INTERNATIONAL NETWORK FOR BAMBOO AND RATTAN
(INBAR)

TRANSFER OF TECHNOLOGY MODEL
(TOTEM)

BAMBOO SHOOT PLANTATION

by

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TRANSFER OF TECHNOLOGY MODELS (TOTEMS)

Transfer of Technology Models (TOTEMs) are focussed educational tools providing relevant information and distance training on one specific area of bamboo/rattan management, processing or utilization. They are a means of technology transfer between similar regions throughout the world, with the emphasis on South-South transfer for livelihood development. They enable those involved in the management and use of bamboo and rattan resources to more efficiently and effectively develop and use skills relating to these resources.

TOTEMs are primarily intended as practical information resources and teaching aids for those at the local extension level in their communities, who can utilize them to assist local community development. Each TOTEM consists of a detailed written report of the technology, a PowerPoint presentation, a video, and, where relevant, a set of technical photographs. They also include information on target users, financial analyses of sample set-ups from the partner country preparing the report, and information on where to source particular technologies (such as equipment). The TOTEM thus provides all the information required for establishing similar technologies within interested countries and regions.

- The **report** contains all the technical details of the particular processes involved, as well as other relevant information for establishing the technology such as costs of business establishment, running costs and cash flows.

- The **PowerPoint** presentation contains details of the relevant technologies and their applications, and is intended to provide an overview of the potential of the technology for development.

- The **video** provides a visual guide to the processes involved and helps to bring them alive in the minds of the learners.

The different parts of the TOTEM are targeted at slightly different audiences, via the local extension workers. The report and film are intended to be the main means of extension to the individuals and communities who will implement the technology and who will directly benefit from it. The PowerPoint presentation is primarily intended as a tool for the extension worker to sell the technology and its role in development to those who provide the infrastructural, policy and financial support for its implementation, such as government departments, donors and NGOs. There is considerable flexibility, however. Local extension workers will be able to incorporate the TOTEMs in their own work as they wish, and using the bibliography and list of web-sites will be able to adapt and develop the TOTEM to suit their particular requirements and conditions.

This TOTEM on **Bamboo Shoot Production** has been produced by Xiao JiangHua and his team at the Research Institute of Subtropical Forestry, Fuyang, China. The report part of this TOTEM describes the technology for producing and establishing shoot-producing plantations for rural development in regions where bamboo is available as a raw material. It is intended to be used in conjunction with the illustrative video included in this TOTEM package

The first part of the report introduces the technology, discusses its history, its development attributes, its benefits and it's applicability. The second part of the report provides detailed

information on the technical aspects of establishing and managing a bamboo shoots plantation and a shoot-canning factory. **Appendix I** is a bibliography of publications. **Appendix II** shows a recommended afforestation model for bamboo shoot plantations. **Appendix III** gives a brief economic analysis of the bamboo shoot canning factory.

This TOTEM is one of the first to be produced by INBAR/ RISF and your feedback is most welcome - kindly contact INBAR or RISF with your comments or suggestions.

Note 1: This TOTEM has been edited at INBAR and differs slightly from the form in which it was received from the authors.

Note 2: All financial calculations are in Renminbi. At the time of writing RMB 8.3 = USD$1

BAMBOO SHOOT PLANTATIONS AT-A-GLANCE

What are bamboo shoots?

Bamboo shoots are young bamboo stems (culms). They are very nutritious and have been eaten as a vegetable for thousands of years in many Asian countries. There are three types of shoots; spring or summer shoots, winter shoots (very tender) and rhizome shoots.

How are they produced?

Most bamboos produce new culms once each year, usually in the spring or autumn. By careful management of bamboo plantations a maximum number of shoots can be encouraged to grow each year. They can then be harvested when they are about 15- 30 cm long, depending on the species.

What is the market for bamboo shoots?

The market for bamboo shoots is very large. Fresh shoots are very popular in many regions, but it is the export market for canned shoots that holds more potential for growth. Increasing populations of Asian peoples in all countries of the world, and popularity of shoots amongst non traditional consumers, means that the market for shoots is presently growing at a rapid pace and can be expected to continue to do so for the foreseeable future.

What is the role of a bamboo shoots plantation in rural development?

A bamboo shoots plantation can bring degraded lands back into production and provide income-generating options for farmers. It is easily adopted because it builds on the inherent plant cultivation skills of the farmers. Bamboos grow better with organic inputs, such as fertiliser, so the production of shoots is not harmful to the environment. Additionally, if established in conjunction with a local shoot-canning unit, benefits to the employees and the wider community will result.

