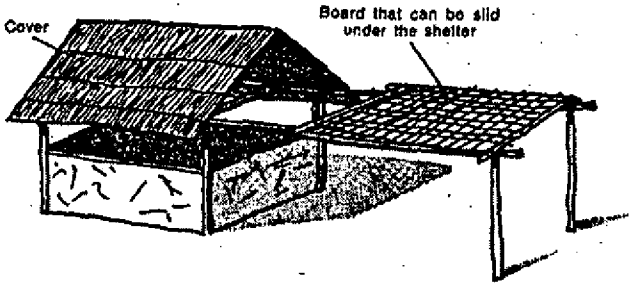
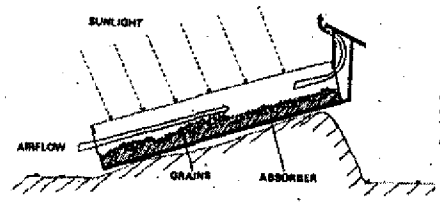


Figure 10: Sliding tray drier (FAO 2006)



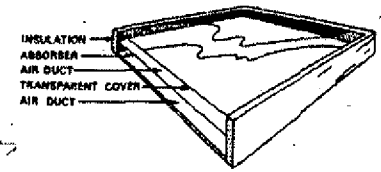


Figure 11: Solar Dryer directly employed, drying box (WOT 2006)

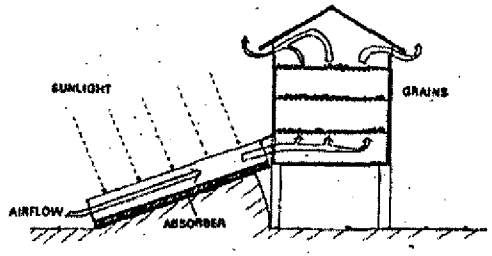


Figure 12: Solar Dryer indirectly employed, drying box (WOT 2006)

In a study that analysed the quality of cocoa beans which were dried in a direct solar dryer at different loadings (20, 30 and 60 kg), was found that the 20 kg treatment produced reasonably good-quality beans as compared to the other loadings. The 20 kg loading is therefore recommended for direct solar dryers. (SCI 2006)

2.2 Artificial drying

The most of the world-wide production of cocoa comes from countries where the beans are dried in the sun. In certain regions the use of artificial drying can be necessary for two main reasons:

- **Climatic conditions:** if the period of the harvest is corresponding to the rainy season, lack of dry periods after harvesting and fermentation: Brazil, Ecuador and South East Asia, sometimes in West Africa. In Brazil great part is dried with sunlight, small part artificially. In Cameroun, Costa Rica, Zaire & Samoa are used artificial dryers.
- **Quantity of beans:** big size of plantation need large drying areas (in peak periods) (ICCO 2006) (FAO 2006) (Wikipedia 2006)

The cocoa beans can be dried in one to two days with artificial drying.

Artificially dried beans can be of poor quality. There is to be taken special care in the use of artificial dryers of:

- **Contamination:** Contamination from the smoke/combustion gas of fires or furnaces
- ***Too short drying duration:*** Drying is made too quickly (FAO 2006)

A study made in 1980 (IFCC 1980) came to the conclusion that natural dried cocoa was preferred over artificial dried cocoa (laboratory comparisons) and that conditions of the drying should be:

- Temperature of 65–70°C
- Medium wind speed for ventilation: 0.4–0.5 m/s (Jacquet M. et al 1980)

We have to distinguish an integral artificial drying from a drying after a pre-drying or a solar drying. The dryer types to be used are different. Directly after fermentation the cocoa beans are covered with rests of mucilage and water, what signifies that the use of classic materials which are used in driers for cereals is not appropriate. It is recommended to use aluminium (invulnerable), or possibly wood or plastic. (FAO 2006)

2.3 Dryer types

2.3.1 Non mechanical dryer types

2.3.1.1 Simple dryers, cement oven

The cocoa beans are placed on an oven; upon cement or tile floor, which is heated from the base of the oven with firewood. The beans are becoming smoky if the fire gets too hot and they get burned if they are not stirred. (Ecoport 2006)

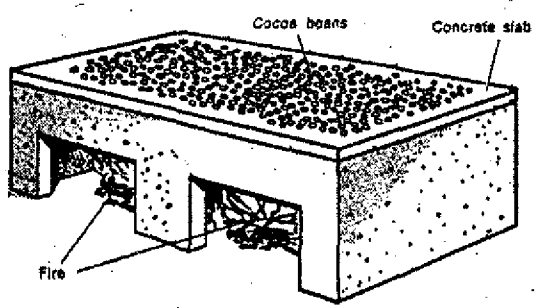


Figure 13: Concrete Slab Drier (FAO 2006)

In Cameroon the cocoa farmers are turning away from their cement ovens, because of:

- Tendency to crack the cement and allow smoke on to the drying beans
- Heavy demand for fuelwood (New Agriculturist On-line 2006)

2.3.1.2 *Hot-air dryer, Model SAMOA or BROOKS*

One of the best known hot-air dryers are the "Samoan" dryers or convection dryers. The Samoa dryer consists of a metal tube where the heat source is put:

- Furnace: where the fire is lit, use of wood, coal, diesel or fuel oil for heating
- Steel tunnel: heat is transmitted underneath drying deck
- Chimney: carries the smoke away from the beans
- Drying deck and mat (netted): platform where cocoa beans are spread

A Samoa dryer is working with air convection and is not including a ventilator. It is simple in constructions and has been used in Western Samoa, Cameroon, Brazil and the Solomon Islands. Other advantages are that the beans are dried with the necessary rapidity (if the construction is adapted, the temperature can be increased or be diminished easily) and great part can be constructed with common materials. Precautions have to be taken to avoid contamination with smoke (chimney sufficiently high and far away, drying platform and the smoke ducts impermeable). (New Agriculturist On-line 2006) (ICCO 2006) (Ecoport 2006)

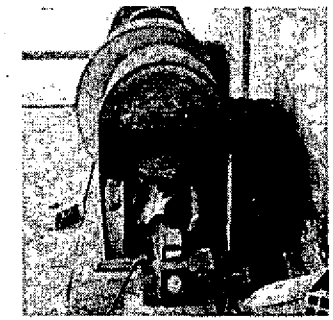


Figure 14: Cocoa drier fuelled by gas, heat is transferred into the metal pipe right of the burner. The pipe runs under a large tray (http://www.lava.com.au/index.html)

2.3.2 Mechanical dryer types

Mechanical dryers are used in larger plantations. They are only profitable if a large volume of cocoa is to be dried. An additional fan forces the hot air draught through the beans. (ICCO 2006)

2.3.2.1 Static dryer

Static dryers are often used in plantations. These consist of a drying platform (metal trellis or perforated plate). The hot air is coming from an exchanger generator supplied either with fuel or with wood. The fuel is used more and more for reasons of conveniences of use and adjustment of temperature.

