Product Development and Processing of Lesser Used Timber Species

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Introduction

This presentation is a concentrate of the experiences gained from the Product Development Segment in the ITTO-TEDB-FORIG Project "Industrial Utilisation of Selected Ghanaian Lesser Used Timber Species". The completed project segment is presented in three reports:

- Phase I: Furniture Production, April-May, 1996.
- Phase II: Product Development, August-September 1996.
- Phase III: Product Development Completion, July-September 1997.

In the beginning of the project, some 16 different Lesser-Used species were identified as potential useful species. During the progress of the project, this number was scaled down for a number of reasons, as we have heard and will hear more at this conference. When this segment of the project started in April 1996, the following species were selected for down-stream processing:

Species	Density
Ceiba (*Ceiba pentandra*)	304 kg m^3
Kyenkyen (*Antaris toxicaria*)	432 kg m^3
Celtis (*Celtis mildbraedii*)	751 kg m^3
Essia (*Petersianthus macrocarpus*)	814 kg m^3
Denya (*Cylicodiscus gabonensis*)	958 kg m^3

The Terms of References for this segment included the following areas:

- Manufacture of Furniture
- Manufacture of Parquet Flooring Panels
- Manufacture of Pallets; and should include:
  - Machining Characteristics
  - Gluing Properties
  - Finishing Properties

Product Development

Garden Furniture

At the start of this project segment, we identified garden furniture as the most suitable prototype furniture, for a number of reasons:

- The timber made available had a moisture content (MC) ranging from 15 to 25% while the production of indoor furniture requires a MC below 10%.
- Very few, if any, industry in Ghana has adequate resources in the form of management/personnel skills, drying capacity, machines or quality standards to embark export of indoor furniture.
- The knock-down concept, which is a prerequisite for furniture production for export, is not yet established within the furniture industry in Ghana.
- The international furniture market is extremely competitive and requires a thorough market intelligence on actual fashions, trends, designs etc. An introduction of LUS requires an extensive and professional marketing campaign. At this stage of the project this would be premature venture to undertake

- Garden furniture and related products on the other hand can be produced with less sophisticated equipment and quality standards are less stringent.
- Export of garden furniture, made from LUS, could be achieved within a relatively short period, approximately 1 to 2 years while export of indoor furniture would take considerable longer time due to the need of solid transfer of know-how to the industry.

In the production of prototype garden furniture it was our ambition to include as much as possible of industrial applications, such as:

- Production and Raw material Economy
- Aesthetic and Functional design, without compromising on comfortability and durability.
- Marketability

The collection of prototype garden furniture consist of the following items:

- Round and rectangular dining table
- Coffee table
- Armchair
- 3-seatee Sofa
- Sunbed

Various items of the garden furniture collection has been produced in four different LUS:

- *Ceiba*
- Kyenkyen
- *Celtis*
- Essia.

Some of the items have a mixture of LUS e.g. *Ceiba* for slats, Kyenkyen for frame (for lightweight reason) and *Celtis for legs* (for durability). From Product Development point of view the most beautiful and attractive prototype furniture produced in the project is an armchair made in Essia. No doubt, this LUS has a brilliant future as a raw material for furniture.

Garden Accessories

Deckboards, which is a huge consumption product throughout Europe with several millions of deckboards sold every year, have been produced in *Celtis*, Kyenkyen, Dahoma, Essia and Denya. This product is very easy to produce, compact in format with approximately 4000 boards to fill a 40' container. The samples of the deckboards have been impregnated, some with colourless protection to enhance wood texture, some impregnated with CCA. The result is a combination of beautiful deckboards, each species with is own beauty in colour and texture. Modelling with different species, or same species in different impregnation, is creating an additional attraction of the deckboards.

The most beautiful deckboards is made from Denya, which exceeds e.g. teak with its lively texture and attractive colour. The high density however makes it somewhat difficult to produce. Both machining and assembly is a bit complicated. With TCT tooling in the machines and pre-drilling for the nails, this problem is possible to overcome. Its solid weight in combination with appetising texture would make this deckboard highly attracted around the world. Another suitable species for deckboards is Essia, although not so durable as Denya but still attractive. The other species could be used as well but durability and wood texture makes them less attractive.

Parquet Flooring Panels

The project was fortunate to be allowed access to professional parquet producing machines at FABI Timber Ltd in Kumasi for the trial production of parquet strips. Three species were tested, Celtis, Essia and Denya. The other two were judged to be too light and soft to sustain the wear and tear of a flooring material. The test results indicate that Essia and Denya can be used for parquet strips while Celtis will be less economical attractive due to an abnormal reject percentage, mainly from a common discoloration (grey staining). Denya on the other hand might be difficult to produce due to its density and therefore might be rejected by the producers. The location of a parquet-moulding factory in Kumasi is a great advantage for continued trials with production of parquet panel made from LUS.