How do I establish a bamboo shoots plantation?

All that is required to establish a bamboo shoots plantation is land and bamboo propagules. The costs of establishment are thus limited to the cost of the propagules and the labour. Ideally some linkages to shoots processors would be established to guarantee a market for the shoots. Alternatively the plantation may be established in conjunction with a shoot-processing unit. Both could be established as part of one community cooperative and producers and processors would benefit.

PART ONE

INTRODUCTION

DEVELOPMENT ATTRIBUTES, TARGET GROUPS and BENEFITS of a

BAMBOO SHOOTS PLANTATION

1. Bamboo shoots

Bamboo shoots are a traditional vegetable for many people, especially for oriental peoples, and bamboo shoots are becoming more and more popular. However, the availability of fresh edible bamboo shoots is very limited for much of the year and in many places of the world generally lasts for only one to four months. In many parts of the world bamboos are not grown for shoots due to unsuitable socio-economic and ecological environments For example, Australia has approximately 1.5 million people, or 8% of the population, from an ethnic Asian background. Until recently it was not realised that Australia is now consuming somewhere between 4, 000 and 12, 000 tonnes of imported canned bamboo shoots each year. The demand for shoots is even larger in the USA and some other countries.

2. History of the development of the bamboo shoots industry in China

China has a long tradition of cultivating, processing and preserving bamboo shoots as food. In China, modern bamboo silvicultural practices for producing shoots started in the 1950's. A series of systematic silvicultural and processing techniques has been developed, which includes high-yielding cultivation and management of natural stands and plantations and establishment of factories for preserving and processing bamboo shoots. These bamboo silvicultural and processing technologies have greatly promoted the bamboo shoot industry in China. In 1999, bamboo shoot production was the largest component of the exports of bamboo products from China. The annual export of canned edible bamboo shoot products is worth nearly US$200 million, which is almost 40% of all bamboo exports.

3. General development attributes and advantages

The main development attributes of the technology are as follows:

- Income generation for poor rural people
- Improves and broadens farmers plant cultivation skills base, making the farm enterprise more resilient
- Increases the area of managed bamboo resources
- Brings degraded land back into productivity

The main advantages of the technology are:

- It is builds upon rural farmers own inherent plant-cultivation abilities and hence is easily adopted

- It is extremely environmentally-friendly - organic inputs such as fertiliser are better for bamboo growth than inorganic ones

4. Suitable agro-ecological regions

A bamboo plantation may be established in most tropical, subtropical and temperate regions of the world. The shoots of many different species are edible and selection of species adapted to the particular climatic conditions prevalent at a particular location is essential. Bamboos may be grown on farmland, hillsides and along riverbanks and a shoot plantation is particularly suitable to help restore degraded lands, such as those left after shifting cultivation. The plantation may also be established in areas of high rainfall and steep topography, where erosion is a problem.

5. Target groups

The main target groups are the cultivators and harvesters of the bamboo plantation and the technology is ideally suited to poor rural farmers. Another target group are the employees of the shoot-processing unit that may be established concurrently. The shoot-processing unit would employ unskilled, semi skilled and technically trained personnel. If the plantation and unit are established as community cooperatives then the community as a whole will benefit.

6. Requirement for success

The essential requirements for successful implementation of shoot production technology are:

- Availability of natural bamboo forests and plantations for producing bamboo shoots.
- Availability of management skills for shoot-producing bamboo plantation.

Additionally, if a canning unit is to be established concurrently the following will be required:

- Appropriate technology, machinery and technically trained personnel to set up and manage a canned shoot production unit.
- Mechanism to promote the sale of fresh and canned shoots for domestic and export markets.
- Financial support.

Concluding remarks

A bamboo shoot plantation is an excellent means of sustainably developing rural communities in bamboo growing regions. Bamboo cultivators will be the direct beneficiaries but the community as a whole will benefit especially if the processing of shoots remains within the community through the establishment of a community shoot-canning unit.

The bamboo shoots industry in China has been shown in a recent INBAR funded study to preferentially increase incomes of the poorest members of the society compared to more affluent groups although the incomes of all community participants increase. A bamboo shoots plantation is a proven means of reducing rural poverty.