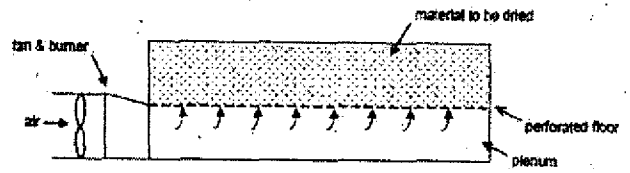


Figure 15: Static drier with ventilation, or trough dryer (GPEKS 2006)

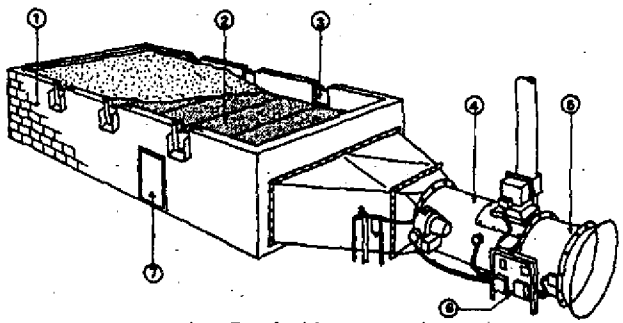


Figure 16: Static drier with ventilation

These static driers are generally of a low cost to purchase, but they show a few disadvantages:

- Little economic in use
- The air is not recycled
- The air leaves at the end of the drying after having crossed the layer of cocoa with too low relative moisture (poor thermal efficiency).

- No movement (turning) of the beans in the dryer → possible catch in mass of the cocoa (especially in wet phase of drying (60 to 30 % of water), difficulties to homogenize the mass

It is important to work with a thickness of layer as high as possible to dry the product economically (In general the layer is 30 to 40 cm). Anyhow this type of drier is especially useful when the product to dry has finished the fermentation process, in complement with solar drying. (FAO 2006)

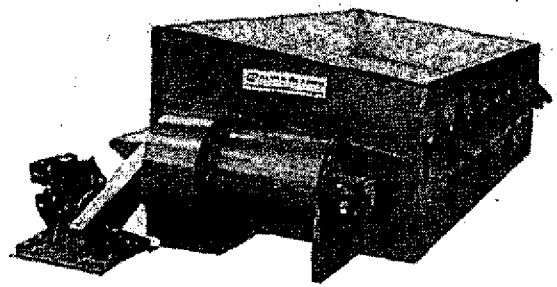


Figure 17: Batch Drier of Alvan Blanch (Alvan Blanch 2006)

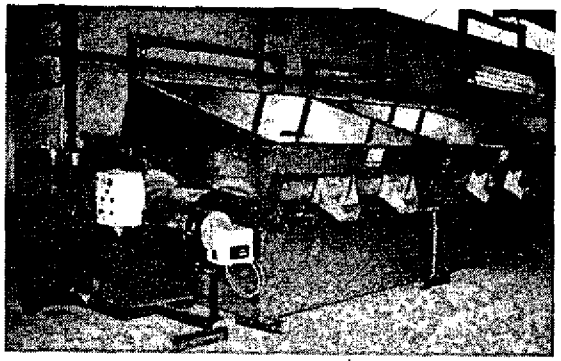


Figure 18: Batch Drier of Electra (Electra 2006)

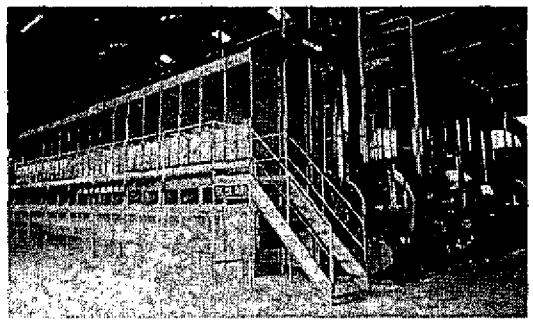


Figure 19: Static drying plants with sloping surface (Scolari 2006)

2.3.2.2 Movable tray dryers / Tunnel dryer

The beans are loaded on trays that are stacked on a movable truck. The dryer consists of an oven-like enclosure where the trucks are rolled into. The air flow through an inlet duct and is heated up to the drying temperature, then distributed from side to side, or bottom to top, in a circular motion. The movable tray dryer can be automated (with continuously moved trucks). (Ecoport 2006)

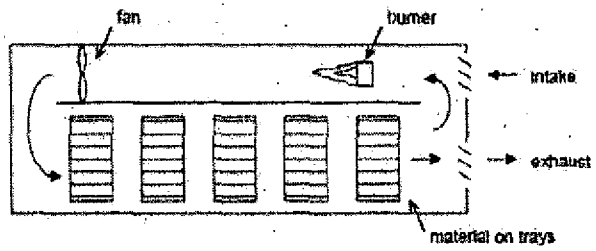


Figure 20: Tunnel dryer (GPEKS 2006)

2.3.2.3 Rotary dryer

The driers of the type "Guardiola" or "Okrassa" are often used especially in coffee-drying. They are composed of a perforated and compartmentalized cylinder, assembled on a frame. The beans are placed in the cylinder (rotary drum) which is rotating and moving the beans. The distribution of hot air is ensured by a perforated central tube or perforated radial tubes fixed on the hollow shaft coming from an external oven. The drying lasts 10 to

30 hours, depending on the initial moisture-content of the cocoa. It is advised to carry out a solar pre-drying of the cocoa beans during 24 hours to avoid plugging the perforations of the drum.

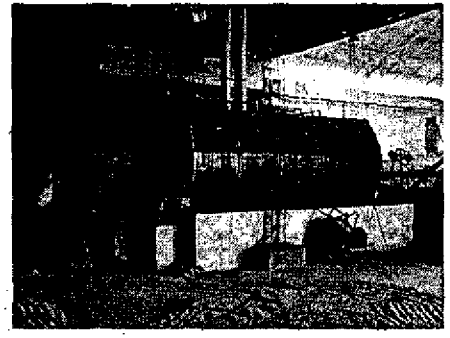


Figure 21: Rotary drier "Guardiola" in a coffee plant, Bolivia (CPTS 2004)

As disadvantages of the rotary dryer are to mention:

- High investment for the capacity of drying, equipment of this type is only profitable if a large volume of cocoa is to be dried
- Weak thermal efficiency
- High installed capacity (power) / kg treated cocoa
- Difficult filling and emptying (FAO 2006) (Ecoport 2006)