Pallets

Pallets have been produced in Kyenkyen and *Ceiba* according to the European standards plus one of the most commonly used in ASEAN and accordance with the ISO standard Serie 1: Information gathered about the use of pallets in Ghana reveals that pallets are used very sparsely. The industry appears not yet have started to appreciate the benefits of palletised handling. Large processing industries such as GHACEM (cement industry) have their production adopted to completely without pallets. Other production industries have some internal palletised transport but the pallets are made in various formats and mostly from scrap wood. In the dissemination of the LUS project to the industry it is therefore important that the benefits of the use of pallets for internal as well as for logistics is given a predominant role.

From material point of view, Kyenkyen appears to be durable enough, even to meet rigid EU standards. Celtis and Essia has been judged to be "too exclusive" to be used in such a low-grade product as pallets. Ceiba is yet to be tested as pallet material. Together with the pallet trial, some collapsible pallet collars, which are part of the European exchange system, were also produced. The price calculations shows that a Ghana made pallet can compete with Europallets produced in Europe from low grade spruce or pine, although those pallets are made in highly automated lines with a capacity of approximately 15 000 to 25 000 pallets per shift. The market price in Europe has for a long time been established around US$ 9. A similar pallet produced in Ghana could be landed in Europe for around US$ 7,50, including a 25% net profit for the producer. The major obstacle to overcome, however, is the very high standards, which in certain areas are more rigid than the BSI standards for furniture. All Europallets carries a burnt-in seal, which is a guarantee for its acceptance as an interchangeable pallet throughout Europe.

One possibility to get around this obstacle could be to make direct offers to mega-users of pallets such as the car industry (FIAT, VW, Opel, GM, FORD, VOLVO etc.) The only competing means would however be the price in combination with reliable deliveries in time and quantities.

More scientific testing of the pallets such as drop test or nail holding capacity has not been carried out for the simple reason that standards (ASTM-BSI-ISO) has not been available at FORIG. Nails of suitable quality for pallet production is not available on the local market and a pulling test machine is not yet installed at FORIG. The local available nail does not provide sufficient holding capacity compared with nails used in pallet production e.g. in Europe. Any testing of pallets assembled with local nails would therefore not reflect the actual durability of the wood species used in the pallet.

Dowel Production

By courtesy of Mr Simon Saoud, MD of A.E. Saoud Ltd., who had imported a new set of dowel making machines, some tests on dowel production from LUS were made. Counterparts at FORIG have taken part in the tests, including the machine technique, operations and maintenance.

Two species, Essia and Celtis were selected for the tests. The other species were judged on characteristics already known not to be suitable for dowels.

Part of the sticks was dried to approximately 6% MC before milling, while the remaining sticks were milled at Equilibrium Moisture Content (EMC) of approximately 15%.

Already at the first stage of milling, it became apparent that Celtis is not at all suitable for dowels. All test samples, both dried and EMC sticks broke into splinters when machined.

Also Essia showed the same tendency, although not so frequent but enough of breaking/splitting to discourage it from dowel production. The few dowel rods produced appeared with an unacceptable rough surface.

As a comparison, a third specie -Danta- was also used with some sticks dried to 6% MC and the rest at EMC. Noticeable better smoothness appeared on the dried sticks which confirms that extra dried wood results in better, and stronger, dowels and less breaking in the machine. The dowels made from Danta will now be used in the furniture samples that will be exposed to fatigue tests in the furniture testing rigs. It has also been introduced to the group of manufacturers tendering for the supply of school furniture to UST.

One more specie, Mansonia, was tested in a small volume. The sticks had been dried to an MC of 9% and the results came out even better than Danta. The dowels will be used in the prototypes made for fatigue testing in order to determine its strength in the joints.

Two more species, Teak and Koto, will also be tested for dowel production as soon as they have been made available and dried.

Continued Product Development

As some of the LUS has been identified as suitable for furniture, a more detailed product development towards different categories of furniture would be desirable. Such a differentiated product development would also assist the industry in their utilisation of LUS.