PART TWO

THE BAMBOO SHOOTS PLANTATION

A: Establishment and management of a bamboo shoots plantation

1. Species and site selection

1.1 Species selection for shoot plantations

Some superior monopodial and sympodial species are shown in table 1:

Table 1 Superior species for edible shoots

Monopodial Bamboos	*Phyllostachys pubescens; Ph. praecox; Ph. praecox f. pervernalis; Ph. propinqua; Ph. dulcis; Ph. irridenscens; Ph. prominens; Ph. flexuosa; Ph. bambusoides.*
Sympodial bamboos	*Dendrocalamus latiflorus; Dendrocalamopsis vario-striata; Den. beecheyana; Den. beecheyana* var. *pubescens; Den. validus; Den. hamiltonii.*

1.2 Site selection

There are more than 100 species or varieties presently cultivated for shoots in China. Different species vary in their requirements for environmental conditions. Bamboo shoot productivity is mainly dependent on the genetic characteristics of the species, environmental conditions and management practices employed. To achieve high yields from plantations, the species must be suited to the particular environmental conditions at that location (climate, soil and topography).

To cultivate high-yielding bamboos for shoots it is necessary to know each species' particular requirement for climate, topography and soil. Most sympodial bamboos have limited cold-resistance and are limited to tropical and subtropical regions. Most of the monopodial bamboos are much more resistant to cold, and can be grown in the warm temperate zone. Some high altitude mountainous bamboo species, such as *Yushania* and *Fargesia* are very cold-resistant, but they must grow in middle or high mountainous areas to the south of the Yangtze River in areas with high relative air humidity otherwise they will not grow well.

Monopodial Bamboos

Monopodial bamboos prefer sites with a warm, moist climate and annual precipitation over 1,200 mm. In China, for instance, their central distribution area is located between the Yangtze River and the north of the Nanling mountains. North of the Yangtse they extend up to the Yellow River basin, where the main climate factors affecting monopodial bamboo's growth are drought during the growing season and severe cold in winter. Monopodial bamboos should be grown in sunny sites with high rainfall in spring and summer and easy access to irrigation.

Monopodial bamboos grow fast and have strong underground rhizome-root systems, which grow 20-30 cm deep in the soil and no deeper than 50 cm. They require fertile, moist, well-drained soils with a pH of 4.5-7.0. The groundwater level should be under 1 m. Monopodial bamboos are not suitable for clayey, barren soil or saline-alkali soil.

Topographical conditions have direct and indirect influences on the growth of monopodial bamboos. The direct influences include prevention of rhizome growth and liability to snow pressure and wind on steep slopes. The indirect influences mainly result from changes of topographical conditions that result in microclimate variations such as air temperature, moisture content and changes of soil condition. In the central distribution area of monopodial bamboos, it is better to select the mountain valleys or the foot of mountains under 800 m altitude to establish shoot plantations.

Sympodial Bamboos

Sympodial bamboos have higher demands for temperature and humidity, and in China they are mainly distributed to the south of the Nanling mountains and in the Sichuan basin. Different species have different requirements for humidity and temperature. For example *Dendrocalamus latiflorus* and *Bambusa oldhamii* require annual average temperatures of 18-20°C, average January temperatures of about 6-8°C and annual precipitation of more than 1400 mm. *Neosinocalamus affinis* and *Bambusa multiplex* are distributed in the northern part of the sympodial bamboo distribution area. They require lower moisture and temperature conditions with annual average temperatures of 16-18 °C, average January temperatures 2-4°C, annual precipitation more than 1,200 mm.

The plantation should be located on foothills and river banks under 200-300 meters above sea level. A relatively level site is required with deep, loose, fertile sandy loam. Dry and barren, rocky or very clayey soil is not suitable for sympodial bamboos.

2. Field Propagation and Nursery Techniques

There are two ways of propagating bamboos: sexual and asexual propagation. Bamboos seldom flower and even when they do only a few mature seeds are produced. Hence raising plants from seed is only possible occasionally. Thus the most common and practical method of raising plantlets is by asexual propagation. This involves the use of offsets, culm (or branch) cuttings, stumps with rhizomes, and rhizomes themselves for direct afforestation or for plantlet preparation in a nursery and then planting out. Culm or branch cuttings are the most widely used method for sympodial bamboo and offsets are most widely used for monopodial bamboos.

2.1 Monopodial bamboos

There are three methods for raising plantlets by asexual means: rhizomes, culms, and cuttings. If there are enough seedlings available, we can toke advantage of the strong

tillering abilities of the seedlings and can combine them with macroproliferation techniques for rapid propagation. The practical procedures for the seedling method are described under section 2.2.

Vegetative methods are widely used. The most common method is the use of rhizome portions with culms attached. A healthy two-year-old culm is selected in spring or autumn and dug out with up to 50 cm of rhizome attached in both directions. Care must be taken to avoid damage to the culm and the rhizome buds. This can then be transplanted to the site, or planted in a nursery for further propagation. Monopodial bamboos cannot be propagated by any of the methods that involve the use of culm buds , such as culm or branch cuttings, or marcotting.

