Feasibility Study on Establishment of Bamboo Shoot Products Plant in Chiang Mai

Charin Techapun

Chiang Mai University
Thailand

Project PD 56/99 Rev. 1(I)

Promotion of the Utilization of Bamboo from Sustainable Sources in Thailand

Royal Forest Department

International Tropical Timber Organization
(ITTO)

Feasibility Study on Establishment of Bamboo Shoot Products Plant in Chiang Mai

Charin Techapun

Chiang Mai University
Thailand

Project PD 56/99 Rev. 1(I)

Promotion of the Utilization of Bamboo from Sustainable Sources in Thailand

Royal Forest Department

International Tropical Timber Organization
(ITTO)

ASKSORN SIAM PRINTING :
1137/1 Soi Bangsaotong Police Station, Charunsanitwong 13, Pasicharoen, Bangkok 10160, Thailand.
Tel. (662) 410-7813, 410-8795-6 Fax. (662) 410-7813

การศึกษาความเป็นไปได้ในการแปรรูปและการจัดตั้งโรงงานผลิตผลิตภัณฑ์จากหน่อไม้

ชรินทร์ เตชะพันธุ์[1], ประเสริฐ หาญเมืองใจ[1], อำพิน กันธิยะ[1] และ รัตติกร เตชะพันธุ์[2]

[1] คณะอุตสาหกรรมเกษตร มหาวิทยาลัยเชียงใหม่ 155 ม.2 ต.แม่เหียะ อ.เมือง จ.เชียงใหม่ 50100

[2] โรงงานแปรรูปและพัฒนาผลิตภัณฑ์ มูลนิธิโครงการหลวง ต.แม่เหียะ อ.เมือง จ.เชียงใหม่ 50100

จากการสำรวจข้อมูลขั้นต้นด้านชนิดและปริมาณของการเพาะปลูกหน่อไม้ในเขตจังหวัดเชียงใหม่ เพื่อคัดเลือกพันธุ์หน่อไม้ที่เหมาะสมเพื่อใช้ในการพัฒนาผลิตภัณฑ์แปรรูปจากหน่อไม้ พบว่าหน่อไร่ และหน่อไผ่ตง มีความเหมาะสมในการแปรรูปเป็นผลิตภัณฑ์ 3 ชนิด คือ ผลิตภัณฑ์หน่อไม้กระป๋องผ่านกระบวนการฆ่าเชื้อด้วยความร้อน ผลิตภัณฑ์หน่อไม้ทอดกรอบ และผลิตภัณฑ์หน่อไม้ผ่านกระบวนการทำแห้งแบบเยือกแข็งจากการศึกษาข้อมูลด้านการตลาดทั้งในประเทศและตลาดโลก พบว่า ผลิตภัณฑ์ที่มีศักยภาพสูงในการแข่งขันเรียงจากสูงไปต่ำ คือ ผลิตภัณฑ์หน่อไม้ทอดกรอบ ผลิตภัณฑ์หน่อไม้ผ่านกระบวนการทำแห้งแบบเยือกแข็ง และผลิตภัณฑ์หน่อไม้กระป๋องผ่านกระบวนการฆ่าเชื้อด้วยความร้อนตามลำดับ เนื่องจากผลิตภัณฑ์แปรรูป 2 ชนิดแรก เป็นผลิตภัณฑ์ใหม่ที่สามารถรองรับตลาดอาหารสุขภาพได้ดีโดย กลุ่มเป้าหมายคือกลุ่มของอาหารว่างขบเคี้ยว ประเภทเดียวกับมันฝรั่งทอดกรอบ แต่ผลิตภัณฑ์แปรรูปจากหน่อไม้ให้คุณสมบัติด้านอาหารสุขภาพที่เด่นกว่าในเรื่องของการเป็นอาหารเส้นใยสูง เหมาะสำหรับผู้ที่ควบคุมน้ำหนัก ส่วนผลิตภัณฑ์หน่อไม้กระป๋องผ่านกระบวนการฆ่าเชื้อ ด้วยความร้อน เป็นผลิตภัณฑ์ที่มีจำหน่ายในลักษณะของการผลิตในปริมาณมาก และมีการแข่งขันกันในตลาดสูงอยู่แล้ว เมื่อศึกษาอายุการเก็บของผลิตภัณฑ์ทั้ง 3 ชนิด พบว่าผลิตภัณฑ์หน่อไม้ผ่านกระบวนการทำแห้งแบบเยือกแข็ง มีอายุการเก็บนานที่สุดสามารถเก็บไว้ได้นานถึง 3 ปี โดยคุณภาพไม่เปลี่ยนแปลง ผลิตภัณฑ์หน่อไม้กระป๋องผ่านกระบวนการฆ่าเชื้อด้วยความร้อน มีอายุการเก็บได้นาน 2 ปี และผลิตภัณฑ์หน่อไม้ทอดกรอบมีอายุการเก็บ 1 ปี

ทำการออกแบบสายการผลิตผลิตภัณฑ์แปรรูปจากหน่อไม้ทั้ง 3 ผลิตภัณฑ์ตามหลักเกณฑ์ของกรรมวิธีการผลิตอาหารที่ดี (GMP) และตามมาตรฐานสากล HACCP ในระดับโรงงานต้นแบบ และทำการศึกษาความเป็นไปได้ในเชิงพาณิชย์พบว่าธุรกิจการผลิตผลิตภัณฑ์หน่อไม้ทอดกรอบมีความเป็นไปได้ในเชิงพาณิชย์มากที่สุด โดยให้ผลตอบแทนจากธุรกิจสูงสุด 1.2 เท่าของเงินลงทุน (B/C) มีระยะเวลาคืนทุนสั้นที่สุดคือ 3.7 ปี และให้ค่าอัตราผลตอบภายในโครงการสูงสุด 31.7 % (IRR) รองลงมาคือธุรกิจการผลิตผลิตภัณฑ์หน่อไม้กระป๋อง ผ่านกระบวนการฆ่าเชื้อด้วยความร้อน และธุรกิจการผลิตผลิตภัณฑ์หน่อไม้ผ่านกระบวนการทำแห้งแบบเยือกแข็ง ตามลำดับ

CONTENTS

Term of Reference:

1. Conducting a feasibility study on the establishment of bamboo shoot products plant in Chiang Mai Province. The topics of study were bamboo shoot marketing, bamboo shoot processing of 3 potential bamboo species and quality control.
2. Design shoot plant cottage industry
3. Preparation of technical report at the end of mission including finding and recommendation and submit to project leader.

Summarization of the activities

The project divided into two phases. The activities of the first phase was to investigate the type, quality and quantity of bamboo shoot in the Chiang-Dao district. At least three types of bamboo shoot had potential for commercial production in the next study. Local villagers in the area of study already had basic processing knowledge to preserve the bamboo shoot (sterilized product) but the production was only for consumption, not for sale. This was important in the sense that if commercial scale production was to be achieved cottage factory with an appropriate technology must be provided. We strongly recommend that the villagers had high potential to establish and to run the bamboo-shoot products plant cottage industry, especially for sterilized product. At present, we have completely designed the plant cottage industry with an appropriate technology based on the standard of Good Manufacturing Practice (GMP) regulation law of Thailand and also the international regulation of HACCP.

Sterilized bamboo is normally served in a high value market in and the demand for the product is still high, especially during the out of bamboo season. To increase value added of bamboo shoot, the product development section was also established for this purpose. We designed to develop new product for the cottage factory, which was crispy bamboo chips (like potato chips). However, normal production process for potato chip was not suitable for bamboo chip and therefore specific technique, vacuum deep-fried method had to be applied to the process. This new product aimed to serve as a health food snack containing high fiber content.

Another developed product was a freeze-dried bamboo shoot. The shoot was preserved as a dried product with a shelf life of more than 3 years in normal packaging under normal condition. Before cooking dried bamboo was soaked in water for a while after which its character would be recovered to that of the original shoot. This product was for exporting.

In the second phase, the factories of novel bamboo product and sterilized product were designed. Financial analysis was also made at the end of the project. The three kinds of product offered an opportunity for good investment with high benefit and short payback period.

Introduction

Mae-Mae's forest-dependent community in Chiang-Dao district, Chiang Mai province, Thailand, holds the greatest stake in the sustainable use and management of their surrounding natural resources. The forest uses by community has resulted in valuable indigenous knowledge concerning patterns and processes of biologically diverse forests.

The national consultant team started this part of the project on mid September 2002, The objectives of the project were:

1. To conduct a feasibility study on the establishment of bamboo shoot products plant in Chiang-Dao area by studying:
   - Shoot marketing
   - Shoot processing of 3 potential bamboo species
   - Quality control
2. To design shoot plant cottage industry

The research team consisting of national consultant, coordinator and members of the leader project visited the project site to collect the technical data at Mae-Mae Village, Chiang Doa District, Chiang Mai province on mid September, 2002. At Mae-Mae Village, all villagers participated in the project. The orientation and discussion were very constructive. Bamboo shoot selection survey results indicated that 5 species of bamboo could be considered for developing and testing edible products. The selected species are shown as following:

1. Pai Liang (*Bambusa* sp.)
2. Pai Seesuk (*Bambusa blumeana* Schult)
3. Pai Tong (*Dendrocalamus asper* Back)
4. Pai Saang (*Dendrocalamus strictus* Nees)
5. Pai Rai (*Gigantochlao albociliata* Munro)

Statistical survey of local, national and export markets (Please see Chapter II), indicated that only three species as shown below could be selected for commercial scale uses.