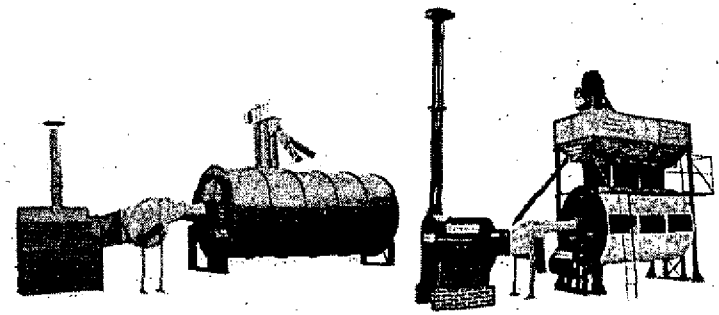


Figure 22: (left) Rotary cylindrical drier for coffee, cocoa and cereals of GRACIANO LTDA., Brazil (GRACIANO 2006)

Figure 23: (right) Rotary cylindrical drier for coffee, cocoa and other grains of PINHALENSE S/A, Brazil (PINHALENSE 2006)

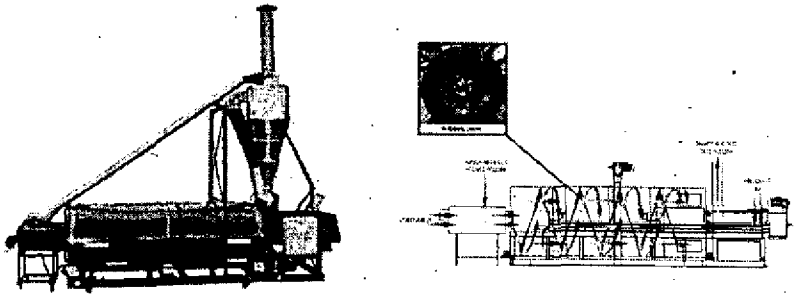


Figure 24: Batch rotary drier of Alvan Blanch (Alvan Blanch 2006)

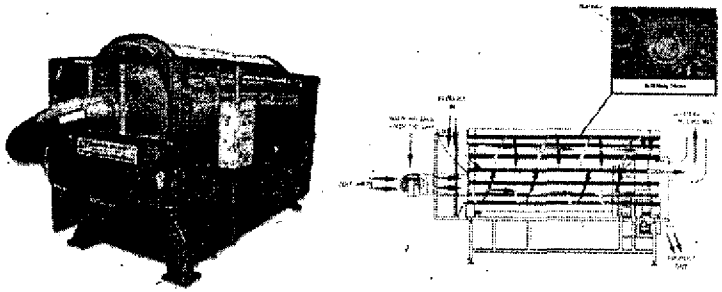


Figure 25: Continuous Rotary Drier of Alvan Blanch (Alvan Blanch 2006)

2.3.2.4 Conveyor belt dryer

In the conveyor belt dryer the material is transported on a perforated belt through the dryer. The hot air is passing under-and-through or over-and-through the belt and the product bed. The air then is reheated and recirculated. Usually these dryers have multiple zones and may have different airflow zones, different temperature profiles and control. At the end the saturated air leaves the dryer via a central exhaust duct. (Globalspec 2006)

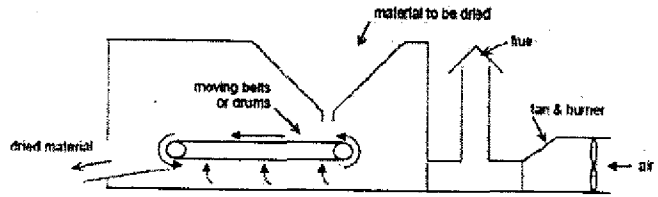


Figure 26: Belt or drum dryer (GPEKS 2006)

One belt drier

Figure 27: One-Belt Drier with alternating ventilation in the different zones of dryer (Stela 2006)

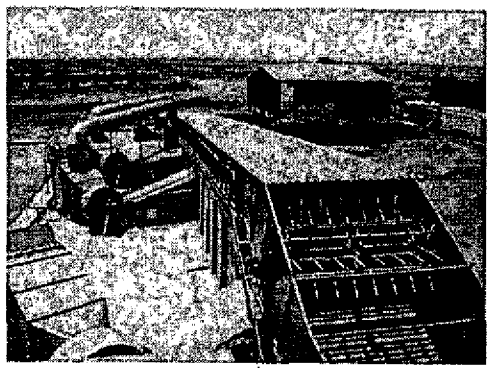


Figure 28: Single flow Conveyor Drier of Alvan Blanch (Alvan Blanch 2006)

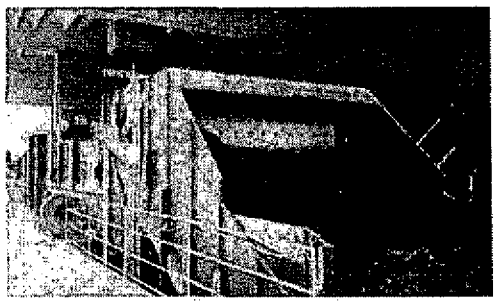


Figure 29: Horizontal drying plants with the mechanical removal of the product like cereals, vegetable seed, washed seed, maize seed, soy, colza, sunflower, shredded maize (Scolari 2006)

Two-belt drier with cooling zone

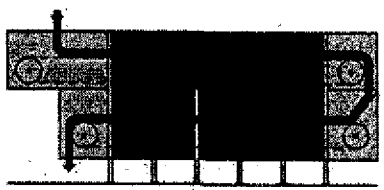


Figure 30: Two-Belt Drier (Stela 2006)

Pre-drying and main drying are carried out on the first belt, the final drying in the first section of the second belt. The last belt section is designed as cooling zone. (Stela 2006)

Multiple-belt drier

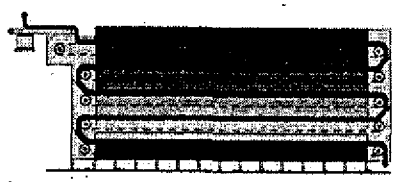


Figure 31: Multiple-Belt Drier (Stela 2006)

High drying capacities are achieved on small base areas. The moisture in products with a long retention time is distributed especially homogeneous because of the multiple mixing

when the product is delivered onto the following belts. The speed of every separate belt is infinitely variable by frequency converter. Thus the drier can be adjusted optimally to the product to be dried. (Stela 2006)

Feed-and-turn drier / Continuous flow drier

In this system hot air is blown through a double bottom and the product. The product is mixed and conveyed during the whole drying time by a mobile paddle mechanism. With a travelling mechanism the paddle wheel is moved across the drier for several times during the whole drying process, what guarantees an optimum mixing of the product and consequently a constant and homogeneous drying. The feed-and-turn drier can be operated in batch mode or continuous mixed flow drying mode. The batch drying is used for small and the continuous drying for large product quantities. (Stela 2006)

