PRODUCTION, PROCESSING AND STORAGE OF CHESTNUTS IN TRUNG KHANH DISTRICT OF CAO BANG PROVINCE, VIETNAM

David Klinac

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Overseas Travel Report

D. Klinac
HortResearch
Ruakura Research Centre
Private Bag 3123
Hamilton
New Zealand
Phone: +64 7 858 4650
Fax: +64 7 858 4700

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This report has been prepared by The Horticulture and Food Research Institute of NZ Ltd (HortResearch) which has its Corporate Office at Batchelar Centre, Private Bag 11 030, Palmerston North and has been approved by:

_____	_____
Research Scientist	Portfolio Manager
Date: _____	Date: _____

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I . INTRODUCTION

The following report was based on 10 days spent in Cao Bang province and Trung Khanh districts, visiting the communes of Phong Chau, Chi Vien and the villages of Phia Bo, Na Man, Na Than, Na San, Na Pa, Na Tuong and Na Tuy (October 12 - 21/2000)

Objective:

Advise on viable options to introduce appropriate, relatively low cost processing that would facilitate preservation of chestnuts in traditional growing areas of Cao Bang province

- Assist and advise the provincial and district level extension staff as well as chestnut growing farmers regarding suitable low cost methods of processing and storing chestnuts to avoid post- harvest destruction of the crop.
- Recommend appropriate measures to be taken at farmer, district and province level to improve processing storage and marketing of chestnuts from Trung Khanh.

II. SUMMARY OF KEY POINTS

In general

1. The basic chestnut resource available is very good, with easy peel chestnuts well suited to processing
2. Given the limited resources available, the local chestnut growers are actually producing quite a good product.
3. None of the problems observed are significantly worse than could be expected. None are untreatable.
4. There is considerable underdeveloped potential for expansion and improvement.
5. A sound basis exists for the development of a successful, regionally based chestnut industry, if desired

But…

6. At the moment, many chestnut trees in the region are not performing nearly as well as they could be.
7. Production and quality may even be declining overall, with increasing age and deteriorating tree health
8. With so much highly variable seedling production, individual tree and nut quality ranges all the way from excellent to very poor
9. further expansion is limited by the lack of both reliable plant material, and of handing, storage and processing facilities,
10. There is also no real "chestnut industry/growers association " organisational structure yet to help address these deficiencies

Specifically with regard to chestnut handling, storage, processing and marketing, the options most likely to be of benefit are…

1. Better tree and orchard care to reduce the incidence of fungal rots
2. Better harvesting and handling to reduce the subsequent development of fungal rots
3. The use of flotation grading to separate healthy nuts from those with internal rots
4. The use of organically - acceptable, food grade dips to help control surface moulds
5. Controlled drying to reduce the susceptibility of chestnuts to fungal rots

6. Improved packaging in the form of open mesh bags, ventilated boxes, plastic bags or MA (modified atmosphere) bags.
7. Shell removal to facilitate further processing and add value
8. The production of dried chestnuts, chestnut flour, peeled whole chestnuts (fresh, dried or frozen), chestnuts biscuits and perhaps chestnut juice and alcohol
9. Longer-term, the introduction of new cultivars and improved storage techniques such as access to cool storage (-2^{0c} to $+2^{oc}$)
10. The creation of a chestnut grower's association and industry group to oversee and co-ordinate all stages of production, processing and marketing

SUMMARY

Fungal infection is the major cause of chestnut storage, handling and processing problems. The levels of fungal infection are worse in old, dirty, crowded, shaded orchards and in nuts from old diseased trees. With chestnuts, prevention is usually better than cure. The first priority then is improved tree and orchard care and hygiene to minimise subsequent difficulties as much as possible. This is also the area where most local orchards are in most need of improvement.

Waiting for nuts to fall naturally; picking up off the ground as soon as possible; avoiding split, immature and insect damaged nuts and not mixing good nuts with bad all helps reduce subsequent rot development. This is not always done as thoroughly as it could be.

Flotation grading is a simple means of separating out those nuts with otherwise hard to detect internal Phomopsis rots. "Vortexx" and "Tsunami" are 2 useful, food grade, organically acceptable chemical dips to use against surface mould fungi such as Penicillium, Botrytis and Mucor.

The drier the chestnuts the less fungal spoilage there will be and the better they will store. Unfortunately, these can also reduce weight and retail value. Local growers already practice partial drying of their chestnuts. More controlled drying could be used to produce a wider range of value-added saleable products such as dried packaged chestnuts and chestnut flour. However, This also requires the chestnuts to be peeled first. Fortunately, Trung Khanh chestnuts are very easy peel and a small mechanical sheller could make it even easier. Once peeled, there are then a wide variety of further new chestnut products that could be profitably produced.

There will still be a market for high quality, fresh chestnuts, especially in the larger sizes. More attention should therefore be paid to increasing nut size. New packaging techniques and materials may help make this even more profitable but will need careful evaluation and development in the absence of easy cool storage access or improved rot resistant cultivars.

Since much of this goes beyond the resources likely to be available to individual growers it is also recommended that a chestnut growers group and chestnut industry body be set up to help introduce, co-ordinate and supervise these new developments.

III. CHESTNUT GROWING IN VIETNAM

i) A brief comparison of chestnut growing in NZ compared to Vietnam….

- NZ has a more temperate climate with lower altitude, flat land production.
- Soil fertility in NZ is higher, overall, with a milder, wetter climate
- NZ commercial chestnut selections are mostly Japanese C.crenata) and European (C.sativa) hybrids, grown as grafted or budded trees. Most Vietnamese chestnuts are C. mollissima (Chinese) seedlings.
- Vietnamese planting density is high by NZ standards
- This reflects the smaller size of C.mollissima trees (1/2 – 1/3 the size of NZ trees the same age)
- Similarly, the yield per tree is lower and the nut size is smaller in Vietnam
- NZ chestnuts are not so sweet and not so easy to peel, however
- No NZ commercial orchards would be older than 20 years
- Flowering in NZ is December - January and harvest May -June
- Chestnut wood is not widely used for timber in NZ, yet
- The average NZ chestnut family orchard is 2 – 3 ha with trees bought from a commercial nursery and mostly grown as centre – leader trees on flat land
- Vietnam has more serious insect pets than NZ. NZ has a higher incidence of some fungal diseases.
- Most NZ chestnuts are produced organically
- Fallen nuts are collected daily by hand, mechanical sweeper or vacuum harvester
- Most NZ chestnuts are dipped, washed then stored in either 20 kg mesh sacks or plastic bags (with holes for ventilation)
- Most storage is in on. farm or centre cool store at –2 to + 2^{o}C.
- Most NZ chestnuts are exported overseas or processed
- Prices are similar to those in Vietnam

ii) Problems and concerns most commonly raised by growers…

* **an epiphytic/ parasitic plant** : commonly found growing high in the tree ,often towards the outside edge of the canopy where it cannot easily be reached or removed. Growers remove it if they can, but often they cannot. It may not be directly parasitic, but it does seem to strangle and smother at least some young growth.

This is not recognised as a chestnut problem in any of the available chestnut literature. It may be specific to Vietnam. It could be seen growing on several other tree species. It may be a problem already encountered elsewhere on other Vietnamese forestry species.

It could be possible to control it with a contact herbicide. Being evergreen the best time to spray it could be in winter, after the chestnut tree has lost its leaves. It would then also be easier to find and herbicide application would be less risky to the chestnut tree.

We do not have this problem in NZ but we do have many similar woody weed species growing in our forests where conventional herbicide application would be too damaging to intermixed native vegetation. HortResearch has developed special hand – operated pruning secateurs for use in these situations. They are connected to a small, pressurised container of chemical in gel form, a blob of which is automatically dispensed onto each cut surface. A single cut, per plant, is enough to administer a lethal dose, without risk to surrounding vegetation. This allows for more precisely targeted chemical application (of either herbicide, fungicide or growth regulator) and is safe to both the operator and to the environment.

The long handled (2m) version of this equipment might be useful in both epiphyte/ parasite control and in the targeted application of protectant chemicals during normal pruning. HortResearch is developing a range of chemicals especially for use in these situations. I will send details.

While the main grower concern is the removal of the parasite, it may be that its presence is a useful indicator that a previously healthy, fast growing tree has gone into decline. The parasite problem often seemed worst in older, weaker trees on sick branches. Young, healthy fast-growing trees may not be such suitable hosts for it. Its presence may be symptom of an already sick tree, not necessarily the cause . An even simpler control measure may therefore be to promote younger, healthier regrowth. Prevention may also be better and easier than cure: simply by keeping the tree as healthy and vigorous as possible to start with.

Alternatively, it appears as if the Mac Pup fruit is considered edible by many Chinese and so may even have commercial significance. More botanical information and investigation on this and other such parasites is still required.

*** Insect damage**: a wide variety of insect pests were found in and on chestnut trees throughout the region. Most are not found in NZ but all could be considered typical of C. mollissima grown in this part of the world. Their association with local chestnut trees here is perfectly normal. While many pose significant problems for chestnut growing, eradication is not an option.

Learning to live with them is. While there are specific control strategies that can be implemented for the more serious pests often the best approach is, again, of prevention rather than cure: keeping the tree as healthy and vigorous as possible for as long as possible: minimising the opportunities for pests to invade, establish, weaken or kill what could otherwise have been a healthy tree. In most cases , a degree of insect pest presence in and on each tree can be tolerated and is perfectly natural. The aim of good tree management should be to prevent this getting so out of balance that productivity and tree health declines further. Because of the invasive nature of many of the chestnut pests, it is often not possible to save severely affected trees. Unfortunately these are the most obvious trees, about which growers are naturally most concerned.