2.2 Sympodial bamboos

Raising **seedlings** of sympodial bamboo by seeds generally involves sowing individual seeds in shallow holes dibbling in trenches with 5-8 seeds per hole. Cover the seeds with a layer of 3-5 cm soil, place a layer of straw on top and water them in. When the seedlings are about 10 cm high they can be transplanted in groups of two or three. One to two year old seedlings can be used for establishing the shoots plantation.

There are several methods of **vegetative propagation**. Culms can be buried whole. They then develop new plantlets at each node. Alternately one and two-noded culm cuttings can be used. Other methods include layering and offset planting. Select healthy and strong propagules 1-2 years old with plump buds and no diseases or pests for propagation. Propagation should be done generally from February to April (in China) before culms start assimilating nutrients and before the their buds have germinated.

3. Afforestation techniques for bamboo shoot plantations

3.1 Nursery site preparation

The nursery should be selected on the lee side of gently sloping hills in a sunny location with good drainage and with water resources nearby for ease of irrigation. The soil should be loose and fertile sandy loam or loam, with acid, slightly acid or neutral reactions. The groundwater level should usually should be less than one meter. Rocky, sandy, clayey or heavy saline-alkali soils should not be selected as nursery land.

Before raising seedlings, the land requires overall soil preparation i.e. loosening soil to increase the ability of preserving fertility and humidity, weeding, and sterilizing for eliminating soil pest. Overall soil preparation can create favorable conditions for bamboo seedling growth and development. The soil in the nursery should be deep ploughed and carefully prepared before freezing in winter or after defrosting in

spring. The best time for ploughing is the beginning of winter. Remove roots and rocks and rake the soil level.

After deep ploughing, the nursery soil should be made into a seedbed. This is usually 1 metre wide and 15-20 cm high and its length can be determined according to the terrain. It is necessary to apply sufficient manure or plant ash as a base fertilizer for improving bamboo seedling growth and root development.

3.2 Planting season

Monopodial bamboo can be planted every month so long as we pay attention to the key techniques. The planting survival rates in autumn, winter and spring are all above 90 % and the highest survival rate is in spring. Large-scale plantations are best established in winter and early spring when bamboo rhizomes and buds grow slowly. At that time removing bamboo for planting causes minimal injury to the sap flow of the rhizomes and roots, and also has little influence on bamboo forest growth. It also causes minimal nutrient loss of the propagules during transportation. On the contrary, even if a bamboo planted in growing seasons survives, there is a heavy sap flow from the wound, which is not favorable to bamboo forest growth. At the same time planting in the growing season requires more intensive techniques and more labour.

Monopodial bamboos are distributed widely. Climatic conditions in different areas and growth habits and character of different bamboo species affect planting times. Bamboos that shoot early cannot be planted too late. In northern distribution areas, planting should be a little later (Feb.-March) and in the southern areas planting time can be a little earlier.

Sympodial bamboos can be planted throughout the year. But the best time for planting is in the dormant season i.e. from January to March or in the rainy season in the summer. Planting in high temperatures and drought seasons requires intensive management techniques and requires more labour.

4. Management of a bamboo plantations for shoots

4.1 Intercropping

It has been shown that inter-cropping in newly established bamboo stands increases productivity and economic returns from the land. The crops suitable for intercropping in bamboo stands will depend upon local conditions and may involve beans, watermelon, maize, cassava and green manure crops. Crops that are heavy feeders, such as buckwheat and sesame seed, are not recommended. Crops should not be planted too close to the bamboo plants otherwise their growth may be disturbed, with taller crops planted about 1 metre away. Inter-cropping with sun-loving plants will not be possible when the stand canopy is closed about 1 to 2 years after planting.

4.2 Weeding and soil-loosening

Weeds should be controlled effectively to avoid their competition with bamboos for soil moisture and nutrients. In young stands without intercropping, weeding is done in June or July and repeated in August or September of each year. Weed control in mature stands may be achieved in a single operation in July or August.

Soil-loosening in bamboo plantations is important, as maintaining a good soil structure in the stand will help the growth of shoots and the root system, as well as improve water conservation. Soil loosening is done once or twice a year from November to February and involves surface tilling to a depth of 15 to 20 cm.