1 Pai Saang (*Dendrocalamus strictus*)
2 Pai Tong (*Dendrocalamus asper*)
3 Pai Rai (*Gigantochlao albociliata*)

Chapter I Technical Data on Post-harvest

The objective of this study is to investigate the shelf-life and optimum conditions for storage fresh bamboo shoot. The post-harvest treatment and storage conditions are very important factors for controlling the quality of fresh bamboo shoot during experimented trials to develop bamboo products by team members.

It can be summarized that these following methods should be maximizing freshness and minimizing microbial food safety hazards in fresh bamboo shoots.

Typical composition of fresh bamboo shoot:

The average typical composition of fresh bamboo shoot is given below:

Moisture	88.80 %
Protein	3.90 %
Fat	0.50%
Minerals	1.10%
Carbohydrates	5.70%
Calorific value	43.00 Kcal.

Handling condition: In general, bamboo shoots easily absorb oil, Therefore care should be taken during machinery/transport to prevent oily smell in the product. Raw bamboo shoots were washed, harden layer base removed and then boiled to remove hydrocyanic acid.

Shelf life studies: Actually, fresh bamboo shoot should be consumed soon after harvesting to prevent bitter taste occurring. It is most preferable to dig in the morning and sell in the same day. However, the bitterness occurrence can be avoided by minimising exposure to sunlight. Browning of bamboo shoot during storage depends on time and temperature of storage conditions.

Sterile process: This is a convenient method used to preserve bamboo shoot. Shoots should be sterilized or processed within 24 hours after harvesting to maintain freshness. Sterilized bamboo shoot usually loses its aroma and crunchiness.

Cooking: Optimal cooking conditions for minimizing hydroxycinnamat (HCN) levels and irritant sensation in bamboo shoots were 2-3 minutes at 95-105 ^{O}C and pH 5.5-5.7.

Effect of temperature: In preliminary work, raw bamboo shoot obtained from Mae-Mae station was measured for respiration rates at –20 ^{O}C, +4 ^{O}C and +20 ^{O}C by storage in uncovered and plastic-wrapped treatments. it was found that storage temperature influened quality. Shoots stored at +4 ^{O}C under wrapping could be stored for 6-10 days whereas those stored at lower temperature (–4 and -20^{O}C) could maintain its quality up to 3 months.

Approximate yields: Sufficient amount of fresh bamboo shoot for industrial purpose is not yet available. This is because bamboo plantations have just started recently (recent years) and basically the crop takes 3 to 7 years from establishment to the first harvest. However, yield survey revealed that at least 10 tons/season should be available.

The renewable resource of bamboo and bamboo shoots are commercially utilized in Thailand. At present, bamboo is mainly consumed for construction, and mat and baskets making, etc. approximately, 20,000 tons of bamboo shoots are consumed annually for production of canned bamboo shoot (see marketing data in Chapter II). Keeping in view the existing resource and its utilization, there is a good opportunity for commercial utilization of bamboo in the following sectors:

(Bamboo shoots can be processed into the following products :)

a) Canned Bamboo shoots:
    i) In brine
    ii) In curried vegetable
    iii) In syrups
b) Bamboo shoot candies
c) Bamboo shoot chutney
d) Bamboo shoot sweet pickles
e) Fermented bamboo shoots (Locally named as Nor-Mai Dong)
f) Bamboo shoot powder
g) Dried bamboo shoot

There is a good demand for the above bamboo shoot products (oriented food: b,c,d,e) in local markets and export markets (international). Besides, bamboo snack (like potato chip or French-fried) was also developed under this project as another kind of new product development for both local and export markets.

CHAPTER II Marketing Survey

Domestic market (Chiang Mai)

Development of fresh bamboo domestic market was rated as high potential. Bamboo shoot consumption in Chiang Mai consumers varied considerably, but could be as high as 400 ton /year with 20 % consumption increase. Shoots can be supplied domestically for half year from June to September. From the local market survey in several districts of Chiang Mai (Table 2.1), consumption of bamboo shoot varied considerably depending on the amount and price of fresh bamboo shoot, the latter varied from 5-20 Bath/kg. Eighty percent of fresh bamboo shoot in Chiang Mai is Pai Sang, Pai Tong and Pai Rai. The proportion of fresh bamboo shoot of Pai Tong, Pai Sang, and Pai Rai was 3.5 : 1.5 : 5. Therefore, it is reasonable that these species of bamboo shoot should be selected for further studies.

Table 2.1 The amount and average price of fresh bamboo shoot in Chiang Mai local market (June-September,2002).

District	*Average amount of fresh bamboo shoot (ton/day)*	*Average price/kg (Baht)*
Muang Chiang Mai	5*	7
Hang-Dong	0.2	10
San-Sai	0.2	10
San-Patong	0.25	10
Fang	5*	7
Chiang-Dao	2*	7
Doi-Saked	0.3	10
San-Kampange	0.1	10
Hot	0.1	12
Sa Mueng	0.5*	10
Mae Rim	0.3	10
Mae Jam	0.05	12
Jom Tong	0.2	12
Mae-Jo	0.2	10
Sarapee	0.2	12
Total	*14.3*	*10*

* Data of Fang, Sa Mueng, Muang Chiang Mai, and Chiang-Dao districts may be related to the amount of fresh bamboo shoot supply as raw material for bamboo canning factory.

Export market

Thailand is internationally competitive in basic processed shoots since production is labour intensive. However, Thailand is able to compete for higher quality near-fresh shoots. The major producers are those in Northern and Western parts of Thailand, hence there is opportunity to collect fresh shoots during the season. Bamboo is most valued in fresh, dried and canned forms. Imports of processed shoots are expanding in USA, Japan and Taiwan, but their prices are getting low as dictated by China.

Requirement of Exported Market:

Hong Kong: Fresh and canned bamboo shoots are imported from China and re-exported to Singapore, Taiwan and USA.

Singapore: Canned shoots are mainly consumed. Frozen cooked shoots are also used.

Japan: In 2000, Japan produced 50,000 t of bamboo shoots, However, shoot production is declining. The Japanese production season runs from March to July. Japan also import bamboo shoot during November to March, in frozen (without sugar), canned and dried forms. Therefore, there is a gap in supplying from July to November, which is an important opportunity for Thailand (for exporting) Nevertheless, Japan imports most of frozen and canned shoots from China because of their lower price (Table 2.2). Bamboo shoots are minor ingredient for tsukemono (pickled vegetables) preparation with the use of higher than 12,000 t in 2000. Japanese also use dried bamboo shoots mainly for Chinese style cooking.

Table 2.2 Japanese imports (t) of bamboo shoots in 2001 (Ministry of Finance via JETRO 2002)

Source	Dried	Canned
China	1,385	101,918
Thailand	0	13,139
Taiwan	1,535	5,773
Other	0	439

USA: Bamboo shoots is imported from Thailand (>25,000 t/year). But the import proportion from China is increasing while the overall volume remains static.

Discussion

Bamboo shoot from Chiang Mai for exporting market is approximately 800-1,000 tons per year. Most of them are sterilize bamboo shoot in brine or in water. Nowadays, there are approximately 15 factories located in Chiang Mai producing sterilized bamboo shoot for export market. Most of the factories are located in Fang district and Sansai district wheareas the main sources of raw material are in Chiang-Dao, Fang, Sa-Meung, and some parts of Chiang Rai province. Bamboo raw material is also available in Kanchanaburi, and Ratchaburee provinces, in which sterilizing factories are also located. From this point or view, there is a high competition in sterilized bamboo shoot product and this is the main reason of why new product must be developed.

From the previous export technical data, there was a high competition on worldwide market for fresh and canned bamboo shoot products. New high quality product from bamboo shoot was necessary to be developed. Snack from bamboo shoot was one such a kind of new products. It contains a high fiber content and could be promoted as a high dietary product. This is one of our objectives to be achieved in this project. Two forms of bamboo shoot snack which was developed including dried form and freezes dried form. Sterilized bamboo shoot is another kind of product which was investigated for serving domestic market, especially during out of fresh bamboo shoot season. The sterilized bamboo shoot product was developed with an appropriate technology for the community factory. The feasibility study on the establishment of bamboo shoot products plant in Chiang Mai will be described in the next chapter.

Chapter III Feasibility Study on the Establishment of Bamboo Shoot Products Plant in Chiang Mai

In this chapter, the possibility of the establishment of bamboo shoot products plant in Chiang Mai will be described. Three products including sterilized bamboo shoot, bamboo shoot snack, and freeze-dried bamboo shoot are chosen for the feasibility study.

The objectives of cottage food processing enterprise development in rural villages are:

- To solve the problem of seasonal surplus of bamboo shoot
- To enhance the technology of crop processing, and market value of products
- To develop new products from bamboo shoot

Methods Used

There are several ways to help local Farmers' Associations to develop small-scale food processing. The first method is to establish a factory in the area covered by a particular Farmers' Association. Management of the business and marketing of the products are carried out by the Farmers' Association. The second method is to establish a factory for a community commercial group. The members of this group have priority to supply raw materials for processing, and sell the product by themselve.The third method is to establish a packaging and delivery center in the area covered by the Farmers' Association. The finished or semi-finished product produced by the farmers is packed and sold by the local Association or passed to the commercial distributors.