- **Chestnut gall wasp (Dryocosmus kuriphilus):** This is the most common insect pest of chestnut throughout Asia and parts of the US. The tiny wasp lays its eggs in the terminal buds of new shoots and the developing larvae cause the shoots to become stunted. Because these new shoots are where most chestnut production occurs, the result can be considerable loss of production. The characteristic galls on young, stunted chestnut shoots are common throughout Trung Khanh region, but no more so than should be expected.

Chemical control is possible, though difficult. Some success has been achieved with spray applications timed to kill the adult wasps in flight, before eggs are laid. Better results have been achieved through the use of naturally resistant trees and biological (rather than chemical) control techniques eg: through the use of natural predators.

Gall wasp is not found in NZ so I have no direct experience with its control. Nor is it a problem in Europe. The best source of further information on this is from Japan.

One simple response may be to just cut back into healthy wood, past the limit of stunting. This should help encourage new, healthy shoot growth to replace that lost

- **Insects eating the nut:** Characterised by a small hole (0.5 – 1.0 mm diam) in the chestnut, possibly still with an insect larva inside. Both moths and weevils usually lay their eggs inside the developing chestnut, while still in the burr. In Europe and the US this includes Curculio weevils, Laspegresia splendana moths, and Pammene uliana moths. (Different species may be found in Asia). These are major pests throughout much of the world and evidence of chestnut damage was seen throughout Trung Khanh province. Most growers did not regard it as a serious problem, perhaps because only a small portion of each nut was usually affected . However this often provides an entry point for fungal rots and will render affected nuts unfit for processing or export. It will also interfere with flotation grading and adversely affect storage life. While not a significant problem at the moment, it may grow to be one in future years.

Hot water soaking (50 - 60^{o}C) for several minutes will usually kill any larvae still in the nut, after harvest. Adult moths may be killed by chemical sprays or caught in sticky traps. Some larvae overwinter in the soil or leaf litter. Running poultry beneath the tree can help control numbers along with general orchard hygiene and the removal and burning of infected nuts and burrs.

- **Borers ants and termites:** These are not specific to chestnut trees and can cause problems on many tree species. In NZ only borers cause significant tree damage. Usually the borer beetle prefers to enter the tree through existing damage, dead wood or exposed pruning cuts. Once inside the tree it is very difficult to eradicate so it is better to try to minimise the chances of it

ever entering. Keeping the tree strong, rigorous and as healthy as possible will help. This includes maintaining wide spacing and good sun penetration. Often, as soon as chestnut branches become badly shaded they will die. This often happens with canopy closure when trees are planted too close together. The branches die back and provide easy entry for the borer.

Wherever possible, physical damage to the trunk or branches (e.g. cattle damage) should be cleaned up by cutting back to healthy wood and bark. This will also hasten healing and regrowth and remove sheltered sites for insects. All major pruning cuts and branch removals should be made by cutting back into healthy wood. Cutting back to as near the trunk or branch union as possible will help healing and prevent the formation of dead stubs : ideal for insect entry. As much dead wood as possible should be removed. On major cuts or damage, extra protection can be provided by painting with pruning paint. Special commercial formulations are available which both help healing and provide a barrier to pest and disease entry (I will send further information from NZ). Growers may even prepare their own using thick, oil based paint, perhaps with fungicides and even insecticides mixed in.

Cutting back on removing dead wood or sick branches can also be used to promote new vigorous regrowth. This can help "rejuvenate" an old or sick tree, in decline.

*** Tree care**: Most growers were aware that many of their chestnut trees were not as well looked after and as healthy as they could be. Much of this could be put down to lack of time, especially when the chestnut season overlapped with that of rice. The same problem occurs in China. Here the response has been to keep the tree small (so that all burrs can be knocked off with sticks for a once-only harvest) and to encourage bushy, multi-stemmed trees requiring minimum tree care. This can be counter-productive, however. Flowers and fruit only develop on new shoot growth. A chestnut tree needs to be kept growing vigorously to bear a large crop. This means a large tree. Often a large, single trunk can also absorb more physical damage (insect or cattle) and is easier to both protect and repair

A once-only harvest, while quick and easy ,also produces a poor crop of low quality chestnuts, many of which are not ripe and will go rotten quickly.

I think many Trung Khanh chestnut trees could benefit greatly from some winter " clean up " pruning aimed at encouraging strong upright growth, vigorous new shoot growth, and the removal of dead wood and sick branches: as outlined for standard forestry and fruit tree management practice.

*** Lack of nuts inside burrs:** This was a commonly reported problem with this year apparently being especially bad. It is not a pest and disease problem, merely the natural result of inadequate pollination. It is a common sight on chestnuts worldwide.

Ideally, every burr on the tree should contain 3 (or sometimes more) large, high quality nuts at harvest. But sometimes many burrs fall off the tree empty (often early) or even large burrs may contain only 1 –2 good nuts. May be there will be 2"outside" nuts but no " middle" nut in the burr. All these nuts come from flowers that have not been fully pollinated. Especially if the

weather was unusually bad (cold, wet) over the flowering period, conditions many not have been suitable for pollination to occur. In this case, even if there were many flowers, there may be only few nuts at harvest.

Poor pollination may also be due to a lack of pollenisers. Each chestnut tree has both male and female flowers, but they are not self-compatible. Pollen must come from another tree, of a different variety (if grafted or budded) or possibly a different seed line (if seedling). Some combinations of trees are incompatible or only partially compatible. Some trees produce very little pollen. Some trees flower at different times. There are many reasons pollination can fail. Without observing the flowering process and seeing the results (at earliest harvest) it is not possible to say for sure how serious the pollination problem is, or what causes it.

Improving pollination may, however, be a quick and easy way of both improving yield and nut quality. The chestnut species is unusual in that pollination directly affects the quality (as well as the quantity) of nuts produced. Shape, size, colour, taste, storage life, susceptibility to fungal rots processing suitability and peelability are all influenced by pollen source. part of the "secret" of Trung Khanh's superior quality of chestnut may be the identity of the pollen producing it. Planting even more of these special polleniser trees may be very beneficial. Identifying a "superior" polleniser may also be a way of naturally extending the storage life of the fresh chestnuts harvested.

This is an area that could benefit from further study. If a specific pollination problem was identified then possible remedial action could include identifying, selecting and planting improved polleniser trees or perhaps introducing beehives to aid pollination. Chestnut honey can also be a valuable commercial product. In Europe it is highly valued for its medicinal properties.

* **Small nut size:** This can also be due to poor pollination. Because this season was unusually dry, it was more likely due to lack of water. The 2-3 weeks prior to harvest are very important in determining final nut size. Shortage of water then will mean small nuts. Because all producing chestnut trees in Trung Khanh are seedlings, however, there is likely to be great natural variation in individual tree performance: including tree shape, size, health, yield, nut size and nut quality. Some trees will be much better than others. These trees should be identified and selectively propagated.

Small nuts may also be symptomatic of a sick tree, especially if the tree has always shown good nut size in the past.

* **Irrigation:** Chestnut trees do not normally require a lot of water. Except in very dry reasons they should not need irrigation. The heavy day soils with good water holding capacity, seen throughout Trung Khanh , should also help. If water is short, nut size should suffer first, rather than the tree itself. Trees with major trunk or root damage may however simply be unable to take up enough water to survive, even when it is available. Removal of topsoil, exposure of tree roots, and soil compaction (due to stock or people) may all aggravate this and the tree will wilt, especially during summer.

What is often more damaging to chestnut trees is soil waterlogging and " wet feet".

*** Ink disease:** (Phytophthora): This is a soil fungus, which can kill chestnut roots, staining them black or purple inside, like ink. C. mollissima is not nearly as susceptible to this disease as European and NZ chestnuts , but one example was found of sick trees, with what looked like this disease, in Trung Khanh. Often the first symptom is the sudden and unexpected wilting and possibly even death of previously healthy trees, during summer. A whole tree or just part of a tree may be affected, depending upon the seriousness of root damage. In severe cases the root damage will extend up the trunk, above soil level, to form a characteristic large canker or " collar rot". The tree then may die, simply through lack of water, even in a wet soil, in wet weather.

The problem may even be worse in wet soils because the soil fungus prefers wet, warm, waterlogged conditions and because chestnut roots do not. Several times it was reported that Trung Khanh chestnuts grew badly at the edge of limestone lakes, but did very well slightly higher up the hillsides. This may be partly due to ink disease. (A soil test can be used to confirm its presence or absence).

In the sites where ink disease was found there had also been removal of topsoil and organic matter and possibly some physical root damage. All this could have made ink-disease worse. To prevent ink-disease it is best to have good drainage, good soil structure, high organic matter content, high soil microbial content, high soil calcium content and low pH. Mulching around the base of the tree, out to the edge of the canopy, is often good practice and also helps conserve soil moisture.

The presence of lots of mushroom and fungi under chestnut trees is usually a good indication that good conditions prevail. Many of these species of fungi can form symbiotic mycorrhizal associations with the roots of the chestnut tree. These help the chestnut tree grow by helping find soil nutrients and water. They can also help protect against disease. Such roots look characteristically branched and often covered with white threads of fungus. They are the sign of a healthy tree. They were totally absent in the site where ink. disease was suspected.

If a chestnut tree is suffering from ink-disease, treatment is possible using foliar sprays or tree injection of phosphorous acid (available in a variety of commercial formulations). It is important that the symptoms be recognised early and that the tree is treated early, before damage becomes irreversible.

*** Fertilisers:** chestnuts do not require unusually large amounts of fertiliser, but they do respond well to a balanced fertiliser programme, either organic or artificial. As some growers observed, adding fertiliser produced faster growth and earlier cropping. Adequate fertiliser is also important for tree health and disease resistance. In particular, chestnuts require adequate nitrogen (N), potassium (K) and perhaps magnesium (Mg) and phosphorous (P). Nitrogen is important for tree growth. Phosphorous is important for flower production. Potassium is important for nut development . Nitrogen fixing plants can supply N naturally (eg. legumes, lupins) and should be encouraged. (Some data on recommended nutrient levels from Europe and Asia is attached)

Magnesium deficiency is common in chestnuts, showing up as characteristic interveinal chlorosis on older leaves, late in the season. It does not, however appear to cause any serious problems. Some Trung Khanh soils seem naturally high in manganese (Mn). This may be part of the reason for the areas suitability for chestnuts. Manganese levels can sometimes also influence soil boron availability and this is suspected to be important for NZ chestnut production.