4.3 Fertilizing and earthing up

The results of soil chemical analysis shows that bamboo plants will consume 500-700 g N, 100-150 g P and 200-250 g K from the soil per 100 kg of bamboo shoots produced. Accordingly, the nutrient requirements of plantations yielding 15, 000 kg fresh shoots per hectare per annum can be met by applying 75-105 kg N, 15-22.5 kg P and 30-37.5 kg K per hectare each year. Chemical fertilizers are usually applied two to four times during the shooting stage at intervals of one or two months. It is applied in 10-15 cm deep drills that are prepared about 50-60 cm around the clump. Alternatively, 37, 500 kg organic fertilizers such as barnyard manure or beancake and rapecake can be used. Application in the drill is best done in combination with soil loosening in the winter months. When green manure is employed as fertilizer, it can be applied at 75 tonnes per hectare, and can also serve as a protective layer to reduce evaporative moisture loss.

The edible parts of newly germinated bamboo shoots are very tender and delicate with light yellowish sheaths, but they turn tough with green sheaths after they emerge from the soil. This procedure can be delayed, thus improving the quality of edible part, by earthing up the base of the clump to a depth of 20-30 cm at the beginning of shooting. In order to stimulate development of shoot buds, the soil cover should be removed to expose the bud to high temperature and light in next March or early April.

4.1.4 Shoot harvesting and culm retaining

Sympodial bamboos produce shoots from May to October with most production in July to August. Edible shoots should be harvested before they become tough. Any delay will result in loss of quality and quantity. Generally, the initial shoots and most of those produced in the summer are harvested, but those produced towards the end of the shooting period will be selected and retained as mother culms.

The operation of shoot harvesting varies with size of shoots for processing different products. The elongated shoot at 1.3-1.5 m in height, which is used for processing fermented dry shoots, is simply cut down at the ground level after removal of the soil cover. Processing of all other shoot products requires younger shoots harvested at a

height of about 30 cm. The practice of harvesting involves removing soil around the shoot, cutting it off from the rhizome and finally returning soil to the harvesting hole. The basal part of the shoot can be retained intact and shoot buds on it may develop as shoots in the present or coming year.

Shoots produced around August and September should be retained as mother culms to maintain a reasonable culm-density in the stand. Over-harvesting will result in a decline of both quality and quantity of shoots in coming years and even cause serious degeneration of the stand. Three or four shoots well distributed within the clump are normally retained to develop per clump annually. Culms of over three years of age are harvested every winter to keep the stand at reasonable age-structure and density of culms.

B: Processing of Shoots

1. Introduction

Fresh shoots contain about 90% water and 3% of the protein required by the human body. Bamboo shoots contain 17 kinds of amino acids and are especially rich in saccharopine, speramic acid and glutamic acid. Over 2.5% of the shoot is carbohydrate that can be absorbed by the human body and shoots also contain about 0.5% lipids. In addition, bamboo shoots contain the elements Mo and Ge, which have anticancer and aging-resistant functions, and Zn, Mn, Cr and other trace elements. They can be used to produce medical products and as a health food. The main nutrient components of moso bamboo shoots are listed in table 3.

Table 3 List of main nutrient components of moso bamboo shoot in Anji county of Zhejiang Province

Nutrient Component		Winter Bamboo Shoots	Spring Bamboo Shoots
Moisture (g)		88	92
Protein (g)		3.07	2.15
Fat (g)		0.7	0.5
Carbohydrate (mg / 100 g)	**Total carbohydrate**	6.72	5.6
	Oligose		0.35
	Sucrose		18.36
	Glucose		0.07
	Fructose		0.09
Trace Elements (mg / Kg)	Cr		0.44 - 0.12
	Co		0.05 - 0.02
	Cu		0.619 -3.17
	Ni		0.758 -0.385
	Zn		3.41 - 1.75
	Fe		5.91 - 2.34
	Mg		48.6 -28.66
	Mn		1.71 - 0.91
P (mg / 100 g)		64	44
Ca (mg / 100 g)		1.9	5.8

2. Storage and processing of bamboo shoots

2.1 Principle and methods of storing and preserving of bamboo shoots

The purpose of storage and preservation is to maintain the color, smell and taste of the natural bamboo shoot, to reduce rotting and increase its selling price. After harvesting, a bamboo shoot is still a living organism. The components of the shoots will change throughout storage and these changes are influenced by temperature, moisture, microorganisms and the means of storage.