Procedures

The following procedures may be different from one area to another because of reflecting the difference in corp nature and region of origin. The basic prerequisite for all projects is that the method will be organized by members of Farmers'Association. The main interest are in postharvest practices, or packaging and transportation or other aspects. An important first step is to provide training courses or lectures to members for improving their techniques of breeding, planting, fertilizing, farm management or harvesting. The second step is to specify the factory

location and the production scale. This is determined by the Farmers' Association or Community Group. The design of the factory, the layout of facilities, the pilot runs, and the production will se carried out under the guidance of this report.

GENERAL FLOWCHART OF STERILIZED BAMBOO SHOOT PRODUCT

Although cottage food processing is a small scale operation when compared to other food enterprises, it is still necessary for such businesses to follow the Good Manufacturing Practices (GMP) which is a regulation law of Thailand. Furthermore, it is necessary to follow the regulation of Hazard Analysis and Critical Control Point (HACCP) for the export markets.

The general procedures and sanitary precautions of the sterilized bamboo shoot product are as followed (see Fig. 3.1, 3.2, 3.3)

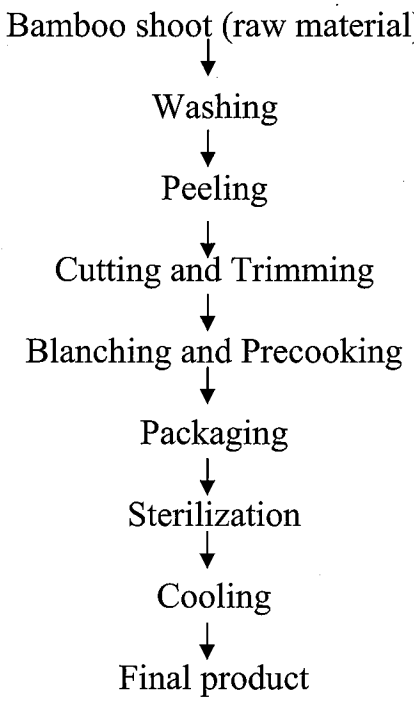


Figure 3.1 Flow chart for bamboo shoots preserved by sterilization method.

Washing

Thorough washing of bamboo shoot is an essential step to reduce the initial microbial count of the raw materials to a minimum before any further treatment. Water with residual chlorine content of 10-20 ppm is recommended.

Peeling

Generally, there are three methods used for peeling, including lye peeling, abrasive peeling and manual peeling.

Lye peeling uses a perforated metal drum with an inlet through by bamboo shoots are fed Once in the drum, the shoot rotate in a bath containing hot sodium hydroxide solution (5-10%), the period of immersion can vary according to process requirements. However, lye peeling with caustic soda is no longer recommended for peeling fresh produce because of public concern for food safety.

Abrasive peeling is carried out with an abrasive peeler. This is a simply drum with a rough inner surface and a motor. After putting bamboo shoot inside the drum, the inlet is covered and the drum is allowed to rotate for a short time. This method is more suitable for root vegetables like bamboo shoot, because the latters are usually rather soft. Sweet potato is normally peeled by this method.

Manual peeling is carried out by hand. This is a simply and low cost technique. No special equipment is needed, but labor cost will be increased. However, this is an advantage in case of community factory as its member can join this activity.

Cutting and trimming

Cutters are usually designed according to the shape of the particular crop. Bamboo shoots are first sliced by a fixed knife in a high-speed revolving drum, from which the slices pass by centrifugal force to a row of cross cut knives, spaced on a rotary block at intervals to suit the size required. The cross-cut knives cut the slices into strips, which pass on to a third set of circular knives that cut the strips into cubes. The last block of knives can be removed if a strip or chip cut is required.

Blanching and precooking

To obtain good cooking bamboo shoot slices water-soluble material such as pungent organic acid must be leached out. Basically, blanching process is employed to inhibit enzymatic browning in vegetables. The functions of blanching for bamboo shoot are:

- To inactivate enzymes present in bamboo shoot;
- To remove gasses from the tissues;
- To soften the tissues;
- To decrease the number of micro-organisms, and clean the tissue.

Blanching is essential for bamboo shoot preservation. It is done by using hot water or steam. A conveyor is suitable for a continuous process. Guaiacol test is used as an index to indicate the activity of peroxidase. Whether fruit or vegetable needs to be blanched or not depends on the activity of polyphenoloxidase or peroxidase, and the characteristics of the final product.

Precooking is necessary for de-aeration to remove oxygen from the texture and inner fiber of bamboo slices and also in the packaging material. This can be done by parboiling or steam directly.

Packaging

Bamboo shoot can be storaged by many methods. The shoots are canned in tin can, processed in five-gallon tanks or processed in food grade plastic bag with vacuum wrapping. After packaging, de-aeration by steaming is needed.

Sterilization

Product sterilization aims to destroy or remove all microorganisms from the bamboo shoot product. Whatever method is employed, the purpose of sterilization is to make sure that no living organisms remain. Both the physical removal and inactivation of microorganisms can be reached by many different methods. The chosen method should base on the following four main criteria:

1. Effectiveness in achieving an acceptable level of sterility

2. Reliable and ease of validation
3. Positive or negative effects on medium components
4. Capital expense and operating cost

When evaluated with these four criteria, two sterilization methods are suitable for large-scale industrial sterilization. Thermal treatment seems to be a suitable method because of its relatively low cost, its effectiveness in achieving an acceptable level of sterility, and the ease of validation. In a commercial sterilization, the levels of time and temperature are needed to achieve the complete sterilized product. Normally, sterilization at 121 ^{O}C for 15 minuets is a standard commercial level. However, lower or higher operating temperature and time can be used depending on the F_0 value in each product. In this case, retort or steamer is suitable for this purpose.

Cooling

After reaching up to the standard value of temperature and time, cooling down of product to room temperature is required. In the case of using a retort, it is very easy to cool down by circulating water into the retort.

Storage

Both materials and units of packaging must be satisfied by the following requirements:

- They must be able to protect the product from moisture, air and light, and provide insulation from insects and vermin.
- They must be sufficiently strong and stable to protect the product from damage by abrasion, especially during transportation and storage.
- Packaging materials must be safe when directly contact with the product.
- The size and shape must be acceptable from distribution and storage point of view.

Low temperature is the major requirement for storage of all processed foods whereas high temperature accelerate the Maillard reaction, which is temperature dependent. Ideally, a warehouse temperature should not exceed 20°C. All warehouses must be able to withstand rodent and insect infestation.

Raw bamboo shoot

Cutting

Peeling

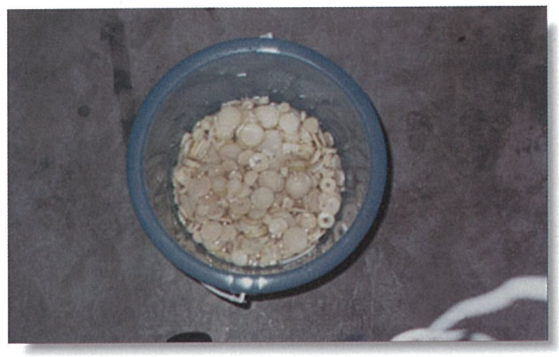
Washing

Steam Cooking (Sterilization)

Sterilized bamboo shoot product

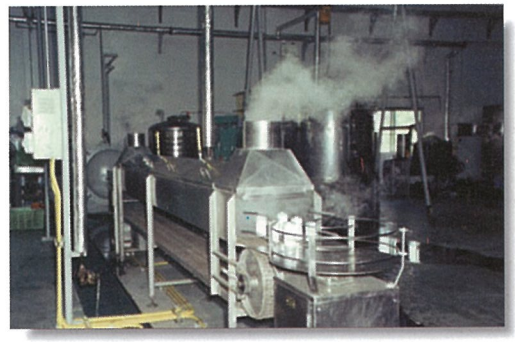
Fig 3.2 Sterilized bamboo shoot production by Mae Mae's villagers.

Raw bamboo shoot

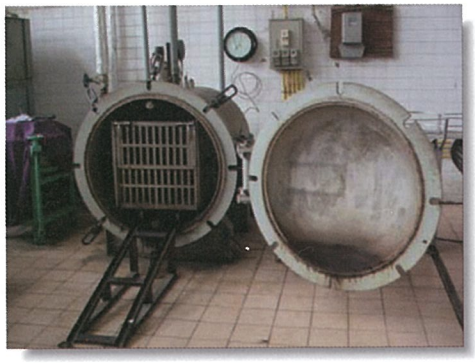


After slicing

Filling with brine or water



De-aeration



Steam Cooking (Sterilization)

Sterilized bamboo shoot product

Fig. 3.3 Product development of bamboo shoot snack at Faculty of Agro-Industry, Chiang Mai University.

GENERAL FLOWCHART OF BAMBOO SHOOT SNACK

To increase value added of bamboo shoot, the product development section was established for this work. We designed to develop the new product for the cottage factory, which was the crispy bamboo chip, like a potato chip.

The same as sterilized bamboo shoot product, the production of crispy bamboo chips (snacks) has to follow the GMP and HACCP.

The general procedures and sanitary precautions of the bamboo shoot snack is shown in Fig. 3.4.

Figure 3.4 Flow chart of bamboo shoot snack production by deep frying method.