*** Cattle damage**: Many young trees, especially, were severely damaged by cattle grazing or even jut rubbing against them. In some areas most of the younger trees planted had been destroyed by cattle. Even where the trees survived I suspect it was this damage that often allowed subsequent insect pests to become established and thrive. While organic fertiliser and weed control from the cattle would have benefited the trees, I feel this was greatly outweighed by the damage caused. If this could be prevented then I think tree health could be greatly improved.

In NZ, sheep and cows are often grazed under chestnut trees but the trees are protected, either by wooden, wire or electric fences. A cheaper option, effective against sheep, is to tie small chestnut branches (removed during pruning) around the trunk, but I am not sure if this would work against cattle. It may harbour unwanted insects. Large trees with strong, single trunks seemed to cope better with cattle damage and perhaps should be encouraged.

*** Tree spacing and shading:** Sometime chestnut trees were planted too close together or were being shaded by other trees. Especially in older blocks, trees were now shading each other.

Chestnut trees need a lot of light and are very sensitive to shading. If too shaded, branches will die back and rot allowing insect pests to become established. New shoot growth will also be reduced and so production will fall. Chestnuts from such orchards typically are also more rot prone, harder to store and harder to process. As a general rule, the canopies of adjacent trees should not be allowed to touch. Trees may therefore be quite close together while small, but certainly not when they are large. If tree production does start to decline in a block, it may pay to selectively remove sick trees altogether and replace with a new tree, or cut back hard to new wood, or even coppice to the trunk and allow it to regrow. By then it may be time to remove the adjacent trees, and so on, as part of a gradual replacement and renovation process.

*** Interplanting:** This is a useful way of making use of bare land while still keeping your chestnut trees at wide enough spacings that they will not shade each other, as they get older. Examples were seen of chestnuts successfully interplanted with several annual crops: soybeans, cassava and sweet potato. Mostly, though, the cultivation of these was extended too close to the chestnut trees. Weeding and harvest could both have damaged the chestnut trees roots. I would not recommend sugar cane or maize for interplanting because of the high fertiliser demand and the potential for excessive shading. I would recommend interplanting with green crops such as legumes and lupins, which could be used as either a source of much around the base of the chestnut tree or for incorporation as organic fertiliser.

*** Older trees losing production and going rotten inside:** This was quite common and can be considered a natural consequence of poor tree health, inadequate tree care, excessive shading etc. Chestnut trees can remain productive for many years, but only if healthy and only if they keep producing new fruiting shoots each year. Many of the older trees seen were doing neither. Instead, gradual die back of old fruiting branches was allowing entry to wood rotting fungi and insects which were then leaving the tree unfit even for timber use. Several stumps were seen where large trees had been cut back near ground level. In a healthy tree this should have caused it to coppice, producing a mass of new shoots. However many of the trunks seen were too rotten even to do that.

I think a significant problem for Trung Khanh may be the gradual loss of these older trees (several years earlier than necessary), which have previously been the best producers for the region. If the tree seen over the last 2 weeks are representative, then there may be a lack of healthy younger trees coming on ready to replace them. There may be a temporary drop in both production and quality before these older trees are adequately replaced. Improved tree management could, I think, help lengthen the productive life of some of these older trees considerably.

*** Who will buy our nuts if we do grow more?** This is a marketing problem, not a tree health or a production one, and one which I am much less qualified to answer. NZ also has considerable problems marketing its own crop. I think a major advantage for Trung Khanh is that its chestnuts already have a high reputation for quality. The harvest season coincides with the main period of demand in the large Japanese, Taiwanese and SE Asian markets. If anything, the Vietnam harvest season may be slightly earlier. This would be a good thing, as early - season chestnuts traditionally sell for the highest prices. If harvest could be brought forward even earlier (by selecting earlier varieties for example), then this would be even better. Japan is the worlds largest chestnut consumer but can produce less than 1/3 of its own requirements. Taiwan will pay high prices for large, good quality chestnuts but cannot grow them, at all. Singapore is another good market. Perhaps Thailand and Cambodia also. NZ tries to sell to these countries but we are out of season and far away. A big advantage for Vietnam may be that it is the closest country to the tropics where chestnut production is still possible.

The highest prices are usually paid for the largest chestnuts. Nuts from Trung Khanh have the advantage of good taste and are easily peeled. These should both be useful marketing advantages over several other countries. The size of Trung Khanh nuts does, however, need to be improved.

NZ is trying hard to develop a “chemical - free, residue - free, organically – grown” label for its chestnuts and to promote their high health and high nutritional value. Many other countries cannot grow chestnuts without quite heavy chemical use. NZ can. Especially for the US and European markets, this is a definite advantage, especially in the health food sector. This is an approach Vietnam could also take with its chestnuts. To get to far away markets, though, you first need a product that will not go rotten en route.

*** Nuts going rotten:** This is a problem for chestnuts everywhere in the world, especially in old, dirty orchards. Unlike most other nuts, chestnuts do not contain fat or oil, so they do not go rancid. But they are very susceptible to a wide range of fungal rots. These fungi fall into 2 broad categories: those that form a surface mould on the outside of the nut, after harvest; and those that form a soft rot inside otherwise healthy - looking chestnuts.

Surface moulds (usually Penicillium, Botrytis, Mucor and related species) can be picked up by nuts falling on the ground or simply from airborne spores. They grow fastest in warm, wet, high humidity conditions. They are the main cause of spoilage for chestnuts stored in plastic bags or similar packaging. They can usually survive heat treatment (50 – 60^{o}C) but will grow more slowly at low, cool storage temperatures (-2 to + 2^{o+}C). They are less of a problem on dried chestnuts. Chemical surface sterilant chemicals can help eliminate them, prior to storage.

Harder to detect are internal rots. Many chestnuts may look and feel perfect from the outside, only to reveal a fungal rot when cut open. These nuts often taste very bad and the fungus usually responsible (Phomopsis) has the potential to produce harmful mycotoxins. Some countries, such as Australia, ban the import of mycotoxin containing foodstuffs. Phomopsis also prefers warm, wet conditions, but will still grow slowly in quite dry nuts. It can be killed by heat (hot water treatment) at 50 – 60^{o}c for 15 – 20 minutes (but such nuts must still then be carefully dried and cooled to prevent surface mould growth). Phomopsis does not usually continue to grow in cool storage. None of the above fungi is easily controlled by fumigation in the orchard.

Standard practice in NZ is to …

- Keep the orchard floor as clean as possible (to minimise fungal spore numbers)
- To pick up chestnuts as soon as possible after they fall (every day)
- To remove burrs and rubbish at the same time (good orchard hygiene)
- To rinse chestnuts in water (to remove dirt and grass)
- To dip chestnuts for 5 minutes in a chemical surface sterilant (previously sodium hypochlorite now “Vortexx “
- or “Tsunami”: see attached info.)
- Rinse in water again to remove any residues
- Pack in either 20 kg ventilated plastic bags (short-term) or open – mesh 20 kg sacks or paper bags (long-term)
- Store in cool store (-2 to + 2^{o}C)

Plastic bags have the advantage of minimising weight loss and therefore maximising returns to grower (since prices are paid per kg and by individual nut weight). Surface moulds are a problem, though, and so plastic bags should only really be used in conjunction with surface sterilants and coolstores, and even then the bags must have holes to allow some air movement and to prevent anaerobic fermentation. (Special MA, modified atmosphere plastic bags are partial exception). Open – mesh sacks minimise these risks but cause the nuts to dry out faster,

losing weight. Chestnut are not sun dried in NZ but rather allowed to dry in the coolstore, at temperatures less likely to encourage fungal growth.

In general, the drier the nut, the better it will store; similarly, the colder the nut, the better it will store.

Internal Phomopsis rots require slightly different treatment. The main problem here is simply one of detection. Flotation grading (separating healthy "sinkers" from rotten " floaters" in a tank of water adjusted to a key, threshold density) is used to remove all suspect nuts: either dumped or sold as quickly as possible. Healthy nuts are then stored in the same way as described above.

It is important that as few rotten nuts as possible (either surface moulds or internal rots) be stored in the same bag as healthy nuts. (Further details of all these and following procedures, are given in the following attached extracts in section VI).

Less commonly used in NZ are modified atmosphere (MA); controlled atmosphere (CA) storage; and hot water treatment. These are sometimes used in Australia , USA, Japan, China and Europe.

Other techniques used overseas….

- Soaking chestnuts in water for 9 days, changing the water each day (France)
- Soaking chestnuts in water for 3 – 7 days, unchanged (Italy)
- Storing in a mixture of sawdust and sand (China)
- Irradiation (US, Europe, China, Japan)
- Storage in brine (China)
- Fungicide dips (China)

An alternative approach to the problem of chestnuts going rotten is simply to freeze or process them first. Chestnuts can usually be held in a coolstore at down to –2 to – 3^{o}C before freezing. This helps suppress fungal growth. Freezing at lower temperatures (eg - 18^{o}C) will prevent all fungal growth. Some NZ chestnut exports to Japan are therefore frozen as soon as possible after harvest, hopefully before most fungal rots have had a chance to develop.

If freezing is not practical, then processing as soon as possible after harvest may be a better option: turning them into a product that is easier to transport and which has a much longer shelf-life.