Maintaining moisture in the shoot is one of the vital factors for preserving the fresh character of bamboo shoots. If significant moisture is lost the shoot will lose its fresh, plump outward appearance and quality will deteriorate. At the same time, enzyme activity will increase and hydrolysis of carbohydrates will occur. As a result, the shoots will start to rot. The carbohydrates in bamboo are mainly glucose, fructose and sucrose and these are the basis of respiration. Carbohydrates will be consumed gradually with increasing period of storage. Therefore, it is necessary to decrease the respiration rate and the consumption of carbohydrates during storage.

Under oxygen deficient conditions (when the oxygen content is less than 2%) anaerobic respiration occurs. Alcohol, acetaldehyde, carbon monoxide and a little heat are released.

Due to the accompanying release of heat energy the temperature of the stored heap of bamboo shoots will increase during storage and the shoots will rot very easily. Therefore, when bamboo shoots are heaped up in a processing mill, they should be sheltered from sunlight to prevent color and quality changes.

Suitable low temperatures can control moisture transpiration of bamboo shoots and damage by microorganisms.

Mechanical damage can induce high respiration and invasion of microbes, and hence cause rotting of bamboo shoots.

As the respiration rate is related to moisture, temperature, humidity, and the activity of enzymes the main ways of keeping bamboo shoots fresh during the storage period are as follows:

1) Store bamboo shoots in a cool and moist place in order to decrease respiration rate. The temperature in storage should be maintained at about 5°C and the relative air humidity at about 85%. The temperature must not be so cold such that the cells freeze.

2) Add some salt to control enzyme action.

3) Place bamboo shoots in cans and kill bacteria by high temperature treatments.

4) Store bamboo shoots under oxygen insulation conditions to control the activity of microorganisms.

5) Add chemical preservatives to preserve cooked shoots.

2.2 Production techniques of canned moso (*Phyllostachys pubescens*) bamboo shoots

2.2.1 Raw material requirements

Bamboo shoots should be less than 35cm long, without diseases, insect damage or mechanical damage. The time from harvesting to processing should be no more than 14 hours during the summer and 24 hours in the winter. The weight of each bamboo shoot should be no more than 1.5kg.

2.2.2 Technical process

The processing of bamboo shoots can be divided into the following stages:

Grading of raw material → preliminary cooking → cooling → removal of sheaths and reshaping to improve appearance → rinsing → shaping →grading → placing in cans → adding water → sterilizing →sealing the cans →cooling the cans.

To achieve the required quality, every technical process should be done perfectly. For instance, the time of preliminary cooking should be decided according to the size of the bamboo shoots. Generally speaking, bamboo shoot 25-35cm in length should be cooked for 90 minutes and 1,000kg of shoots can be cooked at one time. The steam pressure should be above 4kg/cm^2. If preliminary cooking by steaming, place 10-20cm of water into the pot in order to submerge the steam pipe. After the water has boiled, put the container of bamboo shoots into the pot and cover the pot with canvas or an iron lid. When the canvas is raised by the steam pressure, continue cooking for 70-80 minutes. If cooking with boiling water, fill the pot half full with clean water. After the water starts boiling, put the container of shoots into the water and cover with an iron lid. After the water starts boiling again, continue cooking for 90 minutes for large bamboo shoots, or 60-70 minutes for small ones.

Cooling: The cooling process should be rapid and complete, otherwise the bamboo shoot will become red. After cooking, place the container of shoots into a cooling water vat and move it up and down two or three times. Alternatively, use pipes to direct cool water into the bottom of the pot to cool down the bamboo shoots to room temperature.

Shelling of bamboo shoots: Cut off the tough base of the shoot. The surface should be cut smooth. Use a spring bow to cut off the tender sheaths completely, and wash off soil and other spoil from the bamboo shoot. Then put it into a rinsing pool after weighing. The whole shelling process should be as rapid as possible, otherwise the flesh of the bamboo shoot will become dim and the fragrant smell will be lost.

Rinsing: If the air temperature is lower than 18°C, the water temperature in the rinsing pool should be raised to 20°C, because lower temperatures will hinder the fermentation of lactic acid by bacteria. The temperature should not be higher than 23°C. At the same time, adjust the pH of the water according to the regulations of different regions. Using ordinary water (at about 25°C in Zhejiang province) to rinse bamboo shoots, it takes some 28-36 hours with water changes every two hours.

When rinsing, the bamboo shoots should not emerge above the surface of water, otherwise they will become sticky and quality will decrease. The shoots should be shielded from direct sunlight to prevent colour changes.

Grading: Grade the preliminary cooked bamboo shoots into standard shoots (grades A, B, C) and substandard shoots (damage, broken,). In total there are 39 grades and sub grades, of which:

1) Grade A: The body of the bamboo shoot has dense nodes and is plump and straight. The whole length is about one and half times the diameter of the base, and the height of the root node section is about 60% of the whole.