Apart from the garden furniture already made within the present project there are other categories of furniture that could be developed such as:

- Home furnishing, including sets for various uses e.g. bedroom, living and dining rooms, etc.
- Institutional furniture for Government, Hospitals, Day Care Centres, Schools etc.
- Office furniture for private as well as communal consumption
- Public furniture for hotel & restaurant, resorts etc.
- Kitchen cabinets and wardrobes, including doors made from LUS

Each category requires different quality standards and designs as well as marketing approaches. In future dissemination to the industry it will be necessary to combine the LUS as raw material with linkage to the above mentioned categories in order to encourage specialisation which in turn will promote efficiency, quality and competitiveness within the industry.

Other products where LUS could be used are for example wooden toys. Suitable species are *Celtis*, Essia as well as Kyenkyen.

Wooden toys are normally a "mass production" and divided into different categories such as:

- Push-pull toys, cars, trains, boats, animals, etc.
- Stacking toys, mostly made from turned parts
- Building/construction blocks = simple mass-production
- Educational toys, including puzzles in plywood
- Riding toys,
- Children's furniture

As the different categories requires different sizes of wood, toy production results normally in a quite high utilisation of the raw material. By using a combination of LUS, quite colourful and eye-catching toys in natural wood could be produced.

Wooden toys are "big business" with huge quantities exported from Asia to EU and US. Most of the wooden toys produced in Asia today is made from rubberwood (*Hevea Brasiliensis*), which has a major draw-back with customer repelling due to its initial toxic boron treatment. LUS would here, as raw material for wooden toys, have a natural advantage over rubberwood.

Production of wooden toys, contrary to plastic toys, is quite labour intensive due to its manual handling of each individual operation, in particular sanding and finishing operations. Many producers in EU, and US, have therefore due to high labour costs, turned to developing countries for their production. With a combined transfer of know-how in design, appropriate production technique and marketing, Ghana could become a dominant producer of wooden toys. The convenience of two harbours is an important advantage for overseas export.

One area dealt with only in a marginal way in this project is the joinery, mainly because dried timber has not been made available. However, the results from the furniture production give a clear indication that several LUS could be used for doors and frames, windows, skirting and mouldings. It would though be necessary to first establish some kind of standards in order to minimise the present waste occurring in the production (over-dimensioned frames, innumerable sizes etc.).

Industrial utilisation of LUS

Five species of LUS has been tested for industrial utilisation. A sixth species, Ohaa, was originally included but has not been made available in sufficient volumes during project period.

The tested species are:

- Ceiba (*Ceiba pentandra*)
- Kyenkyen (*Antaris toxicaria*)
- Celtis (*Celtis mildbraedii*)
- Essia (*Petersianthus macrocarpus*)
- Denya (*Cylicodiscus gabonensis*)

Individual Observations

Ceiba

This species has the lowest density of all LUS tested. Some prototype garden furniture has been produced. A few samples will be exposed to fatigue tests when the furniture testing equipment is in operation. In spite of its light density, garden furniture made from Ceiba has attracted the attention of international buyers who have requested samples with different finish applications, One set, plus finishing samples has been produced at FORIG's workshop and was Mid-September -97 shipped over to US for a market reaction survey.

With regard to pallet production, Ceiba could be used for one-way pallets, but it is doubtful if it would receive a certification as an interchangeable pallet, e.g. Europallet.

Ceiba has for a quite long time been used as middle core veneer in plywood. Its present use has led to the fact that today it is a species that is considered as "over exploited". Its sustainability appears however to include such large volumes that it will sustain also future harvesting.

Kyenkyen

This species has been used for prototype of garden furniture, pallets, deckboards and parquet strips. From texture and appearance point of view Kyenkyen is suitable for garden furniture. It takes stain and varnish fairly well if precaution is taken during application. Too generous application creates eye-catching spots with quite deep penetration. Fatigue tests will be the final determination with regard to its suitability as furniture raw material. As a pallet material, Kyenkyen is somewhat heavy and maybe too good to be used for such purpose.

As a flooring material, decking or parquet strips, Kyenkyen appears to be too soft and not enough durable for the wear and tear a floor is exposed to.

Celtis

This species has several advantages as furniture raw material. It is dense enough to create customer confidence with regard to weight. It has an appealing texture and colour. The apprehension so far by the local users regarding the grey/brown discoloration that appears short after sawing/drying can be turned into an advantage if a sorting procedure is applied. Such a sorting program is quite common in industries where clear wood is used for transparent varnish, while pieces with moderate discoloration are stained in to e.g. mahogany, teak or walnut colours making the discoloration to appear as a natural variation of the wood. Pieces with more dominant discoloration is coated with pigmented lacquer e.g. white, blue etc. This procedure is quite common in the industries as a measure to optimise the utilisation of the raw material. The finishing tests of Celtis along these lines have been overall satisfactory with appealing samples in clear varnish, mahogany and walnut stains as well as in white lacquer. Endurance and durability tests will be applied as soon as the testing equipment is installed.