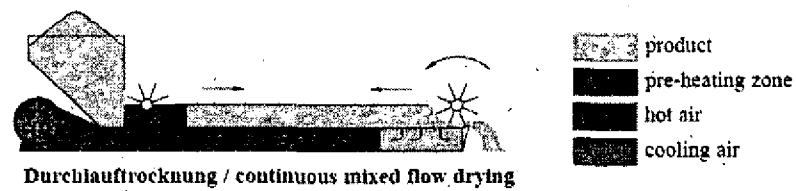


Figure 32: Feed-and-turn drier (Stela 2006)

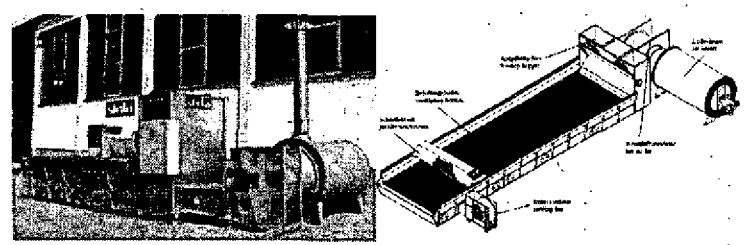


Figure 33: Feed-and-turn drier (Stela 2006)

The continuous double flow drier of Alvan Blanch consists of a conveyor mechanism with a trace chain and louvered bed. The double flow system works with a very high airflow and with low drying temperatures.

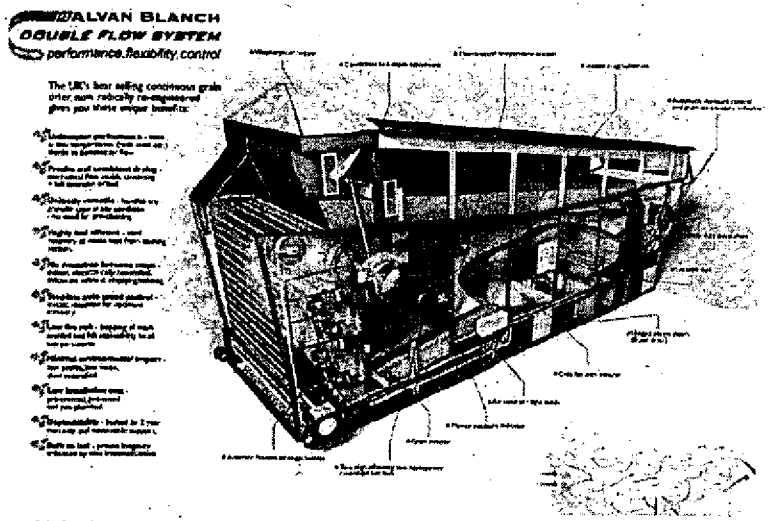


Figure 34: Continuous Double Flow Drier of Alvan Blanch (Alvan Blanch 2006)

Special features of this type of drier are:

- The product passes through the drier at a common speed.
- The moisture released from the drying bed and the warm exhaust air from the cooling section is recirculated to hot fans. Fuel consumption is improved up to 15 %.
- The bed depth can be adjusted to every crop (e.g. reduced depth for dense and very wet crop).
- The air volume can be partially restricted.
- The system has an auto speed control which adjusts the speed of the trace chain to the product moisture levels.
- The drier is controlled with a control system (relay logic or electronic control system). It is automatically shutdown for example in case of grain overheats. This allows an unsupervised operation.

Another manufacturer of continuous flow driers is Chief Industries UK Ltd. The driers are built in Sweden by Tornum.

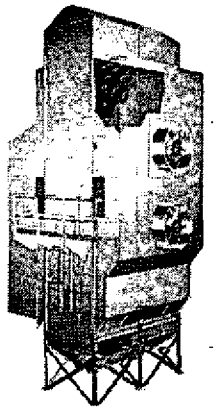


Figure 35: Continuous Flow Drier of Chief Industries UK Ltd. (Chief 2006)

2.3.2.5 Vertical type grain dryer

In warehouses, the vertical drier is often interesting because it allows:

- Important capacity and output
- Generally mayor thermodynamic efficiency
- Continued operation
- Mayor homogenisation of the product
- Easier control of the temperatures
- Possibility of recycling the air.

However, it is necessary to note the disadvantages:

- High investment
- Risk of fast corrosion
- Risk of fire hazards

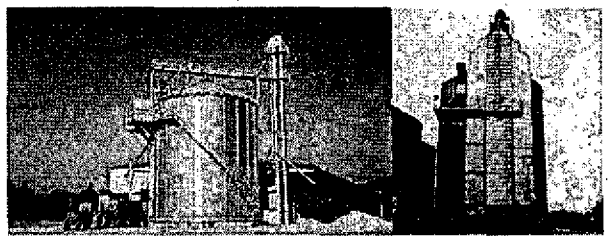


Figure 36: Scolari Top Dry plant for cereals in general, soy, sunflower, sorghum (Scolari 2006)

Figure 37: Scolari Vertical recycling and continuous drying plant for cereals (Scolari 2006)

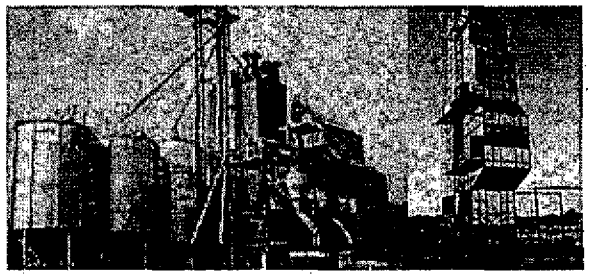


Figure 38: (left) Multi grain dryer range, LAW (PMS 2006)

Figure 39: (right) Multi-grain dryer range, SATIG (PMS 2006)

2.4 Automated Workshops

Fully-automated workshops can be used for fermentation, drying and packing of cocoa. These plants depend on a regular supply and volume of beans. One of the first fully-automated workshops has been put into practice by the IRCC in Cote d'Ivoire. This experimental plant can receive 20 to 25 tonnes of fresh seed per day. (Ecoport 2006)

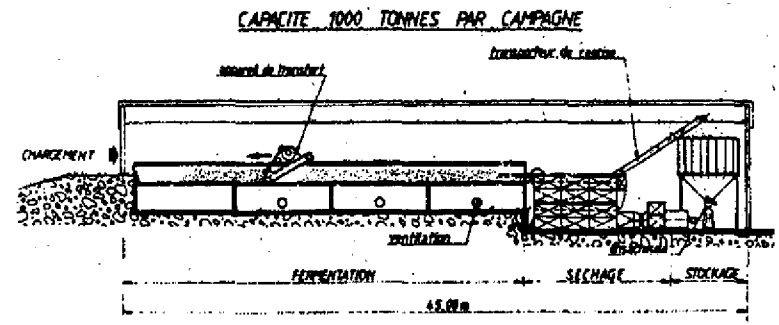
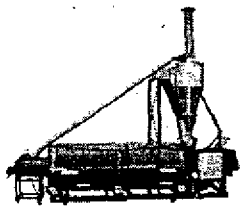
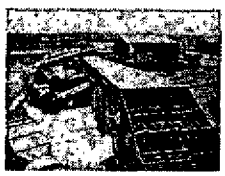