Washing, peeling, cutting and trimming were carried out as described in the previous section. The freezing, de-freezing, deep-frying and drying process are described as followed:

Freezing

Basically, the functions of freezing process for bamboo shoot are:

- To inactivate enzymes present in bamboo shoot;
- To adjust the structure of bamboo tissue, which is suitable for frying process;
- To remove gasses from the tissues;
- To pack the tissues;
- To decrease or stop the number of micro-organisms.

Freezing is essential step for controlling the texture of bamboo shoot product. It is done by using deep freezer at temperature lower than $-20^{o}C$ for at least 2 days. Continuous process is available with Individual Quick Freeze (IQF) equipment. The characteristics of a final product depend on this step.

De-freezing

Defreezing or thawing process is carried out by standing the frozen raw material at room temperature for a while before frying.

Deep frying

Product deep-frying aims to destroy or remove microorganisms from the bamboo shoot product and change the characters of raw material to dried and crispy product by using high temperature under vacuum condition. This step needs special equipment such as vacuum deep fryer. Normal deep fryer or general fryer is not suitable for this product because it causes browning effect.

Drying

Drying process is necessary for this product to minimize oil content, because fried bamboo shoots absorbed some oil into their structure. Centrifugation process is needed to remove the excess oil content following by product drying in a tunnel dryer to reduce moisture.

Packaging and storage

Packaging of this product must be satisfied by the following requirements:

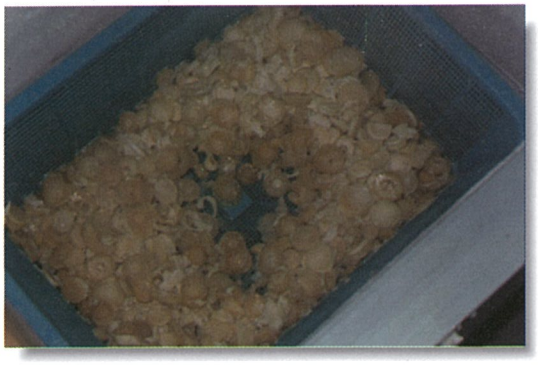
- It must be able to protect the product from moisture and air.
- It must be sufficiently strong and stable to protect the product from damaging by abrasion, especially during transportation and storage.
- Packaging material must be safe when directly contact with the product.
- Its size and shape must be acceptable from distribution and storage point of view.

Normally, the commercial packaging for snack food can be used for this product. Room temperature is available for keeping this product under the nitrogen flush during packing. The shelf-life of this product is certified up to 6 months at 30 ^{O}C.

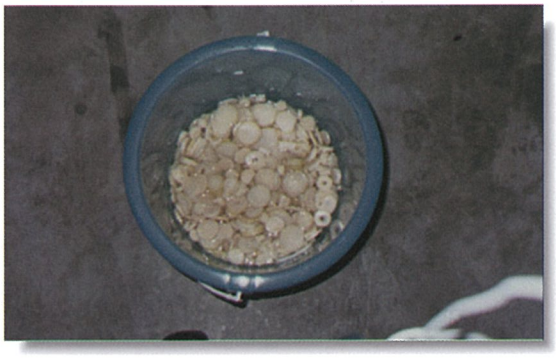
Product Development of Bamboo Shoot Snack
(Pilot plant study at Faculty of Agro-Industry, Chiang Mai University)

By Vacuum Deep-fried Process

Raw Material



Raw material after sliced and freezing



Defreezing

Vacuum Deep Fryer

Bamboo shoot snack after frying

The access oil was removed by centrifugal technique

Product Grading before drying

Drying of bamboo shoot snack

Packing with Nitrogen Flush

bamboo shoot snack product

GENERAL FLOWCHART OF FREEZE-DRIED BAMBOO SHOOT

Another development product is a freeze-dried bamboo shoot. The bamboo shoot would be preserved as a dry product with a shelf life more than 3 years in the normal packaging under normal condition. Before cooking, dried bamboo shoot is merged into water for a while. Its character will be recovered to that of the original fresh bamboo. This product aims to serve as an export product. Flowchart of freeze-dried bamboo shoot production is show in Fig. 3.6.

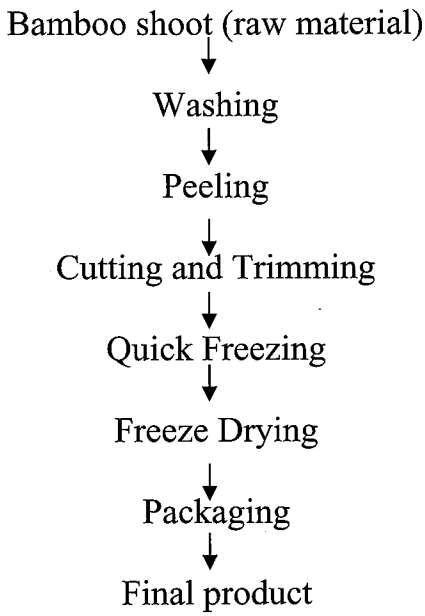


Figure 3.6 Flowchart of freeze-dried bamboo shoot production.

Washing, peeling, cutting and trimming were carried out as described in session for sterilized bamboo shoot product. The quick freezing and freeze drying process are described as following:

Quick Freezing

Quick freezing is employed for changing water form in bamboo shoot structure. The bamboo shoot slice is frozen at the temperature lower than $-40^{\circ}C$ for 1-3 hours. In this step, both free and bounded form of water will be changed from liquid to solid state.

Freeze-drying

Frozen-bamboo shoot slice is dried under low temperature and pressure conditions. The free form of water (solid state) will be suddenly eliminated by sublimation, when vacuum condition was applied. The bounded form of water takes longer time for sublimation, which is normally 3-12 hours depending on the amount of bounded water.

Product Development of Bamboo Shoot Snack
(Pilot plant study at Faculty of Agro-Industry, Chiang Mai University)

By Freeze Drying Process

Raw Material

Raw material after sliced and freezing

Freeze-drying

Freeze-dried bamboo

CHAPTER IV Design shoot plant cottage industry

Pilot plant design for bamboo shoot processing will be discussed in this chapter with the following guideline:

1. Study on the regulation law of GMP and HACCP.
2. Study on an appropriate technology for bamboo shoot processing.
3. Design the shoot plant cottage industry with an appropriate technology.
4. Cost analysis.

The factory building and facilities of three bamboo-shoot products were developed with the same floor plan. The approximately 125 m^2 x 25 m^2 refrigerate room was designed as shown in Figure 4.1. This factory needed the total area of one Rai. The estimated cost for the factory building was 6,000-8,000 Bath per m^2 depending on the price of construction material in the local area. With complete facilities of water and electric supplies, we estimated the cost of this project as following:

Land:	200,000 Baht/Rai
Factory building:	1,200,000 Baht
Facilities:	500,000 Baht
Total:	1,900,000 Baht

The prices of machinery and equipment related to the operating process of the three products are shown in Table 4.1, 4.2 and 4.3,

Table 4.1 Lists of machinery and equipment prices related to the operating process of sterilized bamboo shoot product.

Machinery	*Prices (Baht)*
1. Steam generator: - steam capacity 100 kg/hr	250,000
2. De-aeration system	200,000
3. Retort (sterilizer)	800,000
4. Semi-automatic canning lid closer	250,000
5. Stainless steel table (110x230x80 cm) x 8	50,000
6. Mixing tank (300 liters) x 2	100,000
7. Slicer	100,000
Total	*1,750,000*

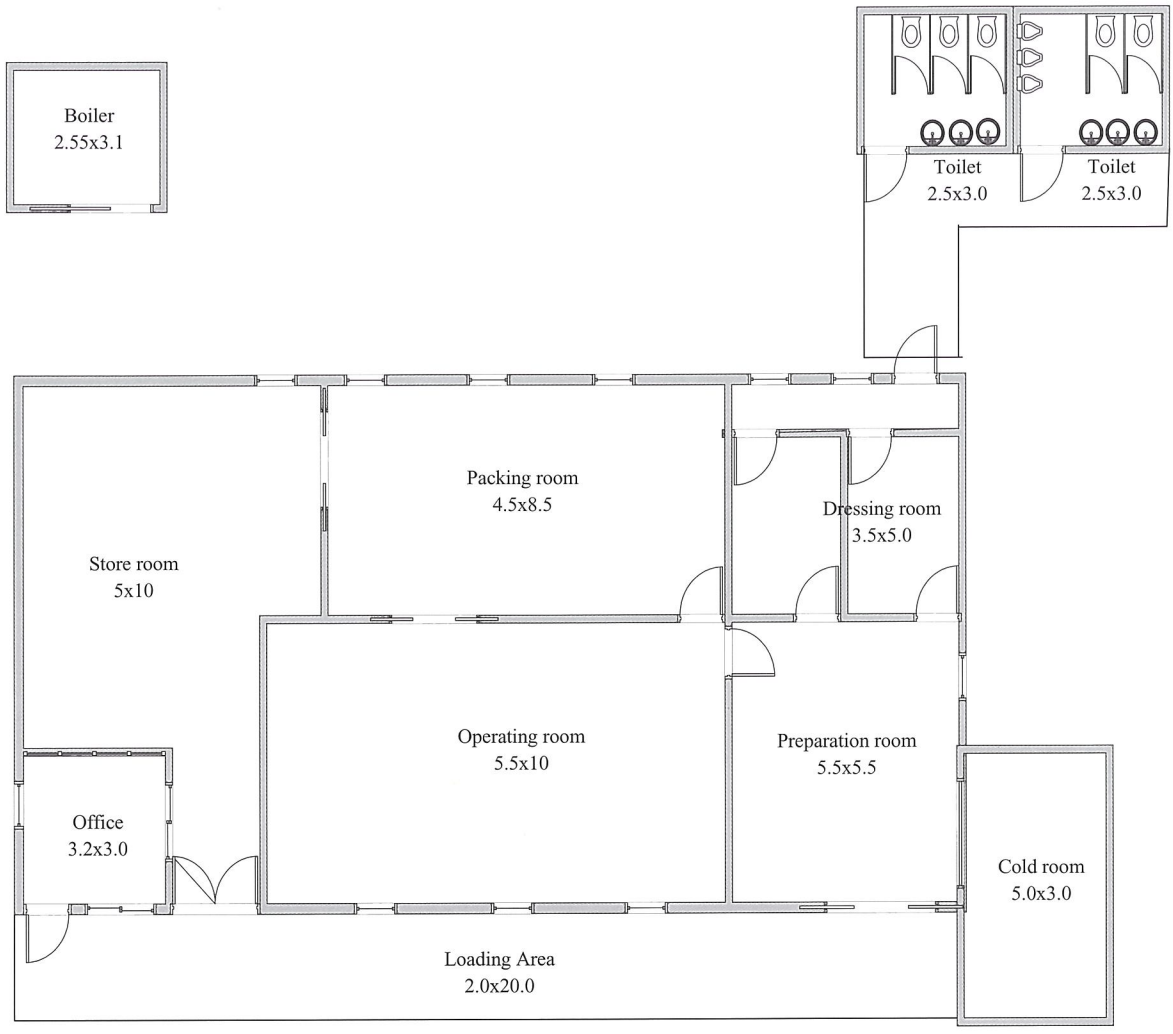
Table 4.2 Lists of machinery and equipment related to the operating process of vacuum deep fried bamboo shoot product.