As for other garden items such as deckboards, partitions etc., Celtis is useful but must be impregnated against termite and borer attacks if used in contact with the ground.

From durability point of view, Celtis can also be used for parquet strips but it is doubtful if it will receive acceptance by the producers because the discoloration would result in a high degree of rejects thus making it less economical. Before proper drying schedules and handling is established to avoid discoloration, Celtis is most likely to be rejected as flooring material.

Essia

This species has been used for prototype garden furniture, deck boards and parquet strips. Its red colour and texture makes it attractive as a furniture material as well as for decking and parquet strips. Other areas of use could be e.g. kitchen cabinet doors, which has a huge market in Europe where renovations/renewals is more a matter of changing doors rather than the cabinets. The high degree of standardisation limits the sizes to not more than four different widths, while the height is the same for both wall units as for the bench units. For high cabinets, there is normally only 3 different widths.

Essia is easy to machine with minimal wear on tools. Sanding with open coat results in minimal clogging of sanding belt. It takes finishing well and sapwood can be stained to match the heartwood. One disadvantage however is an unpleasant smell during machine operations. When coated with sealer and varnish the smell is not at all noticeable.

One major drawback in this project segment has, very unfortunately, been the limited volumes made available. The small volumes at hand have been dried together with other species, resulting in considerable degrading in form of checking and internal cracking. Before any promotion of Essia can take place, proper drying schedules must been worked out as there otherwise is a risk that potential users will reject it due to abnormal wastage from drying defects.

Denya

The high density (958 kg/m^3) restricts the utilisation of this species. Within the project Denya has been tested for deck boards, parquet strips and turnings. It has the most beautiful and attractive texture of all LUS. Machining is somewhat difficult and requires very sharp tools. Tungsten carbide, or stellite tipped tools is recommended. Joining with nails or screws requires pre-drilled holes. Sanding requires precaution as excessive pressure results in clogging of the sandpaper and burning of the woods surface. Denya is easy to bond with PVAC glue and takes lacquer very well. A final sanding before finishing with grit 120, extra open coat, and a sanding of the sealer with grit 240 gives an excellent end finish.

The natural resistance against fungi and insect attacks makes Denya ideal for decking and flooring. No impregnation is necessary, which could be used as a promotional advantage over other wood species that requires impregnation to sustain out-door use.

Conclusions and Recommendations

This segment of the project included research towards industrial utilisation of six Lesser-Used Species. Five of the LUS has been used in an industrial scale to determine its suitability as raw material for a number of products. Three species, Kyenkyen, *Celtis* and Essia has turned out o be the most suitable for furniture and similar products, while Denya, due to its high density, could be used for decking and other garden accessories including flooring. Ceiba is already widely used in the industry for core veneer and even mouldings. A positive development outside the ToR has been the interest shown by the small-scale wood-workers about the LUS and its potentials in a new range of products.

The product development so far has been done within the LUS project, which now is ending. The result, and the spontaneous positive reactions from the industry and the market, gives a clear and solid indication that the LUS has a future as raw material for a wide range of products.

The introduction of new production techniques, e.g. dowel joints instead of tenons / mortising deserves also a continued dissemination to educational centres as well as the industry and small-scale entrepreneurs. Transfer to dowel joints would result in a tremendous saving of raw materials (15-25%) and increase productivity enormously (e.g. from present 3-4 doors per day in a typical small scale carpenter shop to 25-30 per day). Dowel joints are also a prerequisite for export both to the region and overseas.

The results obtained during the project is judged to be of immense value for the industry in Ghana but the continued dissemination is an area of pronounced worry as there is no qualified counterparts left to carry out the information to the industry. The project leader is about to retire and the second in command is leaving for a three year Ph.D. training overseas. The most experienced Technician, and carpenter, is planning to leave the Institute for computer training at the UST. The remaining counter-parts are junior technicians with little or no aptitude to disseminate project results. It would be a pity if the LUS project

potential would be only a paper work left on a shelf to collect dust instead of being used to elevate the industry into exporters of products made from LUS.

It is the Consultant's sincere hope that the achievements from this project is carried forward by FORIG, together with organisations with a commercial approach, e.g. TEDB, FAWAG or KWEL to continue the dissemination of the LUS results. It would most likely result in a faster introduction of LUS as raw material as these organisations have direct links with the majority of the established industries in the country.