*** Processing:** most chestnuts around the world are processed into some form or other. The simplest products are the sun dried or pre-cooked chestnuts, as sold in Trung Khanh. The drying process will help prevent fungal rots but usually reduces the price. The advantage of drying is that by lowering the moisture content of the chestnut, fungal growth is suppressed. In general,

the drier the final product, the longer its storage life. Sun drying, however, is slow and so gives some fungal rots a chance to develop further. Most commercial drying in Europe is therefore done with forced air and added heat, over a period of only 3 – 4 hours. This also allows the moisture content of the chestnut to be reduced further than by sun, alone.

Whereas a fresh nut may have moisture content of 50 – 60%, sun- drying may reduce it to 30 – 40% (slowing fungi but not stopping them); while forced are drying can get down to 10% (for dried chestnuts) or 5% (for chestnut flour). China and Europe both produce large quantities of these very dry chestnuts and flour. The dried chestnut are very hard and packed in airtight plastic bags, can be stored for long periods and are sold around the world, raw or pre-cooked. They are used in soups or stews. The even drier flour can be used just like wheat flour, but is much sweeter and healthier, and since it is gluten –free, it is especially good for people with certain allergies and medical problems.

A necessary prerequisite for most processing applications is shell removal. Some chestnut species (eg. Japanese and NZ) are very difficult to peel. Japan has traditionally sent its chestnuts to Korea or China to be hand peeled before returning for processing. Whole peeled chestnuts may then be preserved in syrup, alcohol or sugar; turned into confectionery; or processed further into a variety of jams, pastes, purees and so on. Europe produces a wide range of these often very expensive products.

Trung Khanh chestnuts are very easy to peel and have good colour and taste. This should be good for many processing applications. For some, you may need to supply the nuts to Japan or Europe for them to process, at least at the start. Other, simpler processing operations could be done in Vietnam eg: shell removal.

This could be done by hand. An Australian chestnut producer is already sending chestnuts to Ho Chi Minh city for hand peeling, before vacuum packing and returning to Australia for sale. It may be easier for them to use Trung Khanh chestnuts or for you to peel and pack them yourself in Trung Khanh.

The NZ chestnut industry and HortResearch have also developed a range of mechanical chestnut peelers. This range from a small model (15 – 20 kg/hr) up to a large packhouse model (0.5 – 1 t/hr). These produce a peeled, fresh, whole chestnut. Machinery is available in USA to produce a peeled, dried chestnut and from Europe and Korea to produce peeled, cooked chestnuts (through much of this machinery is large and expensive).

With shells removed, it would then be relatively easy to produce whole peeled chestnuts (fresh, dried or frozen), chestnut flour and chestnut pieces (eg for muesli or biscuits). Japan has just recently approached NZ about supplying “organically – grown chestnut biscuits”, containing chestnut pieces of about peanut size. This could be another potential product. Chestnut bread, juice and alcohol could also be produced.

*** Other ways of making money from chestnuts:** some possible ideas have already been mentioned….

- Chestnut honey
- Chestnut alcohol (Korea also makes chestnut beer)

- Chestnut juices (freeze fresh chestnuts, thaw, then squeeze. The juice extracted is very strong and has a unique taste)
- Tannin extraction: both the chestnut leaves, bark and shell have a high natural tannin content. In Europe this is extracted commercially and used in specialist tanning applications (eg for shoe leather)
- Timber: Chestnut timber is naturally ground durable (without treatment) and can be used for high value specialist applications such as timber supports for organic wine grape production. The hardwood timber can also be used as a valuable oak look – alike.

  The current practice of ring-barking limbs off producing chestnut trees then leaving disease – prone stubs is, I feel, detrimental to tree health. It would be better if special chestnut woodlots were planted, at close spacing (to force good upright growth) and managed using conventional forestry practice, keeping separate chestnut plantings for nut production. It would be even better if selected seed-lines were used for this purpose. We saw some village seedlings with an excellent upright growth habit that would be perfect.
- Edible mushroom production: This can be encouraged by sprinkling mushroom spores of the desired species about the roots of chestnut trees, either in the field or better still, as a deliberate nursery inoculation procedure. Edible truffles can be a valuable cash crop. A variety of other mushroom species, while not so lucrative, are also edible and marketable and will all help tree growth, by way of their mycorrhizal association with the chestnut tree.

  A variation on this is to use stacked chestnut logs for commercial shiitake (Japan mushroom) production and export: a very common practice now in parts of China. A more sophisticated method uses chestnut sawdust (in plastic bags to grow a variety of other edible Asian mushrooms, under controlled conditions, for the restaurant trade.

iii) Good observations made by local growers: talking with local growers showed a good basic knowledge and experience of chestnuts by some individuals. If the following observations are not already common knowledge, they deserve to be….

- Chestnut trees need sun
- The sunny side of the tree will always have most flowers and fruit
- Many chestnut plantings (especially of older or interplanted trees) are too close, too dense, too shaded.
- These plantings often have the worst tree health problems.
- Unripe nuts (eg. knocked down with sticks too early) have poor colour, flavour and store badly
- The best nuts are those that fall naturally
- Those that fall still in burrs can often be stored longer
- Late season nuts are often small
- Rain at harvest time can cause more rotten nuts
- Drought in the weeks before harvest causes small nuts
- Bad weather at flowering time can cause poor pollination (many flowers but few nuts)
- Chestnuts are sometimes biennial bearing
- Some burrs may be empty or contain only 1-2 nuts instead of 3 (poor pollination)
- Cutting back older branches will help the canopy regenerate.
- Many older trees are also going rotten inside
- Many tree health and parasite problem are worst in older trees: least in younger trees.
- The healthiest trees are often those with single, strong trunks
- Problems are often worst where topsoil and organic matter is absent
- Addition of fertiliser makes younger trees grow faster and come into production earlier
- Trees often grow best on slopes in red/clay mixed with “apatite” (good soil structure and Mn ?)
- Trees often grow worst around the edges of limestone lakes (waterlogging and high pH?)
- Where soil type and tree growth is good, there are many mushroom and fungi growing under the trees
- Cattle damage is a major cause of tree damage and death
- Parasite plants are not only found on chestnuts
- Parasite plant damage is often worse on older trees
- Parasite plant is evergreen (chestnut is deciduous)

- Parasite plants fruit is edible and saleable
- There is wide variation in chestnut seedling form and performance
- Some have a much more upright tree form, especially suitable for forestry
- Some naturally crop about 10 days earlier than average and also have thicker, darker leaves
- There is also a wild chestnut (Castanopsis ?)
- For seedling production it is best to use the central (largest?) nut from 3 – nut burrs
- Empty burrs are a good and long – lasting fuel
- The best burrs have 2-3 (sometime 4) nuts
- The biggest nuts sell best, at highest prices
- Early - season chestnuts usually also sell at best prices
- The centre chestnut in 3-nut burrs is usually a characteristic flattened shape
- Chestnut liquor can be produced through fermentation and distillation. (Chestnut beer is more difficult)
- Maize stubble or mulch around trees helps growth
- Yellow chestnuts (inside) taste better than white ones
- Vietnam chestnuts taste better than those from China
- Fresh nuts that sink in water are better than those that float
- Nuts can be stored in sand for long periods
- Trees grow well amongst rock (apatite) outcrops
- Young trees can be successfully budded
- Budded or grafted trees come into production earlier
- Chestnuts can be successfully interplanted with many annual vegetable crops.
- But chestnuts do not do so well in the same site as maize
- This year there were many flowers but few nuts (poor pollination)
- Grass grub beetle is a problem for young trees (defoliation)
- Insecticide applications have not usually been successful
- Chestnuts stored in plastic bags often go rotten easily
- Drying chestnuts helps them store longer, but at lower price
- Heating (boiling) chestnuts helps them store longer, but at lower prices
- Fresh chestnuts can be stored in sawdust, or sand with good ventilation.
- Some trees turn yellow and die (spring – summer) and nuts fail to ripen (ink disease ?)
- Insects lay eggs in some new branches and reduce production (gall wasp)

iv) Conclusions:

These grower observations agree well with both NZ and overseas experience of chestnuts and my own observations of chestnut production throughout the region

From this, it may be reasonably concluded that …

- The soil and climate of Trung Khanh is naturally well suited to chestnut production
- A selection and evaluation programme could readily identify several new improved chestnut and chestnut related cultivars with superior performance and quality
- That these could then be successfully propagated for further sale and distribution.
- That improved tree care could produce a significant increase in both tree health, longevity ,overall nut production and quality.
- That improved grading, handling and storage technology would be equally useful.
- That both larger nut size, higher yield and earlier harvest would all be realistic goals to aim for: all resulting in a higher return to the grower.

v) key problems

I think Trung Khanh chestnut production has great potential. But I think there are 3 key deficiencies holding it back.....

* current production is limited by tree health and tree management
* future expansion is limited by lack of postharvest handling, storage and processing facilities
* both the above are limited by lack of any growers association / industry structure

At the village level, I think the immediate concern must be the sometimes low standard of tree care and subsequent poor tree health, poor tree performance, and reduced tree life span : even though actual nut quality may still be quite good. I think most growers are aware of this and actually have a fairly good idea of what should be done to remedy it, if resources, time and labour etc. permitted. This in turn, may not however be possible until a successfully functioning chestnut industry exists, with the ability to store, handle and process chestnuts in such a way as to return more to the chestnut growers. But since the development of a successful chestnut industry needs a healthy, well-run ,productive orchard base, this may be something of a" catch-22" situation.
In my opinion, the problems to be overcome are not just technical ones, but also social and organisational.

In terms of the immediate tree health problems and concerns facing chestnut growers at present, I would rate the areas most in need of improvement as.....

1. physical damage due to cattle grazing, then.....
2. inadequate pruning, tree maintenance and wood removal practices
3. sometimes inadequate soil coverage, organic matter and myccorhizal development
4. old age of many trees, with sometimes excessive shading, crowding and intercropping
5. pests and diseases

I'm sure many growers would put pests and diseases at the top of their list, not the bottom. I agree that there are many important pest and disease problems, but they are also mostly quite "normal" for chestnut production in this part of the world. Treatment is possible, and I recommend several specific treatments elsewhere in this report, but for most of these pests and diseases prevention is also better than cure. The best prevention is often the encouragement of strong, healthy, vigorous tree growth. And I think the best and easiest way to achieve this would be through improvements in the tree management points 1-4, above.