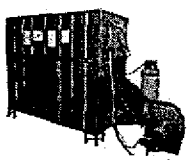
Figure 40: Plant for continuous treatment of cocoa (FAO 2006)

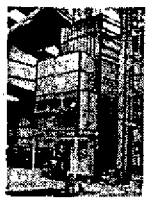
2.4.1 Suppliers and types of cocoa bean dryers

Company	Dryer Type & Capacities	Fuel type/furnace	Details & Costs	Direction / Contact
ALVAN BLANCH Development Co. Ltd, England	**Batch drier** 2.5-15 ton batches. Mobile batch driers: up to 5 ton batches.  Static twin bed drier, 2 beds working with a single fan/furnace: ideal for high moisture crops and allows uninterrupted drying	Automatic oil burner To avoid risk of burner emissions tainting the beans, a heat exchanger is an available option for all static driers.	Price single bed drier 2.5 tons capacity (with el. motor): 7'400 EURO Price single bed drier 2.5 tons capacity (with diesel engine): 11'100 EURO Price twin bed drier 5.0 tons capacity (with el. motor): 11'400 EURO Price twin bed drier 5.0 tons capacity (with diesel engine): 15'600 EURO Price heat exchanger: 7'800 EURO	CHELWORTH, MALMESBURY WILTSHIRE, SN16 9SG, ENGLAND T:+ 44 (0) 1666 577333 F:+ 44 (0) 1666 577339 E: info@alvanblanch.co.uk W: www.alvanblanch.co.uk Keith Eyles, E: keith.eyles@alvanblanch.co.uk Neville Boulton, E: neville.boulton@alvanblanch.co.uk
	Rotary drier 0.8-3.7 ton/hr capacity at 90°C	A full temperature control is possible with two automatic pressure-jet burners (can be fuelled by diesel, gas, heavy oil or multi-fuel options). The dryer can be linked to fired furnaces, heat exchangers or incorporating high or low grade heat from CHP systems.	The fuel consumption is improved by up to 15 % because of air recirculation. And with multiple fans drying, efficiencies can be even more optimised.	

Company	Dryer Type & Capacities	Fuel type/furnace	Details & Costs	Direction / Contact
				
	Conveyor drier Output 8 – 26 t/hr dry maize (45-15%) 	Diesel, gas, heavy oil, multi fuel options. Can be linked to fired furnaces, heat exchangers or CHP systems. The standard furnace is diesel oil fired. The drying temperature may be obtained within a few minutes.	This dryer could be adapted simply and rapidly from grass drying to grain drying, almost all sizes of grain and granular materials may be dried. It can be constructed with local brick and galvanised steel sheets.	
	Continuous flow drier Double flow drier capacity: 12-100 ton/hr Mobile continuous driers: 12-25 ton/hr		See for details in Cap. 2.3.2.4	

Company	Dryer Type & Capacities	Fuel type/furnace	Details & Costs	Direction / Contact
				
ASTRA, India	Batch tray drier	Fuel efficient biomass burning	The drying of cocoa beans was successfully tested (indiaagronet 2006)	Centre for Application of Science and Technology to Rural Areas (ASTRA), Indian Institute of Science in Bangalore Direction not knowed
CHIEF Industries U.K. Ltd, England	In-bin dryer	Waiting for reply	Waiting for reply	Beckingham Business Park, Maldon, Essex. CM9 8LZ. ENGLAND T: 00 44 (0) 1621 868944 F: 00 44 (0) 1621 868955 E: info@chief.co.uk W: www.chief.co.uk Geoff Freed E: geoff@chief.co.uk
	Continuous flow dryer 	Waiting for reply Natural gas LPG and other alternatives for heating the dryer	Waiting for reply When there are large quantities of grain to be dried. Holding capacities of 17 -97 m^3, min. 4.3 tons/h drying capacity at 65°C. Output rollers for controlled discharge. Separate cooling zone with a ventilating axial fan. Close spaced lateral system for even drying and good heat economy. Smooth insides for simple maintenance and a good working environment. Hot- dip galvanised	

Company	Dryer Type & Capacities	Fuel type/furnace	Details & Costs	Direction / Contact
			sheet steel for long life. Easy-assemble construction. Level monitors and a moisture controller that adjusts the dryer's output to ensure constant final moisture content. (Tornum)	
Electra, France	Batch 250 BASCULANT, 2.5x2x1.4m, 5 m^2 	Waiting for reply	Electric Motor: 5 HP	47170 POUDENAS - FRANCE T: 05 53 65 73 55 F: 05 53 97 33 05 E: elevage@electra.fr W: www.electra.fr
Industrias Fimar, Colombia	Vertical dryer for cocoa & coffee with two chambers: dryer and pre-dryer 	Wood, Carbon, Gas, Diesel	Recommended for yearly coffee productions exceeding 500 arrobas Capacity 750 kg to 11'000 kg	Calle 23 No. 17-14. San Gil Santander, Colombia T: (57-7) 7242716 F: (57-7) 7242985 W: www.industriasfimar.com, E: indfimar@hotmail.com
FAO Fumé Industries SA,	Continuous, vertical, mixed-	-	-	5, rue Jean-Marie

Company	Dryer Type & Capacities	Fuel type/furnace	Details & Costs	Direction / Contact
France	flow dryer 			*Texier, ZI de la* Fréminière BP 90210, 35502 Vitré Cedex France T: 00 (33) 2 99 75 73 00, F: 00 (33) 2 99 75 73 20 E: fao.direction@fao.fr W: www.fao.fr
GRACIANO, Indústria e comércio Ltda., Brazil	Rotary cylindrical Drier for coffee, cocoa and cereals 	For the burning of husk, firewood and others (including a cyclone and a fan)	Capacity range: 6m^3 (6000 L/H) - 15m^3	Av.Conde Francisco Matarazzo, 502, Parque Industrial José A. Boso, CEP: 15.803-145 Catanduva-SP / BR T/F: (17) 3522.5150 E: maqgraci@terra.com.br
PINHALENSE S/A *Maquinas Agricolas, Brazil*	Rotary dryer for coffee, *cacao, grains* 	-	uniform drying; short drying time; *quick loading and unloading; fuel* savings; coffee husk burning; great durability	Rua Honório Soares, *80, Espírito Santo do* Pinhal – São Paulo, Brazil T: (19) 3651-9200 F: (19) 3651-9204