2) Grade B: The body of bamboo shoot has short nodes and is slightly crooked. The length is twice the diameter of the base, and the height of root node part is about 50% of the total.

3) Grade C: The distance between joints is slightly long and the middle is plump. The length is about twice the basal diameter and the height of root node part is about 40% of the total.

4) Damaged grade: The height and width of the out of shape part are not to exceed one-fifth of the whole height and basal part diameter of the body of the shoot.

5) Broken grade: The diameter of the broken part at the top of the shoot is no more than 1-1.5cm for small shoots or 2cm for large shoots.

According to the above grading the bamboo shoots will be placed into cans on the basis of their size, colour and numbers. The nodal diaphragm should be removed in order to exclude air during sterilization.

Filling cans: Different sizes of cans are used according to demand. No less than 11kg of bamboo shoots should be placed in an 18 litre can and not less than 5 kg in a 9 litre can. Add clean water to fully fill the can and then sterilize.

Sterilization: Put 46-56 cans into a pot each time and maintain a gap of 3-5cm between rows. Maintain a steam pressure of 4 kg/cm^2 for 90-120 minutes or sterilize in a pool with boiling water. In the pool, a lid is temporarily placed on the cans and they are cooked for 120 minutes. After sterilization, the lid should be removed and the cans fully filled with boiling water. Then the lid can be placed on for 2-3 minutes and sealed in place. Clean the water on the surface of the can and let it cool naturally, and then it can be stored.

Packaging: Every 18-litre can should have a label on it to show the grade, production date, factory and so on (Figure 1).

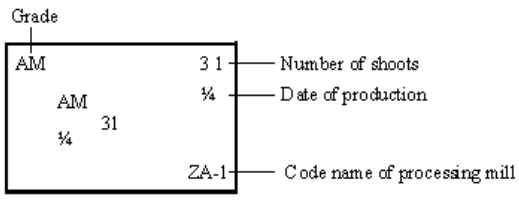

Figure 1 Can label

The colour of the label indicates the grade: the red band stands for grade A, the yellow for grade B, the green for grade C and the white for substandard product.

2.3 Processing of bamboo shoot of *Dendrocalamopsis oldhamii*

Bamboo species of the genus *Dendrocalamopsis*, such as *D. latiflorus Munro*, *D. beecheyana* and *D. beecheyana* var. *pubescens,* are superior sympodial bamboo species for bamboo shoot production. The shoot processing method for bamboo shoots of those species are different from moso bamboo. Here the bamboo shoot of *D. oldhamii* is selected as an example to demonstrate the technical processes involved. The stages are as follows:

Checking and acceptance of raw materials →washing and grading →preliminary cooking →rinsing →removal of sheaths→dressing (cutting off roots, taking off tender sheaths, cleaning the skin of the bamboo shoot and cutting it into cubes) →rerinsing and quality control →filling cans →sealing cans →sterilizing →cooling →washing cans with clean water and storage.

2.3.1 Raw material requirements

The uncooked fresh shoots should have light yellow sheaths, without insect and disease damage. The basal part diameter of the bamboo shoot should be no less than 4cm high.

2.3.2 Preliminary cooking

Large bamboo shoots (basal diameter > 10cm) should be cooked for 100 minutes, mid-sized shoots (basal diameter 8-10cm) for 80 minutes and small shoots (basal diameter > 6cm) for 60 minutes. A 1:1.5 proportion of bamboo shoots to water in the cooking pot should be used.

2.3.3 Rinsing

Rinse for 1.5-2.0 hours. This is much shorter than for moso bamboo shoots because the tyrosine content is low and no white sediment emerges. Other aspects of the canning process are the same as for moso shoots.

2.4 The technical process of the bamboo shoots of *D. latiflorus*

Checking and acceptance of raw material →removal of the tough roots, shell and the tip of the shoot →cutting into two halves →preliminary cooking →rinsing →dressing →cutting into cubes or slices →rerinsing →filling cans →evacuating air from the can and sealing →sterilizing →cooling →wipe water on the surface of the can and storage.

2.5 Production of fermented bamboo shoots

In the countryside, bamboo shoots of moso or *D. latiflorus* are cooked and cooled completely. They are then packed tightly into a wine jug. The mouth of the jug is stuffed with rice straw and the jug is placed upside down in a basin containing salt water in a cool, shady place. After two months the bamboo shoots will become sour and can be consumed.