Machinery	*Prices (Baht)*
2. Steam generator: - steam capacity 100 kg/hr	250,000
2. Vacuum deep fryer (200 liters)	800,000
3. Centrifugal de-oiler	350,000
4. Dryer (300 liters) x 2	200,000
5. Stainless steel table (110x230x80 cm) x 8	50,000
6. Mixing tank (300 liters) x 2	100,000
7. Slicer	100,000
8. Vacuum packing unit x 2	150,000
Total	*2,000,000*

Table 4.3 Lists of machinery and equipment related to the operating process of freeze-dried bamboo shoot product.

Machinery	*Prices (Baht)*
1. Freeze dryer (100 kg capacity) x 2	7,000,000
2. Quick freezing unit	2,000,000
3. Cold room	450,000
5. Stainless steel table (110x230x80 cm) x 10	100,000
6. Mixing tank (300 liters) x 2	100,000
7. Slicer x 2	200,000
8. Vacuum packing unit x 2	150,000
Total	*10,000,000*

Floor plan for machinery and equipment of the three products are show in Figure 4.2,4.3 and 4.4.



Plan Floor : Feasibility study on the establishment of bamboo shoot plant in Chiang Mai, Thailand

Figure 4.1 Floor plan of bamboo shoot factory.

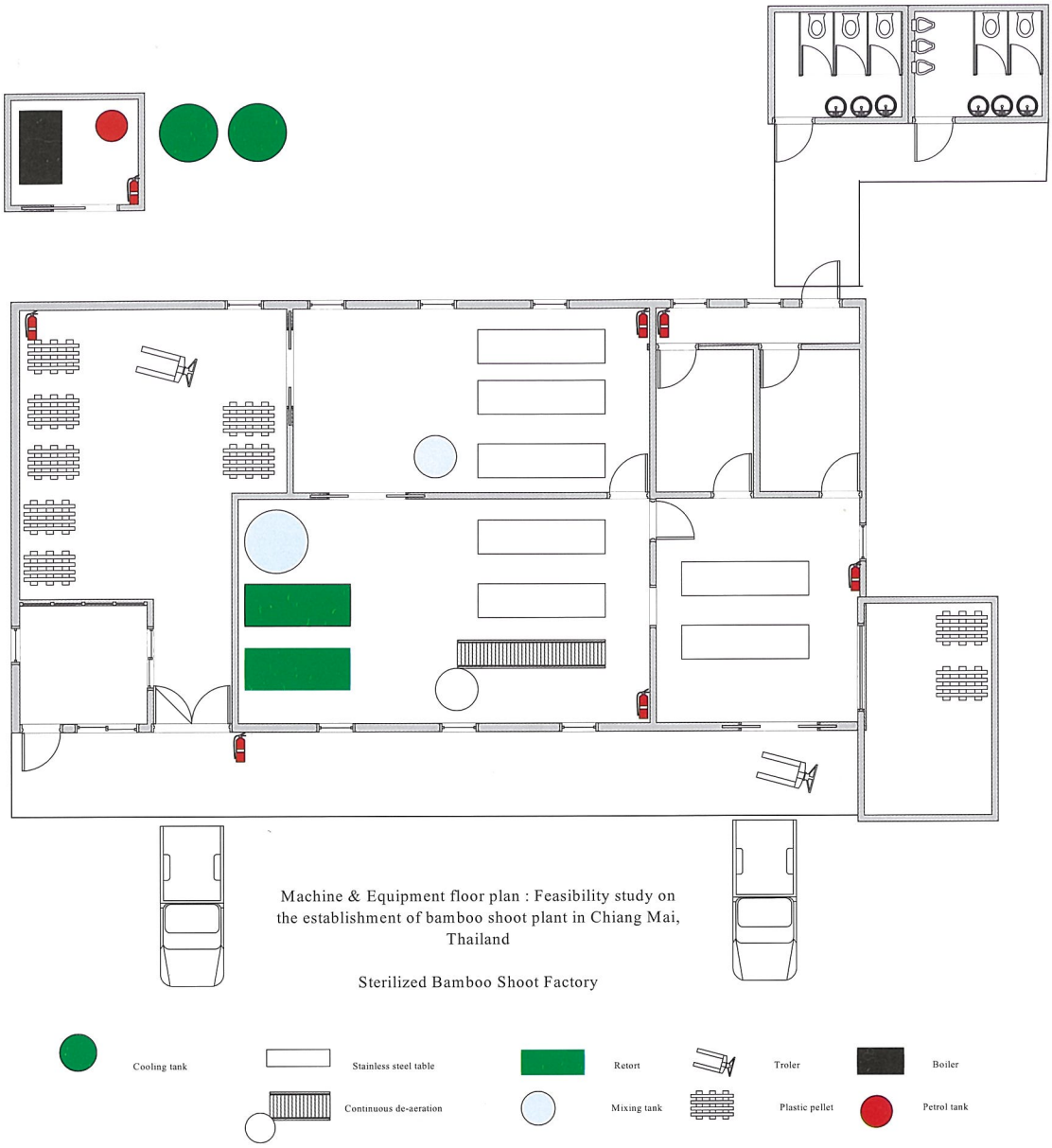


Figure 4.2 Floor plan for machinery and equipment of sterilized bamboo shoot factory.