Such orchard management practices will also help produce a clean, fungus and rot-free nut, much more suitable for extended storage and processing applications.

As for the creation of a chestnut industry, with adequate handling, storage and processing facilities, the best I can do is describe how the NZ chestnut industry have tried to solve many of the same problems faced by Trung Khanh growers. I realise that the NZ, or other, overseas experience may not always be appropriate for Vietnam, however.

IV GENERAL RECOMMENDATIONS

i) specific goals to aim for : all of which I think could be realistically achieved, given adequate allocation of resources .....

* Increase average nut size closer to 50-60 nuts/kg (rather than present 80-100 nuts/ kg)

* bring young trees into useful commercial production 1-2 years earlier

* bring the start of harvest earlier by up to 10 days

* increase the storage life by an extra 2-3 weeks (without coolstorage) or 2-3 months with coolstorage

* double average tree yield

* increase growth rate of trees by 50-100 %

* increase productive lifetime of trees by 50-100 %

* develop a range of new high performance chestnut cultivars, unique to Trung Khanh

* develop a range of processed, value-added products (fresh, dried or frozen whole, peeled chestnuts ; chestnut flour, bread and biscuits; chestnut pastes, purees and jams; and chestnut drink (liquor ,beer or juice)

* be able to market these throughout Vietnam

* be able to export selected, high quality chestnut products overseas

ii) How to get there : There is much that the local chestnut growers can do by themselves without the need for a great deal of expensive technical input. In many cases they already know what could and should be done, but currently lack the time, the resources, or the incentive to carry it out effectively, within the present household-based chestnut production system.

To help chestnut growers help themselves, I suggest an important first step should be the establishment of a collaborative, province-wide, "chestnut growers organisation", or similar body. As in NZ, the purpose of such a body would be to help growers to help themselves, for those tasks beyond the ability and resources of any one household, however skilled and able.

Also required for an effectively functioning chestnut industry, at least in NZ ,has been.....

1. specialist chestnut extension workers
2. an ongoing chestnut research programme
3. links with other similar grower groups and industries, both nationally and internationally
4. access to new technology and new ideas
5. a nursery and plant improvement programme
6. handling, storage and processing capability
7. a marketing and promotions body

I cannot say what may or may not be appropriate for Vietnamese conditions. In NZ however, the chestnut industry consists of the following interrelated parts.....

*** a "chestnut growers association" :** (the NZ Chestnut Council) : this is a voluntary, non-profit organisation, formed with the principal aim of providing a forum for growers to share knowledge and ideas in order to accumulate and distribute "best practice" experience for the benefit of all growers. Activities include regular meetings, seminars, field days and orchard visits. In Vietnam, the emphasis may at first need to be on making the most use of the information already available on chestnuts in the province : especially from the older generation of growers whose skills, knowledge and experience may otherwise be lost. Later, the growers association could act more as the main route for the distribution of new ideas and technology, from both overseas and elsewhere in Vietnam.

In NZ, the national chestnut growers association (The NZ Chestnut Council) now charges a membership fee and also a voluntary levy, payable on a per kg basis, on chestnuts and chestnut products sold. With this income it then publishes a regular newsletter to all members ; runs a series of demonstration and field-days; holds an annual “chestnut dinner” (to try out new recipes and products); sponsors research trials; funds a small organising committee; and supports links with other chestnut grower groups both in NZ and overseas (my trip to Vietnam, included).

The NZCC , as a grower-run organisation, oversees and supervises the activities of the other essential components of the NZ chestnut industry, which are…..

*** specialist chestnut extension workers :** In NZ, this role is filled by private consultants or research scientists, like myself. Better still is the professional extension worker whose job it is to act as a link between growers, researchers and government organisations ; to facilitate technology transfer; to conduct small research trials; and to monitor compliance with industry quality standards .

*** an ongoing chestnut research programme :** to solve more difficult problems the NZCC requests help from the government or private-run research institutes (like HortResearch) to carry out specific trials into key industry problems. The NZCC provides a small financial contribution to this, along with a much greater contribution "in kind" (access to chestnuts, orchard facilities etc). This is sometimes further subsidized by Government grants. (Is the work on chestnut storage in plastic bags in Trung Khanh also being carried out this way ?).

*** links with other groups and industries :** the NZCC maintains active links with chestnut growing groups in Australia, USA, Japan and Europe : exchanging information on a regular basis. This is helped by the NZCC website ("http://www.nzcc.org.nz"), to which Vietnam could contribute. Within NZ, active links are also maintained with other nut groups (hazelnuts,

walnuts etc.) with whom much marketing and promotion is coordinated and facilities (eg. coolstores) shared.
Within Vietnam, the hazelnut industry of Hao Long province could be a natural "partner". Also useful would be links with any provincial or district coolstore users, cannery, bakery or processors with whom it might be possible to share costs.

*** access to new technology :** this should happen, naturally, as part of the above industry structure. But the NZCC also has an "R&D" manager to make sure that it does.

*** a nursery and plant improvement programme :** establishing and running this could be a job for the chestnut extension workers. The aim, as in NZ, would be to try to develop, as quickly as possible, new, high performance varieties (unique to the region) : budded or grafted in commercial nurseries and sold to growers in place of inconsistent, highly variable and unreliable seedlings. To evaluate new chestnut introductions from overseas, a demonstration, trial and extension block would also be desirable (preferably somewhat removed from existing plantings, to minimize cross-pollination).

*** A handling, storage and processing capability :** In NZ, ,simple chestnut washing, dipping and packing is done on the orchard by individual growers, using materials and chemicals supplied by a central packhouse : the costs of which are deducted from their later returns. More sophisticated grading, sorting, sizing and packaging is carried out at the packhouse itself, located as close as possible to the coolstorage facilities. The packhouse weighs and records each growers submissions. These are then pooled. As orders as placed through the NZCC and CENZ (see below), the packhouse then supplies the required quantity of nuts of the required quality. At the end of the season, the returns to growers are calculated and distributed. (An advance payment may sometimes be made to growers at the time of submission, then deducted from final payouts).

The packhouse is registered by the NZCC. It must pay the NZCC a yearly operating fee; a levy on product handled (to fund R&D); and must comply with NZCC quality and grade standards (especially for export). All chestnuts are sold under the NZCC logo. Recipes ,nutritional information and promotional literature is sometimes included.

Processing in NZ is handled somewhat differently. Chestnuts are sometimes supplied straight to bakeries etc. Two specialist, independent processing companies also exist (grower/ shareholder owned and operated). They work with both the NZCC and packhouses, but also return a dividend directly to their grower shareholders.

*** a marketing body :** while NZCC is a non-profit growers group, it also has a commercial arm called "Chestnut Exports NZ Ltd" (CENZ), whose job it is to market and sell all crop passing through NZCC-run packhouses. This includes local market sales, fresh export sales, and sales to other companies (eg. for further processing). CENZ is also a grower-owned and operated body, working very closely with both NZCC and packhouses (and sharing many of the same facilities and staff).

iii) new products/ new technologies : these would be new to chestnut production in Trung Khanh. They may or may not be appropriate for Vietnamese conditions and would need careful testing before adoption

*** grading and sorting equipment :** to automatically size grade and sort chestnuts into small, medium or large categories prior to sale. At the moment this seems to be done by hand, fairly arbitrarily. For many export and packaging applications this needs to be done much more accurately, especially when size is the major determinant of price. NZ uses a rotating drum with different sized holes through which each size of chestnut falls at a different collection point. .A much simpler version could just be a hole-punched or wire mesh sieve or basket, of the appropriate hole size. This could be combined with flotation grading and chemical dipping by simply including it as part of a water/ wash tank. This would allow flotation grading, size grading, chemical dipping and washing to all be carried out simultaneously. On a larger scale, this could be better carried out at a central packhouse.

*** mechanical harvesting equipment :** the faster all nuts can be collected, the better. If labour is short and there is a rush to pick up all chestnuts before rice harvest, then this may be useful. The larger ride-on brush or vacuum harvest equipment is only really suited for large flat, clean, well-kept orchards where the trees are all centre-leader type with no low branches. This type of chestnut orchard does not yet exist in Trung Khanh. Small back-pack vacuum harvesters may be more useful, but are probably still too expensive. The "bag-a-nut" push-along manual harvester may be better, but will only pick up lose nuts. (A soft felt or rubber cover may allow it to pick up burrs separately).

Much European harvesting is done into nets but, again, I do not think this is appropriate for Trung Khanh.

*** mechanical shelling and peeling :** three sizes of NZ-developed machines are available (either 15, 50 or 1000 kg/hr) for either individual, group, or central packhouse use (see further info. and photos attached). These are all purely mechanical sheller/peelers, far simpler and cheaper than most overseas steam and flame-based technology. (Chemical peeling of chestnuts is also available, if mechanical peeling proves unsuitable).

*** mechanical de-burring :** this may be more useful than mechanical harvest. Most NZ chestnut growers now have a small, home-made deburrer : usually 2 small low pressure tyres rotating against each other at slow speed or different speeds. This can be motor or hand driven. Intact burrs, still containing nuts, are fed down between them. The counter rotation of tyres gently squeezes out the nuts. An attached fan can be used to then separate loose nuts from empty burrs. This may be best carried out at a central packhouse.

*** modified atmosphere (MA) or controlled atmosphere (CA) storage :** these have been mentioned earlier as possible ways of storing chestnuts longer. Both rely on elevated CO2 levels to suppress fungal growth, and depressed low O2 levels to suppress chestnut respiration. CA storage facilities are expensive, but it may be possible to make use of existing facilities (and coolstores) built for other crops (fruit or flowers), especially if underutilized, out of season.