Company	Dryer Type & Capacities	Fuel type/furnace	Details & Costs	Direction / Contact
	Capacity range: 1.6 m^3 (1600 L) -15 m^3			E: peamarketing@peamarketing.com.br W: http://www.pinhalense.com.br/
PMS Industries S.A., Luxembourg	LAW multi grain dryer range, semi-industrial: 25-600 T/24h SATIG multi grain dryer range, industrial: 400-2500 T/24h	Gas, diesel, heavy oil, steam, electricity, coal, wood, straw, etc.	Continuous drying or re-circulating drying	PMS Industries S.A. 241, street Arlon, L 1150 Luxemburg T: +352 26 32 14 03 F: +352 26 32 14 04 E: info@pms.lu W: www.pms.lu
Suncue Company Ltd., Taiwan	Ventilating type dryer 	Diesel or kerosene; no gas or biomass type	Widely used for drying cocoa in other countries & well recommended	105 Ren Hua Rd, Da Li, Taichung, TAIWAN, T: 886-4-2496 6699, F: 6688, E: suncue@ms10.hinet.net, W: www.suncue.com
STELA Laxhuber GmbH, Germany	Feed-and-turn drier for corn, wheat, cocoa bean STELA MS 5 and STELA MS 70 Rated Capacity MS 5: 1 to per h, MS 70: 5 to per h	Fuel Type: Natural gas Burner capacity MS 5: 233 kW, MS 70: 965 kW indirect heating Airflow Rate MS 5: 11.000 m³/h,	The feed-and-turn drier is used for small and medium-sized quantities. It is a good alternative for the belt drier in the medium range of capacity from approx. 1000 kg/24 h up to approx.	Öttingerstr. 2, D-84323 Massing, T: +49 (0)8724/899-0, F: +49 (0)8724/899-80, E: sales@stela.de, W: www.stela.de,

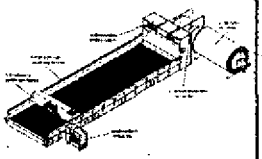
Company	Dryer Type & Capacities	Fuel type/furnace	Details & Costs	Direction / Contact
	Dimension MS 5: 6 x 1,5m, MS 70: 12 x 3m 	MS 70: 65.000 m³/h	15000 kg/24 h. The beans are moved by feed-and-turn device Retention Time at rated capacity is 360 min Total Electrical Power MS 5: 11 kW, MS 70: 50 kW Costs MS 5: 40.000.- €, MS 70: 150.000.- €	Yves-Marc Schade schade@stela.de

Table 1: Suppliers of mechanical driers

3 Alternatives in cocoa drying

3.1 Plastic sheeting

The Italian chocolate company ICAM introduced in a project in Uganda the use of plastic sheeting for the sun drying of cocoa beans. The plastic sheeting, which is converting the sun's ultraviolet rays to infrared, is suspended on an aluminium frame above the beans. In this method, the beans which are raked out on mats under special polyethylene sheets are heated to 50-60°C. In this project the sheeting costs US$60.000, which is too expensive for growers but within reach for exporting firms. (Ehponline 2006)

3.2 Roof integrated panels for Crop Drying System

Commercial dryers on the market have generally been designed for use with oil, propane, wood or steam as the heat source. Burning fuel produces higher temperatures than necessary and the actual dryer efficiency may be low since a lot of the heat is not utilized. Some dryers may need to be modified to enable them to operate with lower temperature air below 60°C which is better suited for solar heating and which would also minimize wasted heat and increase dryer efficiency. Solar panels can be added to the roof or walls of buildings, housing, existing dryers and the panels would either heat or preheat the air entering the fan and dryer. A solar dryer for cocoa beans will handle approximately 5-6 kg/day (initial average moisture content of 50% and a final mc of 7%) for each square meter of solar collector. (GPEKS 2006)

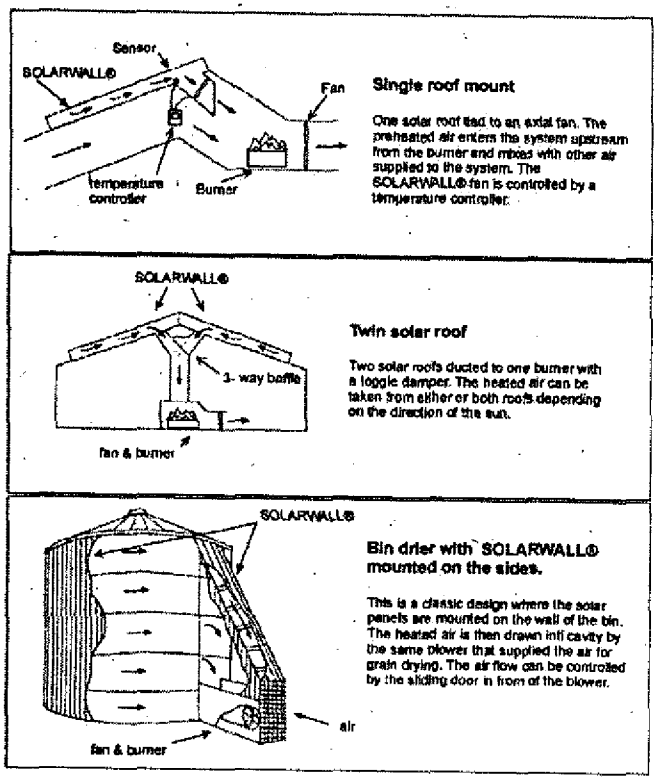


Figure 41: SOLARWALL Drying system (GPEKS 2006)

4 Recommendations

Mechanical dryers are only profitable if a large volume of cocoa is to be dried. We have to distinguish different types of driers which could be appropriate for drying cocoa beans like: Simple dryers (cement oven), Hot-air dryer (SAMOA or BROOKS), Static dryer with ventilation, Movable tray dryers (Tunnel dryer), Rotary dryer, Conveyor belt dryer and Vertical type grain dryer. There are many companies manufacturing dryers, but only few are experienced with cocoa beans. On the other hand the expected quantity of beans in the present Vietnamese project is little and not in the range of some available dryers.

It can be concluded that there is a wide spectrum of grain dryers available. For our application of only 1-2 tons of cocoa beans per day, there are almost no industrial driers on the market. Experts say that for that quantity the capital costs of rotary dryer and continuous flow dryers are too high. The only economic dryer is the batch drier. It can be operated with manual labour for loading and unloading and can be repaired locally (Mr. Keith Eyles, Alvan Blanch). Mr. Neville Boulton of Alvan Blanch recommends drying the beans in a batch dryer at 60°C or below. He says that drying above this temperature will result in excessive moisture differential between the top and the bottom layer of the bed what result in over-drying in the top layer. Usually about 1-2% moisture reduction is achieved per hour.

Mr. Geoff Freed of Chief Ltd. recommends a floor drying system like the in-bin drying with different stages (Drying time 4-5 days, 4 stages, moved beans) He says that the experience of continuous dryer for drying cocoa beans has showed good results, but the quantity of damaged beans is higher in continuous flow driers than in the batch drying process because of the quicker and shorter drying time. He mentions that all types of burner except gas should be indirectly fired (with air to air heat exchanger). His previous experience has been that the direct fired propane gas burners has been acceptable for most "flavour sensitive" crops, but to not have a problem "playing it safe" means to stick only to an indirectly fired option (Mr. Geoff.Freed, Chief Ltd. UK).