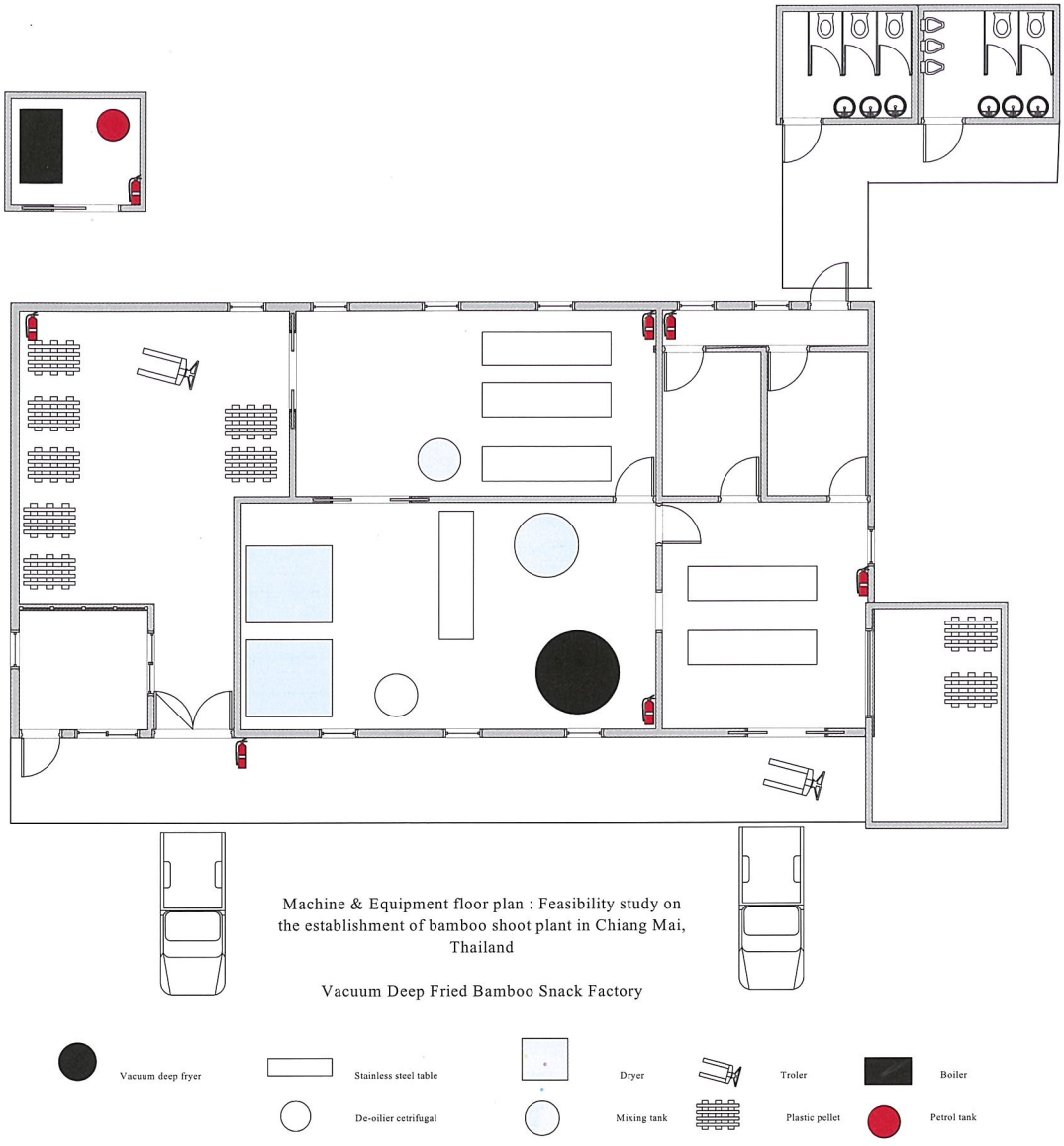


Figure 4.3 Floor plan for machinery and equipment of vacuum deep fried bamboo shoot factory.

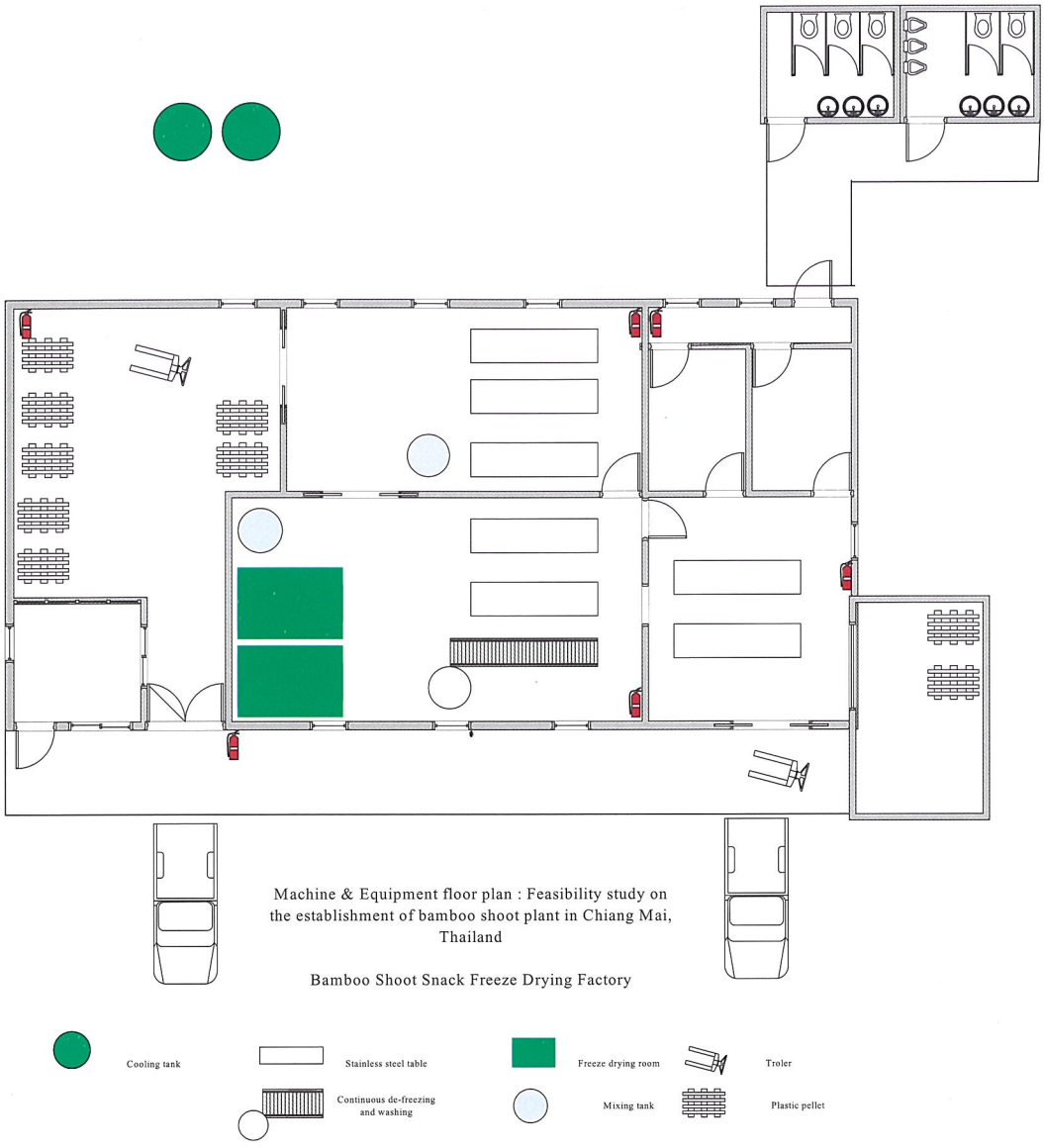


Figure 4.4 Floor plan for machinery and equipment of freeze drying bamboo shoot factory.

Chapter V : Cost-Benefit Analysis

Financial Analysis of Major Projects is important for an investment and cost saving. At the simplest level of analysis, it is necessary to make sure that the total costs of major project are less than the total benefits resulting from the project. There are several means used for financial analysis. The most commonly methods are as following:

- payback period analysis
- accounting rate of return
- net present value
- internal rate of return

Each method has its advantages and drawbacks, so several methods are used for evaluating any given project. All methods as shown above are used for bamboo shoot snack business analysis.

In this chapter, three developed product from bamboo shoot, including sterilized product, vacuum deep fried product, and freeze dried product, were investigated by using the theory of cost-benefit analysis. Please remark that fresh bamboo shoot as raw material for factory could be supplied only 5 months a year during June to October. For another period, we expected to operate business by using another kinds of fruits or vegetables.

1. Total Revenue

The total revenue was expressed by.

Total revenue = price per unit of product (P) X quantity of product (Q)

In this study we expected that the business would run for 7 working hours per day or 26 days per month, or 300 working days per year.

- For sterilized bamboo shoot factory, the production capacity of pilot plant design was 500 kilograms product per day or 1,000 unit product/day (500 grams/unit). The sale price of this product in the local market was about thirty-five Baht per unit.

- For the bamboo shoot snack production by vacuum deep-fried method. The production capacity of pilot plant design was 100 kilograms product per day or 1,000-unit product/day (100 gram/unit). The sale price of bamboo shoot snack product was expected to be twenty Baht per unit.

- For freeze dried bamboo shoot factory, the production capacity of pilot plant design was 50 kilograms product per day or 500 unit product/day (100 grams/unit). The sales price of this product in the local market was approximately sixty Baht per unit.

The total revenue of the three businesses is shown in Table 5.1.

Table 5.1 Total revenue of the three businesses per year.

Business	*Price per unit (Baht)*	*Quantity of product (unit)*	*Total revenue (Baht)*
Sterilized product business	35	300,000	10,500,000
Vacuum deep fried product business	20	300,000	6,000,000
Freeze-dried product business	60	150,000	9,000,000

2. Total Costs Estimation

The total costs of bamboo-shoot snack plant was estimated with the following criteria:

2.1 Investment Costs

- *Land and construction*

From the local surveys, we could estimate that the land price in local area, Chiang-Dao district, was approximately 200,000 Baht/Rai. Total area used in this project was one Rai.

The construction of factory included 125 m^2 of factory building, 25 m^2 of refrigerate room, which could be estimated at 8,000 Baht/m^2. Total cost of construction was 1,200,000 Baht. All facilities such as water and power systems were totally 500,000 Baht.

Total cost of land and construction was 1,900,000 Baht

- *Machinery and equipment*

  Total price of machinery and equipment of the three production lines is shown in Table 5.2

Table 5.2 Price lists of machinery and equipment of production line

Production line	*Total prices (Baht)*
Sterilized product	1,750,000
Vacuum deep fried product	2,000,000
Freeze-dried product	10,000,000

Depreciated value of factory building and machinery of each project is shown in Table 5.4, 5.5 and 5.6. Calculation was made at 5% depreciation per year.