MA storage is much cheaper, needing only the specially made plastic bags (a range of which have been left in Vietnam for testing). For best results these need to be specifically produced for

each type of crop, and matched to its unique respiration rate, and typical storage temperature. Convex plastics NZ Ltd, and ICI Australia can do this. Perhaps somewhere in Vietnam can also.

Another, simpler version of MA storage involves the chemical "semperfresh ". This is a liquid, food grade, non toxic dip for coating fruit. It also provides extra shine, protection from scratching and bruising, and helps reduce moisture and weight loss. I think all these MA methods deserve testing. (Some foodgrade waxes and similar chemicals will also improve chestnut storage and appearance, but are not MA generators).

*** tree injection technology :** this is mostly used to control fungus problems such as "ink disease". A small hole is drilled into the tree trunk (or a series of holes for big trees) and a large ,plastic veterinary-type syringe inserted. A large rubber band or spring then provides positive pressure while normal tree transpiration helps distribute the chemical therapeutant through wood, leaves and roots. This can be very effective and is safer and more selective than many other conventional forms of chemical application. Slow release chemical formulations, including fertilizers and perhaps even insecticides ,can also be used. (I will send more details from NZ)

*** growth regulators :** there was one mention made of these already being used in Trung Khanh, to promote new shoot growth, but I do not have any details. Other growth regulators that have been tested on chestnuts in NZ include NAA (to suppress regrowth from pruning cuts); paclobutrozol (for vigour control); hydrogen cynanamide (to advance time of flowering);and ethrel (to advance ripening and harvest). Specially-made root restriction bags can also induce some of these same effects. None are yet in widespread commercial use however.

*** New chemicals :** I will forward information from NZ on "Garrison" pruning paint. Ecolab NZ has already provided information on its "Vortexx" and "Tsunami" products (attached).

*** biological control :** I am reluctant to recommend too much use of fungicides, herbicides, insecticides and growth regulators. Several would negate any "organically-grown, residue-free" advantages and be dangerous to both users, beneficial insects and fungi (yes there are some) and other tree species. Especially when exporting or processing, there are also problems with residues and food safety.

A much better approach to insect and fungus control, wherever possible, is biological control. This is available for gall wasp (using a predator) and for several moth and other flying insects (using sticky traps or pheromone traps). In NZ, we are now working on a possible means of biological control for fungal rots. At the moment however, this is still experimental and not available commercially. If successful, I hope this would revolutionise much chestnut storage and handling.

*** low cost coolstorage :** coolstorage is the easiest way to store chestnuts long-term, but is a difficult option for Trung Khanh. Another experimental process still under development in NZ is a low cost way of storing fresh chestnuts for much extended periods in coolstorage, but at much higher temperatures (and therefore at much reduced cost) than is currently required. This would make coolstorage a much more affordable and cost effective option for Vietnam. It is still only at the experimental stage ,however.

*** alternative drying techniques :** sometimes conventional chestnut drying produces undesirable off-flavours and smells. We have experimented with both microwaving and dehumidifying options which may help overcome this problem, if it occurs in Vietnamese chestnuts.

iv) plant improvement

*** new selections :** C. mollissima is obviously well-suited to the region. All current production is ,however, apparently based on seedlings. These are inherently highly variable, both in growth form, time of harvest, nut quality, processing and keeping quality. Individual trees were seen, however, with superior growth form (a tall, fast-growing, upright habit). Local reports also mention individual naturally early cropping and high performance trees. All these characteristics would be very useful if they could be replicated on a larger scale, and could be used as the basis of new high performance commercial chestnut cultivars and specific timber selections (which could also help take the pressure off the use of what should be nut producing trees for firewood).

Seed from such trees could be collected and planted as superior seed lines, for evaluation . Better still, graftwood or budwood taken from proven high-performing trees could be used to propagate clonal material (preferably on seedling rootstocks from the same tree, to minimize the risk of rootstock incompatibility). A specialist chestnut nursery could then produce and distribute these trees throughout the region, as has been successfully done for C. mollissima selections throughout China.

It is harder to bud or graft C. mollissima than some other chestnut species, but it can be done successfully. (I will send details).

*** new introductions :** it might be useful to introduce the best of the current Chinese chestnut selections and evaluate them under Vietnamese conditions also (especially the new Chinese variety, reputably able to crop twice a year : although I skeptical of some of the claims made). Like some NZ selections, some local Trung Khanh trees were seen flowering for a second time after harvest, so the potential may exist for them to be also turned into double-croppers.

Another good source of improved C. mollissima selections may be the USA, where they were introduced in the early 1900s to help replace diseased American chestnuts.

*** new chestnut species :** Japanese chestnuts (C. crenata) grown in Trung Khanh would, I am sure, find a ready market in Japan. We have tried to grow pure Japanese varieties in NZ, but we have not met Japanese standards. Vietnam might be able to. One word of warning however : if such Japanese selections were allowed to pollinate local Trung Khanh selections, then the local selections might lose their natural easy- peel characteristics. (As has happened in Korea and elsewhere). This is a result of chestnut's unusual reproductive biology. It may be necessary to plant any introduced Japanese chestnut orchards out of reach of existing Vietnamese production : where cross pollination cannot easily occur. (On the other hand, using Japanese chestnuts as pollinators may help increase local nut size, which, for some processing and marketing applications, may be more important than peelability).

Introduced NZ hybrid or European chestnut selections could help extend the natural harvest season, if desired. These typically flower and crop several weeks later than normal C. mollissima and might be useful in that they could be ready for harvest only after the rice crop is finished .

There is another, less common, Chinese chestnut species (C.henryi) which should cop much earlier than current Trung Khanh selections. This usually has only one nut per burr, but should fetch a high price being so early.

*** wild chestnuts and chestnut relatives :** Chinese chestnut literature describes several "wild" chestnut selections, while English-language chestnut literature describes a chestnut-like species called Castanopsis. Many different forms of this exist, some with edible nuts and excellent timber characteristics, which could be very useful commercially. In one village visited, several very tall, straight trees with acorn-like nuts and chestnut-like leaves were found, meeting these descriptions (but not, apparently, edible). Old chestnut references from the 1940s refer to several very good, edible forms of Castanopsis being found in Indo-China, but no more information was given. The existence and possible commercial potential of these trees may be worth pursuing further.

v) key recommendations

* place increased emphasis on improved tree and orchard health

* aim to increase both tree productivity , longevity and nut quality

* develop a suitable" chestnut growers association" and "chestnut industry" structure

* use this to initiate a regional plant improvement and evaluation programme

*……..to develop improved handling and storage capabilities

*……..to evaluate and adopt new production and processing techniques

*……...to develop closer links other nut crop groups, product groups requiring similar facilities, and other chestnut producing and research organisations

*……to explore expanded marketing opportunities, both nationally and internationally

*…….to investigate other , non-traditional, chestnut-related products and end-uses

Tree health is the area most in need of improvement and where I think most improvement can be made relatively easily and quickly. I think significant improvements are possible in terms of both overall tree yield, productive lifespan and nut quality, including size. The easiest way to improve the returns from chestnuts is to produce big nuts, and more of them.

Further improvement and expansion I see as probably being beyond the resources of individual growers, at the moment, and so requiring the formation of suitable "chestnut growers association" and "chestnut industry" – type structures : to pool and coordinate scarce skills and resources, and to facilitate change.

I hope that this sort of grower driven organisation could then help supervise and direct a dedicated plant improvement and nursery programme aimed at moving beyond the present constraints imposed by a highly variable seedling population, with often low overall performance. If necessary, I would like to see already scarce care and attention spent on a smaller number of excellent trees rather than a large number of mediocre ones, which simply dissipate scarce resources even further.

To justify all this, a higher return to growers is required which can only come, I feel, through better storage, better transport, handling and value-added processing : much of which may only prove cost-effective if carried out at the district and provincial (rather than village/ commune) level.

To do this will require the introduction of new technology, ideas and expertise which will, in turn, require closer links with overseas chestnut groups and research providers. Closer links with other nut groups and related industries in Vietnam could help share the costs. The most cost effective option, initially, may just be to make shared use, wherever possible, of facilities and infrastructure already in place for other fruit or vegetable crops. Extra technology should only be introduced if key elements of this (eg. peeling, drying or coolstorage) are totally lacking. (For this reason I am hesitant to be too specific in saying what is needed most in storage and processing, until I know what skills and capabilities are already available in Vietnam, and where).

If this was the route taken, however, to sustain such an industry expansion would probably also require the development of new markets, wider afield, both within Vietnam and beyond, as well as the development of a more diversified product range (eg. chestnut timber, edible mushroom production and related products). Hopefully at least some of these would then go on to become stand-alone, spin –off industries in their own right.

V : UNANSWERED QUESTIONS

There are several areas which still require further investigation and specific questions that still require answers….

- the identity of the epiphytic plants such as Mac Pup : is it a problem only for chestnuts in Vietnam?; is it truly parasitic ?; how do the forestry people deal with the problem ?; is there one species or several ?; does its fruit have any commercial potential ?

- the identity of the mushrooms commonly found growing under Trung Khanh chestnuts : are any of these edible ?; do any of these have commercial potential ?; are they myccorhizal ?
  how best to control ants, borers and termites on chestnuts : presumably other crops have the same problem and management techniques can be copied from them

- the identity of the various borer and other insect eating insect species encountered : are these the same as found overseas (impossible to identify conclusively at this time of year) ?; are they problems for other crops in Vietnam ?; how do these crops deal with them ?

- Is C. henryi already found in Vietnam ?. If so, has it hybridized with local C.mollissima chestnuts ? (It could have good commercial potential).

- Is Castanopsis already found in Vietnam , and if so, which types ? Again, this could have useful commercial potential.