2.6 Soft packaged bamboo shoots

The soft-packaged or vacuum-packed food was first studied in 1950 in America and was approved for use in food production by the Food and Drug Administration in 1977. In the 1980s, soft packaged food was popular in Japan. In China, the 70 tons of soft packaged moso bamboo shoot have been produced in a processing mill in Gangkou Village, Anji county in Zhejiang province and the product sells well. They are now available from many processors.

The main equipment for soft packaging bamboo shoots includes vacuum packing machines, steam boilers and containers for raw material and products. The packaging bag is a PET/PE 240 × 170mm type, which can hold 500 g of processed bamboo shoots and can withstand temperatures of 126°C for 25 minutes. At this temperature, the sterilisation requirements of processing can be achieved for bamboo shoots.

3. Input requirements

These are shown in Appendix II.

APPENDICES

Appendix I

Bibliographic references:

1. Cultivation and Utilization on Bamboo, Eds: Fu Maoyi, Xiao Jianghua and Lou Yiping, China Forestry Publishing House, 2000. (in press).
2. Lou Yiping and Xiao Jianghua, Cultivation techniques of bamboo forests for industrial materials in China. Ed: Janis Birkeland. Proceedings of Catalyst '97 Conference, December 5-8, 1997, University of Canberra, Australia.
3. Xiao Jianghua and Lou Yiping, Bamboo resource management and the approaches to sustainable development in China. Ed: Janis Birkeland. Proceedings of Catalyst '97 Conference, December 5-8, 1997, University of Canberra, Australia.
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Appendix II (1)

Recommended Afforestation Models for Bamboo Shoot Plantations

Afforestation Model for Moso (*Phyllostachys pubescens*) and *Dendrocalamus latiflorus* shoot plantations

Species	**Density of Plantation** Plants per ha	Site Preparation	Size of planting hole (cm)	Fertilizing (kg/ha.)	Yield (kg)	**Selective harvesting** (timber: kg/ha.; shoot kg/ha.)									
						Total	Year								
							2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20
Moso	450	Weeding Bush cutting	100x60 x50	$P_2 0_5$: 46 N: 120 K_2O: 54 Manure: 10 tonnes	Timber	91,136	0	0	0	4,272	4,272	5,696	5,696	8,544	8,544	8,544
					Shoot	25,700		150	150	800	1,750	2,000	2,000	2,000	2,000	2,000
D. latiflorus	900	Weeding Bush cutting	60x60 x60	$P_2 0_5$: 40 N: 97 K_2O: 54 Manure: 10 tonnes	Timber	74,000	0	1,500	4,000	4,500	4,500	4,500	4,500	4,500	4,500	4,500
					shoot	74,000	0	1,500	4,000	4,500	4,500	4,500	4,500	4,500	4,500	4,500

Appendix II (2)

Economic Analyses of the Recommended Afforestation Models of Newly Established Bamboo Shoot Plantations

Table 2 Economic Analyses of the Afforestation Models (1 USD = 8.3 CNY)

Species	FNPV (CNY) before tax	FNPV (CNY) After tax	FIRR Before tax	FIRR After tax	Unit cost for 1st years (CNY)
Moso	207	-1,052	12.4%	8.5%	5,594
D. latiflorus	10,833	8,832	33.9%	30.7%	4,824

Appendix III Cost Estimation of Canned Shoot Factory (in USD; kg)

	Per shift	Monthly	Annually		
Capacity	15 tones	400 tones	1,200 tones		
Sales value ex-factory	720/ton				
Factory area required	1,200 sq. M (construction area)			Cost: 139,500	

	Raw material requirements	Specification	Usage per unit	Volume required	Unit cost	Waste output vol
1	Bamboo shoots	> 1kg	2 ton/ton		250/ton	50%
2	Packaging	18 litres			110/ton	

	Labor requirement	
1	Labor	90
2	Maintenance/setup	5
3	Management	6

	Machine requirements	Capacity (KW)	Hours/shift	Life-time	Units requirement	fob china	Quantity	Total kg	
1	Boiler	2 tons	24	15 years	1	30,000	30,000	4,000	Local
2	Sterilising equipment	3		15	2	10,000	20,000	2,000	Local
3	Can sealing machine	1		15	2	11,000	22,000	1,600	
4	Cleaning and water pot	1		15	5	500	2,500		Local
5	Tools					10,000	10,000	500	
	total kwh	5					84500		

	Consumable requirements	Specification	Usage per unit	Volume required	Unit cost	Amount
1	Grease					
2	Water					
3	Cutters		3% of sales value ex-factory			
4	Oil					
	Maintenance requirements					

Total: 224, 000