2.2 Operating Costs

Production costs for the first year is shown in Table 5.3

Table 5.3 Production Costs per year: (Baht)

Product	*Raw materials*	*Chemical and ingredient*	*Packaging*	*Fuel and energy*	*Maintenance costs*	*Total operating costs*
Sterilized product	3,000,000	240,000	3,000,000	360,000	50,000	*6,650,000*
Vacuum deep fried product	600,000	240,000	900,000	360,000	50,000	*2,150,000*
Freeze-dried product	300,000	240,000	450,000	360,000	50,000	*1,400,000*

Remarks:

1. Raw materials: 10 Baht/kg : Load of production line is
   Sterilized product, 1,000 kg-raw material per day
   Vacuum deep-fried product, 200 kg-raw material per day
   Freeze dried product, 100 kg-raw material per day
   Calculated at 300 working days per year
2. Chemical and Ingredients: 240,000 Baht/ year
3. Packaging:
   Sterilized product, tungsten cans 1,000 cc., 10 Baht/unit
   Vacuum deep-fried product, vacuum plastic bag, 3 Baht/unit
   Freeze-dried product, vacuum plastic bag, 3 Baht/unit
4. Fuel and Energy: 30,000 Baht/month = 360,000 Baht/ year
5. Maintenance costs: 50,000 Baht/year
6. Other kinds of fruits and vegetables will be used when bamboo shoot is out of season (Nov-May)

2.3 Management Costs (fixed costs)

1. Salary: Total 888,000 Baht/year
   Manager 1 position: 10,000 Baht/month
   Supervisor 2 position: 6,500 Baht/month
   Operator 10 position: 4,000 Baht/month
   Officer 2 position: 5,500 Baht/month
   The calculation based on the 5% increasing of salary each year is show in Table 5.5. In the starting year, it will be calculated only for manager, supervisor and officer.
2. Office work management: 120,000 Baht/year
3. Other payment: 250,000 Baht/year

In this study, the investment money for starting the project could be received from 2 sources including: making a bank loan at 10% interest, and (or) getting money from owner or organization. The data sheet of total cost and total revenue of three development products are shown in Table 5.4, 5.5 and 5.6, respectively.

Table 5.4 Data sheet of cost-benefit analysis for sterilized bamboo shoot project.

	0	1	2	3	4	5	6	7	8	9	10	Total
Cash flow												
1.owner investment	5,000,000											
2. Loan from bank	10,000,000											
3. revenue	-	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	120,000,000
4. Depreciate value	-	170,000	170,000	170,000	170,000	170,000	170,000	170,000	170,000	170,000	170,000	1,700,000
Total	15,000,000	12,170,000	12,170,000	12,170,000	12,170,000	12,170,000	12,170,000	12,170,000	12,170,000	12,170,000	12,170,000	*121,700,000*
Investment costs												
1. Land	200,000											200,000
2. Construction	1,200,000											1,200,000
3. Facilities	500,000											500,000
4. Machinery	2,000,000											2,000,000
Total	3,900,000											*3,900,000*
Operating costs												
1. Raw materials		6,240,000	6,240,000	6,240,000	6,240,000	6,240,000	6,240,000	6,240,000	6,240,000	6,240,000	6,240,000	62,400,000
2. Energy cost		360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	3,600,000
3. Maintenance cost		50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	500,000
Total		6,650,000	6,650,000	6,650,000	6,650,000	6,650,000	6,650,000	6,650,000	6,650,000	6,650,000	6,650,000	*66,500,000*
Management costs												
1. Salary	408,000	1,258,000	1,313,500	1,371,533	1,432,280	1,496,108	1,562,570	1,632,120	1,704,890	1,781,034	1,860,711	15,820,746
2. Office facilities	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	1,320,000
3. Others	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	2,750,000
4. payback to bank	0	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000						10,500,000
5. Bank interested	1,000,000	1,000,000	800,000	600,000	400,000	200,000						3,800,000
Total	1,780,000	4,628,000	4,483,500	4,341,533	4,202,280	4,066,108	1,932,570	2,002,120	2,074,890	2,151,034	2,230,711	*33,892,746*
Total cost	4,678,000	10,028,000	11,133,500	10,991,533	10,852,280	10,716,108	8,582,570	8,652,120	8,724,890	8,801,034	8,880,711	*102,040,746*
Cash flow	10,322,000	2,142,000	1,036,500	1,178,467	1,317,720	1,453,892	3,587,430	3,517,880	3,445,110	3,368,966	3,289,289	-

Table 5.5 Data sheet of cost-benefit analysis for vacuum deep-fried bamboo shoot project.

	0	1	2	3	4	5	6	7	8	9	10	Total
Cash flow												
1.owner investment	2,500,000											
2. Loan from bank	2,500,000											
3. revenue	-	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	60,000,000
4. Depreciate value	-	170,000	170,000	170,000	170,000	170,000	170,000	170,000	170,000	170,000	170,000	1,700,000
Total	5,000,000	6,170,000	6,170,000	6,170,000	6,170,000	6,170,000	6,170,000	6,170,000	6,170,000	6,170,000	6,170,000	*66,700,000*
Investment costs												
1. Land	200,000											200,000
2. Construction	1,200,000											1,200,000
3. Facilities	500,000											500,000
4. Machinery	2,000,000											2,000,000
Total	3,900,000											*3,900,000*
Operating costs												
1. Raw materials		1,740,000	1,740,000	1,740,000	1,740,000	1,740,000	1,740,000	1,740,000	1,740,000	1,740,000	1,740,000	17,400,000
2. Energy cost		360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	3,600,000
3. Maintenance cost		50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	500,000
Total		2,150,000	2,150,000	2,150,000	2,150,000	2,150,000	2,150,000	2,150,000	2,150,000	2,150,000	2,150,000	*21,500,000*
Management costs												
1. Salary	408,000	1,258,000	1,313,500	1,371,533	1,432,280	1,496,108	1,562,570	1,632,120	1,704,890	1,781,034	1,860,711	15,412,766
2. Office facilities	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	1,320,000
3. Others	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	2,750,000
4. payback to bank	0	500,000	1,000,000	1,000,000								2,500,000
5. Bank interested	250,000	250,000	200,000	100,000								800,000
Total	1,028,000	2,378,000	2,783,500	2,841,533	1,802,280	1,866,108	1,932,570	2,002,120	2,074,890	2,151,034	2,230,711	*23,090,746*
Total cost	4,928,000	4,528,000	4,933,500	4,991,533	3,952,280	4,016,108	4,082,570	4,152,120	4,224,890	4,301,034	4,380,711	*48,490,746*
Cash flow	72,000	1,642,000	1,236,500	1,178,467	2,217,720	2,153,892	2,087,430	2,017,880	1,945,110	1,868,966	1,789,289	-

Table 5.6 Data sheets of cost-benefit analysis for freeze dried bamboo shoot project.

	0	1	2	3	4	5	6	7	8	9	10	Total
Cash flow												
1.owner investment	6,000,000											
2. Loan from bank	10,000,000											
3. revenue	-	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	90,000,000
4. Depreciate value	-	560,000	560,000	560,000	560,000	560,000	560,000	560,000	560,000	560,000	560,000	5,600,000
Total	16,000,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	*95,600,000*
Investment costs												
1. Land	200,000											200,000
2. Construction	1,200,000											1,200,000
3. Facilities	500,000											500,000
4. Machinery	10,000,000											10,000,000
Total	11,900,000											11,900,000
Operating costs												
1. Raw materials		1,740,000	1,740,000	1,740,000	1,740,000	1,740,000	1,740,000	1,740,000	1,740,000	1,740,000	1,740,000	17,400,000
2. Energy cost		360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	3,600,000
3. Maintenance cost		50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	500,000
Total		2,150,000	2,150,000	2,150,000	2,150,000	2,150,000	2,150,000	2,150,000	2,150,000	2,150,000	2,150,000	*21,500,000*
Management costs												
1. Salary	408,000	1,258,000	1,313,500	1,371,533	1,432,280	1,496,108	1,562,570	1,632,120	1,704,890	1,781,034	1,860,711	15,820,746
2. Office facilities	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	1,320,000
3. Others	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	2,750,000
4. payback to bank	0	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000						10,500,000
5. Bank interested	1,000,000	1,000,000	800,000	600,000	400,000	200,000						3,800,000
Total	1,780,000	4,628,000	4,483,500	4,341,533	4,202,280	4,066,108	1,932,570	2,002,120	2,074,890	2,151,034	2,230,711	*33,892,746*
Total cost	13,680,000	6,778,000	6,633,500	6,491,533	6,352,280	6,216,108	4,082,570	4,152,120	4,224,890	4,301,034	4,380,711	*67,292,746*
Cash flow	2,320,000	2,782,000	3,016,500	3,068,467	3,207,720	3,343,892	5,477,430	5,407,880	5,335,110	5,258,966	5,179,289	44,397,254

Net Present Value of Project

The Net Present Value (NPV) is a method used to evaluate the major project for considering the time value of money. Essentially, it helps to find the present value in "today's money" of the future net cash flow of a project. This leads to known amount of money needed to implement the project. If the NPV is greater than the cost, the project will be profitable. If the organization have more than one project on the table, they can compute the NPV of each project, and choose the one, which has the greatest difference between NPV and cost.

NPV analysis is generally used to evaluate the project's cash flows, rather than the income from the project that would be shown on an income statement. Because the income statement results in depreciation, but depreciation is not an out-of-pocket expense. For instance, if revenue of 10,000 Baht is reduced to 7,000 Baht of income because of a 3,000 Baht depreciation deduction, the project still can use of fully 10,000 Baht. So, the cash flow figure of 10,000 Baht is the more instructive one to look at. However, if the project are very concerned about the appearance of project income statement. The NPV can be calculated by the following formula:

$$\text{Present Value} = CF_0 \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \frac{CF_n}{(1+r)^n}$$

(Where, CFx = cash flow in period x, n = the number of periods, and r = the discount rate.)

The data sheet of calculation is shown in Table 5.7, 5.8 and 5.9, and the results is shown in Table 5.13.