- Are there any grafted or budded chestnuts grown anywhere in Vietnam, or are they all seedlings ? Are there any selected seedling varieties ? Any or all of these could be a useful shortcut in future plant improvement.

- Are there any soil nutrient analyses available for the Trung Khanh region ?

- Are there any chestnut foliar nutrient analyses available for the region

- Has the food value and nutritional status of Trung Khanh chestnuts been analysed yet (for comparison with overseas chestnuts and for use in marketing and promotion).
-
- Is there a commercial market for chestnut wood ?

- Are there existing mushroom producing companies in Vietnam that would be interested in chestnut wood or sawdust as a growing medium ?

- Is there a problem with inadequate flowering and pollination ? (It was the wrong time of year to tell).

- Are there commercial beekeepers who would be interested in chestnut honey ?

- Are there bread and biscuit makers who would be interested in chestnut flour and chestnut pieces?

- Are there other nut crop groups that chestnut growers could work with ?

- Is there a premium for organically-grown, high health, residue-free products in Vietnam ?

- Is there existing coolstore, peeling, processing, packaging or transport facilities available nearby that could be "borrowed" or shared for use on chestnuts (especially if lying idle out of season).

- Is there any information available on the history of chestnuts in Vietnam ? If not, would it be possible to put together a short publication describing the history of the crop ?

Talking to villagers, district and provincial officials alike suggested that there had been several local initiatives over the years, involving government support to chestnut growers, subsidies to buy seed from china, encouragement to increase plantings, the creation of model farms, demonstration blocks and so on. There seem to have been several surveys carried out into the chestnut growing potential of the region, possibly even including one from Japan. Various growers talked about introductions made by their grandparents. Several claimed to have been the first ones to introduce chestnuts to the region. Some mention was also made of early French introductions and the sending of Vietnamese chestnuts all the way back to France. At one commune visited there was already a very interesting packaging, storage and chemical treatment trial in progress, being conducted by some Vietnamese government department.

Published information in English about chestnuts in Vietnam is rare to non-existent. There is mention, though, of various French involvement with chestnuts in the region, through the 1940s and 1950s, and of highly valued Castanopsis species, of around that time.

If some of this information could be collated and authenticated, then a paper could be presented by Vietnam at the next International Chestnut Conference (held every 2-3 years). The last one was in France. The next one may be in China. I am sure many countries do not know that there are even chestnuts in Vietnam, let alone some very high quality ones. This could be a good opportunity to publicise their existence and explore opportunities for their further development and marketing, worldwide

VI. LOOKING FURTHER AHEAD …..

It should be much easier for Vietnam to establish a large-scale, successful chestnut producing, processing, exporting and marketing industry than it has been for NZ. NZ has had to struggle against the problems imposed by :-

- distance from most export markets
- small grower and production base
- lack of easy-peel cultivars
- out-of-season (Southern Hemisphere) production.

Vietnam has none of these problems. What's stopping Vietnam becoming a major world chestnut producer, processor and exporter are :-

- lack of consistently-performing cultivars
- lack of consistently-performing orchards
- lack of technology, expertise and skills
- lack of an overall industry structure
- lack of handling, storage, processing and exporting infrastructure.

These are all problems NZ could help overcome. They are all problems that NZ also faced in the early years. To follow the European or Japanese models for overcoming these problems would have meant heavy investment in expensive coolstorage, and large, expensive and specialised processing equipment which NZ could not afford and the small size of the NZ chestnut industry could not justify.

Instead, NZ has tried to develop its chestnut industry along lines that other countries' would find difficult to match :-

- a clean and green, organically-grown, chemical residue-free, high-health reputation : with an emphasis on biological control of pests and diseases, (rather than high chemical usage)
- new, unique chestnut cultivars, coupled to high productivity
- new and innovative processing and technology.

I would hope that the same approach could also be useful for Vietnam, and that by utilising NZ experience it would be possible to "fast-track" the development of what would essentially be a "new industry", even though its based on a very old crop.

What NZ can offer ….

- Export, sales and marketing expertise : almost all our chestnuts are exported.

- An organic, clean and green, residue-free label and reputation.
- Skills and expertise : especially with orchard management and plant improvement.
- Some promising new technology, which no-one else has yet got:-
    - flotation grading: The "conventional" alternative for chestnuts is very expensive near infra-red (NIR), nuclear-magnetic-resonance (NMR) or similar computer imagery.
    - low-cost shelling and peeling: low-cost mechanical peeling of fresh chestnuts, whereas most other "conventional" equipment is very large, expensive and produces only cooked product.
    - low-cost handling and storage: the alternative is expensive coolstorage.
    - biological control of pests and diseases: either through tree injection, targeted chemical application or without chemicals altogether.
    - new processing equipment and new product development: especially a "unique" NZ crumbed chestnut, long-life, product.

Most of these techniques are new, not in use outside NZ, and still being improved upon, but they do offer a real opportunity to by-pass many of the key constraints currently holding back chestnut development in Vietnam.

Some specific suggestions for follow-up work ….

: ranging from the simple up to the more complicated and expensive :-

- Joint translation of Chinese ("Ban-Li") chestnut handbook : a copy of this has been left in Vietnam. The chestnut trees growing in Trung Khanh are *C. mollissima* (Chinese)-type. Much of the basic information required by growers is therefore available, but currently only in Chinese. This could be translated far more cheaply in Vietnam than in NZ. It could be carried out as a joint NZ-Vietnam project. NZ could help with technical terminology and cost, in return for access to relevant sections translated into English.

- Vietnam to join the NZ Chestnut Council, subscribe to the "Chestnutz News" newsletter and contribute articles on chestnuts in Vietnam.

- A joint Vietnam-NZ presentation at the next International Chestnut Conference on "Chestnuts in Vietnam" : history, current status, research, and new developments.

- A Vietnam-NZ exchange of chestnut varieties : seed and scion wood from Vietnam, new varieties from NZ.

- Establishment of a demonstration nursery and chestnut germplasm collection : a fixed site to grow-on this imported plant material in Vietnam, and to develop new ones (local and introduced).

- Establish a plant-improvement programme : initially by identifying and selecting high performance seedlines. Later, by propagation (budding and grafting) and breeding.

- Visit from NZ to demonstrate budding and grafting techniques : This could consist of 1 week in Spring (for seed-sowing, nursery establishment and grafting) and 1 week in Autumn (for budding, seed selection and tree selection). It could also be structured to include co-ordination of the nursery and demonstration block, exchange of cultivars, and the plant-improvement programme.

- Introduction of new technology : I will arrange for product samples to be forwarded to Vietnam. Several NZ and Australian companies are also interested in getting in touch. Who with? Products that could be obtained, "off-the-shelf", before next season include :-
    - "Vortexx" and "Tsunami" surface sterilants
    - "Semperfresh" surface coatings
    - MA bags (various brands)
    - "Vigilant" herbicide and applicator
    - "Garrison" pruning paint
    - pheromone and insect traps

- To develop a storage, processing and export industry would need the establishment of additional specialised facilities for :-
    - grading and sorting
    - shelling and peeling
    - packaging and storage.

  This could be provided by a combination of HortResearch and NZCC equipment and expertise, but would require the development, installation and testing of new equipment in Vietnam, and the training of people to operate it.

Initial exchanges between Vietnam and NZ could be carried out by myself and the project office at Cao Bang. This can include product samples and basic information. It may be possible to develop further links (eg. the plant improvement and nursery programmes) as part of future NZ-Vietnam aid packages. Other NZ and Australian companies could deal directly with Vietnam if there was an appropriate English-speaking contact person to deal through. Should such initial trials prove successful, then I am sure HortResearch and NZCC would both very much like to be involved in any future decisions to jointly help develop a successful Vietnamese chestnut industry.

VII : SUGGESTIONS AND REMINDERS FOR EVERYONE ASSOCIATED WITH THE CHESTNUT INDUSTRY

- A good chestnut orchard……
- A good chestnut grower ……
- To help chestnuts store longer and better…….
- Good chestnut trees need……
- Don't……
- 12 ways to help store chestnuts …..
- 12 ways to help process chestnuts …..
- To sell chestnuts for the best price ……..
- A successful chestnut industry….
- 12 ways to ruin a chestnut industry…..
- 12 ways to help market chestnuts…..
- Key steps in the creation of a successful chestnut industry…..
- 12 ways to help share the cost

A GOOD CHESTNUT ORCHARD…….

- has large, fast-growing trees
- has good light penetration with wide tree spacings
- does not have crowded trees shading each other
- has little branch or trunk damage
- has trees with good strong , single, upright trunks
- has little dead wood or stubs
- has lots of new growth each year
- has good free-draining soil with lots of topsoil
- has lots of mushrooms growing beneath the chestnut trees
- has lots of myccorhizal roots
- has good pollination, with many nuts per burr
- has a clean understorey

A GOOD CHESTNUT GROWER ……

- keeps cattle from damaging trees
- does not remove the topsoil
- does not plant so close that trees shade each other
- does not interplant too close to the tree
- removes dead wood and branches cleanly
- does not leave old dead stubs or wounds for pest and disease entry
- adds organic matter and fertilizer to the soil if growth seems to be slowing
- keeps the orchard floor and understorey clean
- waits for ripe chestnuts to fall naturally
- does not knock the burrs off early
- picks the chestnuts up as soon as possible after they fall
- keeps the nuts as clean as possible

TO HELP CHESTNUTS STORE LONGER AND BETTER …….

- keep orchard clean and healthy
- only pick chestnuts when ripe
- pick nuts up as soon as possible after they fall
- remove all damaged, insect-holed, split, rotten or germinating nuts
- do not store these bad nuts with good ones
- the drier the nuts, the longer they'll store
- the colder the nuts the longer they'll store
- the cleaner the nuts the longer they'll store
- always store in well-ventilated packaging
- surface sterilization and washing will help prevent surface moulds
- flotation grading will help remove nuts with internal rots
- high density nuts will store best and taste best

GOOD CHESTNUT TREES NEED ……..