WOOD SPECIES						
Operational characteristics	Ceiba Density 304 kg/m^3	Kyenkyen Density 432 kg/m^3	Celtis Density 751 kg/m^3	Ohaa Density 755 kg/m^3	Essia Density 814 kg/m^3	Denya Density 958 kg/m^3
Cross-cutting Saw-blade Ø 350 mm Z = 80 Rake angle 10° Clearance angle 15° Teeth top level R+L 10°	Very smooth. Slight sanding required.	Smooth. Only slight sanding required.	Very smooth. No sanding required. Powdered sawdust very irritating. Nose mask recommended.		Very smooth. No sanding required.	Smooth. No sanding required.
Rip-sawing Saw-blade Ø 350 mm Z = 24 Rake angle 15° Clearance angle 15°	Easy	Satisfactory	Satisfactory		Satisfactory	Difficult due to hardness. Sharp tools required.
Planing SCM Thicknesser Model 250. HSS knives Feed speed 7m/min	Easy, but very porous surface.	Planes smoothly, no tendency to split.	Satisfactory, but slight tendency to chip if planed against the grain. Nose mask recommended.		Smooth, but surface checks from drying defects may be present.	Smooth, if sharp knives are used.
Drilling/Boring Spindle speed 1400/600 rpm for 8mm/28mm drill bits	Satisfactory, but dust might block holes. Very sharp bits recommended. Gentle boring to avoid compressing of wood fibres.	Satisfactory. Smooth holes. Little or no off-sizes.	Satisfactory, producing smooth holes with little or no off-sizes.		Satisfactory, producing smooth holes.	Difficult. CTC drill bits recommended.
Routing HSS routerbits	Easy and satisfactory in all directions.	Easy and satisfactory in all directions.	Satisfactory in all directions. Slight tendency to split. No chipping.		Satisfactory.	Requires extra power. Chipping may result if dull tools are used.
Moulding Spindle spped 6000 rpm	Satisfactory, but surface porous. Sharp tools required.	Satisfactory across and along the grain. Raised grains occur as angles inclined to the grain. Sharp tools recommended to avoid chipping.	Satisfactory along the grain. At 45° and across the grain, chipping may occur. Sharp tools recommended to avoid chipping.		Satisfactory.	Satisfactory. CTC tools recommended.

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Round-over of edges	Moderately smooth. High feed speed causes rough edge. Must be done gently/slowly.	Moderately smooth. High speed causes tearing of edges.	Smooth in all directions.		Smooth in all directions.	Smooth along grain, but tearing across.
Bending Cold process	Poor.	Fair bending radius achieved.	Satisfactory bending radius achieved.		Difficult.	Impossible.
Turning	Poor results.	Acceptable quality pieces.	High quality pieces.		High quality pieces.	Good quality pieces.
Wear on tools	No wear.	No wear.	Minimal wear.		Minimal wear.	High wear. CTC or Stellite tools recommended.
Gluing PU and PVAC glue	Poor bonding due to porous nature.	Excellent both with PU and PVAC glue.	Excellent both with PU and PVAC glue.		Glues well with both PU and PVAC glue.	Glues well, but requires high pressure.
Sanding Orbital beltsander Belt speed 14m/sec Grit 100, 120, 150 Open resp. closed coat	Easy to sand. Gentle pressure required to avoid excessive removal of wood. Grit 120 along grain and grit 100 for across sanding. No clogging of belt.	Along grain smooth surface with grit 120, open or closed coat. Grit 100 for across grain sufficient. Light to moderate clogging.	Along grain smooth surface with grit 120. Across grain grit 100 sufficient. Moderate clogging.	Along grain smooth surface with grit 120. Across grain grit 100 sufficient. Moderate clogging	Along fibre no noticeable difference between open or closed coat. Grit 150 for along grain and grit 100 for across. Light to moderate clogging.	Long grain extra with open coat grit 150. Across grain grit 120 sufficient. Heavy clogging. Burns easily on across sanding.
Finishing Stain in white spirit, mahogany and walnut colour. Sealer sanded with grit 240 before final coat with clear varnish or white lacquer.	Porous wood results in blemish appearance of stain. Lacquered surface of acceptable finish with 2 coats of sealer + final coat.	Takes stain and sealer well. Lean application of stain recommended to avoid "bleeding" spots. Acceptable finish with 1 coat of sealer + final coat.	Takes stain and sealer well. Lean application of stain recommended to avoid "bleeding" spots. High quality surface with 1 coat of sealer + final coat.		Takes stain fairly well on sapwood. Excellent surface with 1 coat of sealer + final coat.	Takes sealer and varnish well. Beautiful natural wood texture does not require stain. Excellent surface with 1 coat of sealer + final coat