Financial calculation with all details should be realized and be analyzed the use of wood or dried shells in the furnace or other alternative combustible that would be ecologically and economically feasible.

In any case it is recommended (if possible) to carry out at least a solar pre-drying of the cocoa beans with solar panels or with a system with rain protection (cover, plastic tarp...).

5 Literature

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Chief (2006)	Chief Industries, www.chief.co.uk
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Ecoport (2006)	http://ecoport.org/ep?PlantI=2074&entityType=PLCR*"&entityDisplayCategory=full
Electra (2006)	www.electra.fr
Ehponline (2006)	http://www.ehponline.org/docs/2005/113-8/forum.html
FAO (2006)	http://www.fao.org/Waindocs/x5164F/X5164f12.htm#c%20-%20s%E9chage%20du%20cacao http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/006/AD220E/AD220E06.htm coffee and cocoa processing: http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/006/AB780E/AB780E04.htm
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Pinhalense (2006)	www.pinhalense.com.br/
PMS (2006)	PMS Industries S.A., www.pms.lu
SCI (2006)	"Quality of cocoa beans dried using a direct solar dryer at different loadings", Ching L Hii et Al 2006, Journal of the Science of Food and Agriculture
Scolari (2006)	www.scolarisrl.com
Stela (2006)	STELA Laxhuber GmbH, www.stela.de
TIS (2006)	Transport Information Service, GDV Die Deutschen Versicherer, www.tis-gdv.de/tis_e/ware/genuss/kakao/kakao.htm#informationen
VNCPC (2006)	Viet Nam Cleaner Production Centre, information from Le Xuan Thinh, thinh.lx@vncpc.org, june 2006
Wikipedia (2006)	http://en.wikipedia.org http://de.wikipedia.org
WOT (2006)	www.wot.utwente.nl

6 Annex

6.1 Annex 1: General data and requirements for Cocoa bean dryer

GENERAL DATA	
Grain types to be dried	Cocoa beans (raw cacao after fermentation)
Quantity cocoa beans to dry [ton/day]	Case 1: 1 - 2 ton/day, case 2: 10 ton/day
Starting moisture content bean [% w.b.]	Max. 60 %
Country	Vietnam
Location	Dong Nai
Beginning and ending of rainy season	May to October
Harvest period of cacao bean	November to April (main harvest season), sub-season in august (less quantity), harvesting during every time the year
Climatic conditions, Relative humidity [%, range]	50 – 80
Climatic conditions, Temperature [°C, range]	25 – 35
REQUIREMENTS FOR DRYING	
Final average Moisture Content [% w.b.]	7 - 8 %, max. 8 %
Bean temperatures during the drying	(< 55 °C)
Medium wind speed for ventilation	(0.4-0.5 m/s)
Combustible (organic residues, wood, fossil fuel)	Biomass or gas preferred
	Low demand for biomass, gas, fuelwood
Drying process	No risk of corrosion
	No risk of fire hazards
	No catch in mass of the cocoa (especially in wet phase of drying with 60 to 30 % of water)

QUALITY REQUIREMENTS COCOA BEAN	
The flavour is the critical quality standard	No smoky odour, no contamination from the smoke / combustion gas
	No developing of off-flavours
	No mechanical damaged shell

6.2 Annex 2: List of criteria for selecting cocoa bean - dryer

Additionally to the general dryer specification of the company there are certain specifications asked to be given:

DRYER SPECIFICATION FOR 1 - 2 TON COCOA BEAN TO DRY / DAY	
Dryer Type	
Dryer Dimensions	
Grain types that can be dried	
How are beans moved? (homogenization of the product)	
Rated Capacity [t/h]	
Retention Time (duration of drying) at rated capacity [h]	
Min. and max. duration of drying process [h]	Min.: Max.:
Drying Air Temperature [°C]	
Maximum Bean Temperature during drying [°C]	
Fan Characteristics [kW]	
Airflow Rate [m^3/t], Medium wind speed for ventilation	
Recirculation of air, recycling of the air	
Relative moisture air leaving the dryer	
Danger that smoke or combustion gas comes in contact with the beans?	
Fuel Type	
Burner capacity [kJ/h]	
Heat exchanger	
Specific Energy Consumption [MJ/kg]	
Energy efficiency, thermal efficiency	
Total Electrical Power	
Control system	
Control of the temperature	
Control of moisture	
Control of speed, auto speed control?	
Shutdown for example in case of grain overheats?	

University of Applied Sciences
Northwestern Switzerland

Drying of cocoa beans

Materials which are used in drier-construction	
Costs dryer, investment (estimation)	
Operation costs/year (estimation)	
Maintenance costs/year (estimation)	

6.3 Annex 3: List of contacted companies

Company	Type of dryer	Response	E-mail contact homepage
AEROGLIDE Corporation, USA	Continuous, vertical, mixed-flow dryer	No answer	sales@aeroglide.com www.aeroglide.com
AGREMO, Poland	Column, vertical dryer	No answer	agremo@agremo.pl www.agremo.pl
AGREX Spa., Italy	Mobile, recirculating dryer	No answer	info@agrex.com www.agrex.com
AGRIDRY, Australia	Continuous,vertical, mixed-flow dryer, Batch, mobile dryer	No answer	mail@agridry.com.au http://www.agridry.com.au/
AGRIMEC S.r.l., Italy	Grain dryers: Mobile, batch, cylindrical dryer	No answer	info@agrimec.net, http://www.agrimec.net/
AGRINDO P.T. Agrindo Ltd., Indonesia	IRRI batch dryer	No answer	agrindosby@indo.net.id www.agrindo.com
AB AKRON Maskiner, Sweden	Continuous, vertical, mixed-flow dryer	No answer	info@akron.se www.akron.se
ALLSIZE Perforating Ltd., Canada	Natural Air Grain Drying System	No answer	allsize@escape.ca www.allsize.com/
ALVAN BLANCH Development Co. Ltd, England	Continuous, vertical dryer, batch dryer	Recommend batch dryer	info@alvanblanch.co.uk, www.alvanblanch.co.uk http://www.alvanblanch.co.uk/graindrying.htm
BONFANTI R. Bonfanti Impianti Agro-Industriali, Italy	Continuous, vertical, mixed-flow dryer	No answer	info@rbonfanti.it www.rbonfanti.it
CHIEF Industries U.K., Ltd, England	Continuous, vertical, mixed-flow dryer, Batch; recirculating dryer, in-bin dryer	In-bin dryer is recommended, the % of damaged beans is smaller than with the continuous flow dryer	info@chief.co.uk www.chief.co.uk