- lots of light
- wide spacings
- hot summers
- water, but not waterlogging
- nutrients, especially N,P,K and perhaps Mg
- good soil structure with high organic matter
- new shoots each year, to produce flowers
- pollination, to set fruit
- protection from physical damage
- protection from pests and diseases
- good strong trunks and healthy roots
- myccorhizal fungi

DON'T…….

- let cattle damage trees
- plant too close or let trees get shaded
- remove topsoil
- let trees get waterlogged
- leave unnecessary dead wood and stubs
- let the orchard get old dirty and diseased
- let trees slow down and stop growing
- interplant or weed too close to the chestnut trees
- starve the trees of food and water
- pick unripe nuts too early
- let nuts get dirty or lie on the ground too long
- store bad nuts with good

12 WAYS TO HELP STORE CHESTNUTS ……

- dried to low or very low moisture contents (40% down to 5-10%)
- in sand or sawdust (China)
- in brine (China)
- frozen (-18 C) or freeze-dried
- in coolstorage (-2 to +2 C)
- in sub zero storage, without freezing (0 to –2 or 3 C)
- in modified atmosphere (MA) storage
- in controlled atmosphere (CA) storage
- heat treated (50 – 60 C for 15-30 minutes)
- surface coated (with food-grade waxes or “Semperfresh”)
- after soaking in water (France/ Italy)
- after dipping in chemicals (surface sterilants of fungicides)

12 WAYS TO PROCESS CHESTNUTS …….

- dried whole chestnuts
- peeled, whole chestnuts : fresh
- : dried
- : frozen
- : vacuum-packed
- chestnut flour
- chestnut bread
- chestnut biscuits
- chestnut stuffing
- chestnut puree, paste or jam
- chestnut confectionery
- chestnut juice or alcohol

TO SELL CHESTNUTS FOR THE BEST PRICE , THEY SHOULD BE …….

- large and shiny
- dark (ripe) but not black (rotten)
- have a long shelf life
- be free of splits, cracks or scratches
- be free of dirt, grass , stones or sticks
- be free of surface mould
- be free of internal rots
- be free from chemical or other residues
- be firm, not soft, to touch
- be graded by size
- be yellow inside, rather than brown or black, or even white
- be easy to peel

A SUCCESSFUL CHESTNUT INDUSTRY ……

- has a strong, grower-run industry structure
- provides reliable advice and assistance to its growers
- consists of growers who actively support their industry in return
- is always developing new and improved production techniques
- plant varieties
- chestnut products
- chestnut markets
- sets and enforces its own quality and production standards
- has control over its own handling storage and packaging
- promotions and marketing
- research programme
- provides a wide range of consistently high quality products

12 WAYS TO RUIN A CHESTNUT INDUSTRY…….

- variable and inconsistent tree quality
- variable and inconsistent nut quality
- variable and inconsistent orchard practice
- lack of industry structure and coordination
- growers and marketers competing against each other
- lack of basic knowledge about the crop
- inappropriate technology
- losing value-added benefits to others
- lack of investment and basic resources
- dissatisfied customers
- inability to reach potential markets
- weak organisation and fragmentation

12 WAYS TO HELP MARKET CHESTNUTS …….

- with an “organically-grown, residue-free” label
- with a unique “Trung Khanh- grown” label
- promotion of chestnuts as a “health and energy” food
- provide attached nutritional and cooking information
- sell as value-added products, wherever possible
- be easy to use : preshelled or precooked
- be easy to buy : pre-graded and sorted
- : pre-sized
- :pre-weighed
- pre-packaged
- make available extra early or late (ie. out of season)
- make available in new and novel forms (eg. processed or as new varieties of chestnut)

KEY STEPS IN THE CREATION OF A SUCCESSFUL CHESTNUT STORAGE AND PROCESSING INDUSTRY

- a growers group to help coordinate all chestnut related activities
- making “best practice” advice readily available to growers
- industry-wide, enforceable, chestnut quality standards
- nursery and tree quality standards
- an industry group to help coordinate sales and marketing
- access to suitable peeling technology
- grading and sorting technology
- packaging technology
- storage technology
- long distance transport
- promotional and marketing skills
- industry-wide research and plant improvement programmes

12 WAYS TO HELP SHARE THE COST…….

- a collaborative growers association
- shared links with other Vietnam- based nut crops (eg. hazelnuts) facing similar problems
- shared links, especially information, with other overseas chestnut growing groups
- sharing existing coolstore, packhouse, packaging and transport access with other fruit and vegetable industries also requiring the same facilities
- supplying already existing bread, flour and biscuit-making industries
- supplying already- existing canning, cooking and processing facilities ,already in use by other crops
- making use or existing peeling facilities already in use by other crops (eg. fruit and fish processing)
- especially where out of season production means that any of these may be otherwise lying idle (eg. fish factories)
- sharing promotional costs with other “high health/ organic” crops and products
- sharing marketing costs with other high value, perishable fruit crops, with similar problems
- collecting industry levies on product sold, and packhouse registration fees, payable back to the chestnut growers association
- certifying (for a fee) the “organically-grown, Trung Khanh-grown, and residue-free “ label as a trademarked brand or logo

VIII : ATTACHMENTS

- all in English unless otherwise stated
- relevant extracts highlighted in text

A. GENERAL REFERENCES

1. " NZ Chestnut Council Growers Sourcebook " (1999)
   Part I : introduction to chestnut growing
   part II : chestnuts around the world
   part III : orchard establishment
   Part IV : orchard management
   Part V : pests and disease
   Part VI : handling, processing and eating quality

   (almost all you need to know about chestnut growing in NZ)

2. "Growing chestnuts in NZ " (2000)
   introduction
   NZ Chestnut Council organisation
   Chestnut peelers and recipe book
   20 common questions and answers
   index to newsletter back issues
   chestnuts worldwide
   sample newsletters (Feb 1999, May 2000)

   (this is the standard chestnut information package supplied by NZCC to all NZ chestnut growers)

3. "Chestnutz News " (July 2000) : the latest newsletter from the NZCC

4. "Chestnuts : Production and Culture " : Martin Crawford. 1995.,
   (a very good general chestnut reference)

5. " Ban Li" (Chinese chestnuts) : L. Liu, S. Hoa, C. Ho, 1991 (in Chinese)

6. "Marrons et Chataignes " : H. Breisch 1999 (in French)

7. "Handling, storage and processing of chestnuts " : D. McNeil (NZ) 1998

8. "Chestnuts in NZ" : Klinac and Knowles . 1999

9. "NZ Chestnut Research" : Klinac . 1999

10. “Chestnut Research and Production in NZ “ Klinac, Knowles and Nguyen. 1999 (paper presented at the 2nd International Chestnut Conference, Bordeaux).

B. RESEARCH REPORTS

11. “Time of flowering and pollination in some NZ chestnut selections” (includes the use of growth regulators) : Klinac, Lelieveld and Knowles . 1995

12. “Chestnut postharvest storage and handling “. Klinac and Forbes. 1994

13. “Storage techniques for European Chestnuts” : H. Breisch . 1998

14. “Effect of declining moisture content on chestnut storage and quality” (graph) : G. Miller. 1992. (for USA chestnuts only)

15. “Evaluating the use of heat, hot water dipping, controlled drying and low temperature storage on NZ chestnuts “ : Klinac and Nguyen. 1998

16. “Determining chestnut respiration rate and evaluating the effectiveness of MA/ CA storage “ : Klinac and Nguyen. 1998

17. “Control of surface moulds on chestnuts “ . : Klinac . 2000

18. “Flotation grading of chestnuts “ : R. Seelye. 1998

19. “Postharvest fruit density as an indicator of dry matter and soluble solids of kiwifruit” : (the theoretical basis for flotation grading) : Jordan et al. 2000.

C. TECHNICAL DATA

20. Ecolab Industries NZ Ltd (contact details)

21. “Vortexx” product information

22. “Tsunami” product information

23. “Semperfresh” product information

24. Castlechem Industries Australia Ltd (contact details)

25. “Bag-a-nut” (mechanical harvester) brochure

26. “CIFARELLI” (vacuum harvester) brochure

27. “DTR” (temperature recorder) brochure

28. “Longlife” MA packaging and storing instructions

29. “Longlife” MA product description and information

30. “Lifespan” MA brochure

31. “Lifespan” MA packing instructions

32. Convex Packaging NZ Ltd brochure (and samples)

D. MISCELLANEOUS

33. NZCC Chestnut Recipe Book (and nutritional data)

34.”Breakthrough for chestnuts” (newspaper article)

35.”The best nut in the world” (HortResearch Newsletter)

36.”Soil plant testing” and “Preparation and submission of overseas plant and soil samples” (Hill Laboratories NZ Ltd)

37. “Chestnuts in Korea”

38.”Chinese chestnut storage and handling techniques” (ex Internet)

39.”Chestnuts, Nashi and Sphagnum moss “ (NZ University lecture series)

E. PHOTOGRAPHS

40.large mechanical sheller/ peeler (500+ kg/hr)

41.medium sized mechanical peeler (50 kg/hr)

42.small sized mechanical peeler (15-20 kg/hr)

43.whole, fresh, machine peeled chestnuts

44.magnesium sulphate (for flotation grading)

F. PRODUCT SAMPLES

- MA bags from Convex Plastics Ltd
- MA bags from “Lifespan”
- MA bags from “Longlife”
- Chlorine bleach (local)
- Hydrogen peroxide (local)
- Epsom salts (MgSO4 : local)
- Various net, mesh and plastic bags

NOTES

- please do not quote or publish information from authors other than myself without permission
- NZCC would very much appreciate a translation of the Chinese-language publications provided, in return for NZ information
- Please acknowledge NZ Chestnut Council if referring to any NZ chestnut information, and also HortResearch, if referring to technical or scientific reports

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