Company	Type of dryer	Response	E-mail contact homepage
CIMBRIA Unigrain A/S, Denmark	Continuous, vertical, mixed-flow dryer	No answer	unigrain@cimbria.com www.cimbria.com
Electra, France	Batch Dryer	No answer	www.electra.fr
FAO Fume Industries SA, France	Continuous, vertical, mixed-flow dryer	No answer	fao.direction@fao.fr www.fao.fr
FEERUM, Poland	Continuos, vertical, mixed-flow dryer	No answer	feerum@feerum.pl www.feerum.pl
GRACIANO, Indústria e comércio Ltda., Brazil	Rotary dryer	Not contacted	http://66.39.146.46/index.php
GOLDSAAT Agrartechnik GmbH, Germany	Continuous, vertical dryer, Continuous horizontal dryer	No answer	goldsaat@t-online.de http://www.goldsaat.de/
HIGH BEAM Engineering Co. Ltd, Thailand	Continuous,vertical,mixed-flow dryer, Recirculating, batch dryer	No answer	ittivat@highbeamthai.com www.highbeamthai.com
HAN SUNG Industrial Co. Ltd., Korea	Recirculating, vertical dryer	No answer	hs21@hs21.co.kr www.hs21.co.kr
HSHJRFL, Harbin Songhuajiang Hot Air Stove Factory, China	Vertical, tower grain dryer	No answer	hshirfl@hshirfl.cn www.hshirfl.cn
Industrias Fimar, Colombia	Vertical dryer for cocoa & coffee with two chambers: dryer and pre-dryer.	Not contacted	indfimar@hotmail.com www.industriasfimar.com
JAMANDRE Industries, Inc, Philippines	Rotary, flash, rice dryer	Not contacted	jamandreindustries@yahoo.com
KASET PHATTANA INDUSTRY Co. Ltd, Thailand	Recirculating, batch dryer	No answer	sales@kpn.co.th www.kpn.co.th
Kentra Grain Systems Limited, England	Continuous, vertical, mixed-flow dryer	dryers are not suitable for the drying of Cocoa	barryh@kentra.co.uk info@kentra.co.uk

Company	Type of dryer	Response	E-mail contact homepage
Kongskilde Maskinfabrik A/S, Denmark	Continuous, vertical, mixed-flow dryer, In-bin, recirculating dryer, Batch, flat-bottom dryer	Not within their product range or knowledge	med@km.kongskilde.com www.Kongskilde.com
LAW-DENIS Engineering Ltd., England	Continuous, vertical, mixed-flow dryer	No answer	law.denis@virgin.net http://www.law-denis.com/
MIKROTHERM Ltd, Hungary	Continuous, vertical, mixed-flow dryer, Batch, recirculating dryer	No answer	info@mikrotherm.hu www.mikrotherm.hu
PADISCOR Pasig Agricultural Development and Industrial Supply Corp., Philippines	Batch recirculating dryer	No answer	phed@bpre.com padiscor@tri-isys.com
F.lli PEDROTTI, Italia	Mobile, cylindrical, recirculating dryer	No answer	info@pedrottisrl.it www.pedrottisrl.it
PINHALENSE S/A Maquinas Agricolas, Brazil	Rotary dryer (coffee, cacao, grains)	Not contacted	peamarketing@peamarketing.com.br http://www.pinhalense.com.br/
PMS Industries, Luxembourg	LAW multi grain dryer range, semi-industrial: 25-600 T/24h SATIG multi grain dryer range, industrial: 400-2500 T/24h	Not contacted	info@pms.lu www.pms.lu
RAKO Maschinenbau GmbH & Co. KG, Germany	vertical dryer	cannot supply the desired product	post@rako-sulingen.de rako-sulingen@t-online.de www.rako-sulingen.de
RIELA, Karl-Heinz Knoop, Germany	Continuous, vertical, mixed-flow dryer, cylindrical dryer, Roof batch dryer	No experience with cocoa but with crops like wheat, maize,	info@riela.de www.riela.de

Company	Type of dryer	Response	E-mail contact homepage
		sunflower	
SCOLARI Essiccatoi Scolari F.lli s.n.c., Italy	Continuous, vertical, mixed-flow dryer, Flat-bed, continuous dryer	never produced any drying equipment for cocoa beans, need to receive sample of the product	info@scolarisrl.com www.scolarisrl.com Maize dryers of the Scolari type have been used successfully to dry cocoa beans evenly. The layer of beans is subjected to a stream of hot air and the cocoa is agitated mechanically. (Ecoport 2006)
STELA Laxhuber GmbH, Germany	Feed-and-turn drier, Continuous, vertical, mixed-flow dryer, Rotary, tubular dryer	Sent specification of dryer with cost estimation	schade@stela.de sales@stela.de www.stela.de
Suncue Company Ltd., Taiwan	Recirculating, vertical dryer	Sent foto but no specification	suncue@ms10.hinet.net www.suncue.com
Termoplin, Serbia and Montenegro	Drying equipment, tobacco drying chambers	No answer	office@termoplin.co.yu www.termoplin.co.yu
Tornum, Sweden	Continuous flow dryer	No answer	http://www.tornum.se/
VETAL – Agro Division, India	Automatic vertical grain dryer (rice)	No answer	vetal@vsnl.com www.vetal.com
F.lli Zaffrani s.a.s.	Mobile, cylindrical, batch dryer	To be as precise as possible and to be aware of the dimension of the bean, they would need to see the product.	zaffrani.estero@tiscali.it f.lli.zaffrani@mercurio.it www.zaffrani.it

Annex 6 Master students certificates FHNW

Fachhochschule Nordwestschweiz
Hochschule für Life Sciences

This is to certify that

Mrs. Ngo Thi Ngoc Thuy

born on June 6, 1981

Master student at Hanoi University of Technology, Vietnam

has accomplished the Master thesis in the framework of the post graduate educational programme of FHNW - Switzerland on

Recycling of electronic scrap: recovery of valuable metals from printed circuit boards

From February 11 to August 10, 2006

at the

University of Applied Sciences Northwestern Switzerland (FHNW)
Institute for Ecopreneurship
Muttenz, Switzerland

J. Walder

Jürg Walder

Tutor

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Fachhochschule Nordwestschweiz
Hochschule für Life Sciences

This is to certify that

Mrs. Vu Minh Trang

born on May 26, 1980

Master student at Hanoi University of Technology, Vietnam

has accomplished the Master thesis in the framework of the post graduate educational programme of FHNW - Switzerland on

Treatment of textile dyeing baths with membrane technology for reuse of water and chemicals

From February 11 to August 10, 2006

at the

University of Applied Sciences Northwestern Switzerland (FHNW)
Institute for Ecopreneurship
Muttenz, Switzerland

Jürg Walder

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This course was supported by UNIDO and FHNW

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