Table 5.7 NPV, IRR and B/C ratio analysis of sterilized bamboo shoot product business at discount rate of 10 %.

Year	*Total cost*	*$Pvif_{i=10\%}$*	*PV cost*	*Benefit*	*PV benefit*	*Net benefit*	*PV net benefit*
0	4,678,000	1.000	4,678,000	0	0	-4,678,000	-4,678,000
1	10,028,000	0.9091	9,116,455	12,170,000	11,063,747	2,142,000	1,947,292
2	11,133,500	0.8264	9,200,724	12,170,000	10,057,288	1,036,500	856,564
3	10,991,533	0.7513	8,257,939	12,170,000	9,143,321	1,178,467	885,382
4	10,852,280	0.6830	7,412,107	12,170,000	8,312,110	1,317,720	900,003
5	10,716,108	0.6209	6,653,631	12,170,000	7,556,353	1,453,892	902,722
6	8,582,570	0.5645	4,844,860	12,170,000	6,869,965	3,587,430	2,025,105
7	8,652,120	0.5132	4,440,499	12,170,000	6,245,644	3,517,880	1,805,145
8	8,724,890	0.4665	4,072,028	12,170,000	5,677,305	3,445,110	1,605,277
9	8,801,034	0.4241	3,732,519	12,170,000	5,161,297	3,368,966	1,428,778
10	8,880,711	0.3855	3,423,514	12,170,000	4,691,535	3,289,289	1,268,021
Total	*102,040,746*		*65,832,276*	*121,700,000*	*74,778,565*	*19,659,254*	*8,976,289*

NPV = 8,976,289
IRR = 31.89 %
B/C Ratio = 1.13
Payback Period = 2.38 years

Table 5.8 NPV, IRR and B/C ratio analysis of vacuum deep fried product business at discount rate of 10 %

year	*Total cost*	*$Pvif_{i=10\%}$*	*PV cost*	*Benefit*	*PV benefit*	*Net benefit*	*PV net benefit*
0	4,928,000	1.000	4,928,000	0	0	-4,928,000	-4,928,000
1	4,528,000	0.9091	4,116,405	6,170,000	5,609,147	1,642,000	1,492,742
2	4,933,500	0.8264	4,077,044	6,170,000	5,098,888	1,236,500	1,021,844
3	4,991,533	0.7513	3,750,139	6,170,000	4,635,521	1,178,467	885,382
4	3,952,280	0.6830	2,699,407	6,170,000	4,214,110	2,217,720	1,514,703
5	4,061,108	0.6209	2,521,542	6,170,000	3,830,953	2,153,892	1,309,411
6	4,082,570	0.5645	2,304,610	6,170,000	3,482,965	2,087,430	1,178,355
7	4,152,120	0.5132	2,130,868	6,170,000	3,166,444	2,017,880	1,035,576
8	4,224,890	0.4665	1,970,911	6,170,000	2,878,305	1,945,110	907,394
9	4,301,034	0.4241	1,824,069	6,170,000	2,616,697	1,868,966	792,628
10	4,380,711	0.3855	1,688,764	6,170,000	2,378,535	1,789,289	689,771
	48,490,746		*32,011,759*	*61,700,000*	*37,911,565*	*13,209,254*	*5,899,806*

NPV = 5,899,806
IRR = 31.77 %
B/C Ratio = 1.18
Payback Period = 3.73 years

Table 5.9 NPV, IRR and B/C ratio analysis of freeze dried product business at discount rate of 10 %.

year	*Total cost*	*$Pvif_{i=10\%}$*	*PV cost*	*Benefit*	*PV benefit*	*Net benefit*	*PV net benefit*
0	13,680,000	1.000	13,680,000	0	0	-13,680,000	-13,680,000
1	6,778,000	0.9091	6,161,880	9,560,000	8,690,996	2,782,000	2,529,116
2	6,633,500	0.8264	5,481,924	9,560,000	7,900,384	3,016,500	2,418,460
3	6,491,533	0.7513	4,877,089	9,560,000	7,182,428	3,068,467	2,305,339
4	6,352,280	0.6830	4,338,607	9,560,000	6,529,480	3,207,720	2,190,873
5	6,216,108	0.6209	3,859,581	9,560,000	5,935,804	3,343,892	2,076,223
6	4,082,570	0.5645	2,304,611	9,560,000	5,396,620	5,477,430	3,092,009
7	4,152,120	0.5132	2,130,868	9,560,000	4,906,192	5,407,880	2,775,324
8	4,224,890	0.4665	1,970,911	9,560,000	4,459,740	5,335,110	2,488,829
9	4,301,034	0.4241	1,824,069	9,560,000	4,054,396	5,258,966	2,230,327
10	4,380,711	0.3855	1,688,764	9,560,000	3,685,380	5,179,289	1,996,616
	67,292,746		*48,318,304*	*95,600,000*	*58,741,420*	*28,397,254*	*10,423,116*

NPV = 10,423,116
IRR = 23.26%
B/C Ratio = 1.21
Payback Period = 4.82 years

As shown in Table 5.7,5.8 and 5.9, the NPV of three types business are greater than the PV cost. So, the project will be profitable. The highest NPV of 10,423,110 was obtained from the freeze-dried product bushiness. The second and the third one were sterilized bamboo shoot and vacuum deep fried project with NPV of 8,976,289 and 5,899,806, respectively.

Internal Rate of Return

The Internal Rate of Return (IRR) is the method for analyzing a major purchase considering the time value of money. Essentially, it allows finding the interest rate that is equivalent to expect the money return from the project. Once the rate is known, comparison could be made to the rates earned from other projects or investments.

In order to be an acceptable project, IRR of project must be higher in several percentages than those of the cost of borrowing. This is to compensate the company for its risk, time, and trouble associated with the project. Otherwise, if the IRR is less than the cost of borrowing, the project will clearly be a money-looser.

IRR analysis is generally used to evaluate the project's cash flow, rather than the income from the project that would be shown on an income statement (also known as the profit and loss statement). Because income on a P & L reflects depreciation, but depreciation is not an out-of-pocket expense. For instance, if revenue of 10,000 Baht is reduced to 7,000 Baht of income because of a 3,000 Baht depreciation deduction, the 10,000 Baht still can be used. So the cash flow figure of 10,000 Baht is usually more instructive one to look at. However, if the appearance of the income statement is of concern (for example, if you putting business up for sale or seeking major financing in the future, or being under stockholder pressure is anticipated), the income figure may be move appropriate to be used.

The simplest way is the use of the following expression:

$$IRR = DR_L + (DR_U - DR_L)\left[\frac{NPV_L}{NPV_L - NPV_U}\right]$$

When, DR_L = lower discount rate
DR_U = upper discount rate
NPV_L= lower NPV
NPV_U= upper NPV

The calculation data sheets are shown in Table 5.10, 5.11 and 5.12.

Table 5.10 Lower and Upper NPV data sheet for sterilized bamboo shoot snack business.

year	*Net benefit*	$Pvif_{i=31\%}$	$NPV_{i=31\%}$	$Pvif_{i=32\%}$	$NPV_{i=39\%}$
0	-4,678,000	1.000	-4,678,000	1.000	-4,678,000
1	2,142,000	0.7634	1,635,203	0.7194	1,540,955
2	1,036,500	0.5827	603,969	0.5176	536,492
3	1,178,467	0.4448	524,182	0.3723	438,743
4	1,317,720	0.3396	447,498	0.2678	352,885
5	1,453,892	0.2592	376,849	0.1927	280,165
6	3,587,430	0.1979	709,952	0.1386	497,218
7	3,517,880	0.1510	531,200	0.0997	350,733
8	3,445,110	0.1153	397,221	0.0717	247,014
9	3,368,966	0.0880	296,469	0.0516	173,839
10	3,289,289	0.0672	221,040	0.0371	122,033
	19,659,254		*1,065,583*		*-137,923*

$$IRR = 31 + (32-31)\left[\frac{1,065,583}{1,065,583 - (-137,923)}\right] = 31.89\ \%$$

Table 5.11 Lower and Upper NPV data sheet for vacuum deep-fried bamboo shoot snack business.

year	*Net benefit*	$Pvif_{i=31\%}$	$NPV_{i=31\%}$	$Pvif_{i=32\%}$	$NPV_{i=32\%}$
0	-4,928,000	1.000	-4,928,000	1.000	-4,928,000
1	1,642,000	0.7634	1,253,503	0.7576	1,246,979
2	1,236,500	0.5827	720,509	0.5739	709,627
3	1,178,467	0.4448	524,182	0.4348	512,398
4	2,217,720	0.3396	753,138	0.3294	730,517
5	2,153,892	0.2592	558,289	0.2495	537,396
6	2,087,430	0.1979	413,191	0.1890	394,609
7	2,017,880	0.1510	304,670	0.1432	288,960
8	1,945,110	0.1153	224,271	0.1085	211,044
9	1,868,966	0.0880	164,469	0.0822	153,629
10	1,789,289	0.0672	120,240	0.0623	111,472
	13,209,254		*108,462*		*-31,369*

$$IRR = 31 + (32-31)\left[\frac{108,462}{108,462 - (-31,369)}\right] = 31.77\ \%$$

Table 5.12 Lower and Upper NPV data sheet for freeze dried bamboo shoot snack business.

year	*Net benefit*	$Pvif_{i=23\%}$	$NPV_{i=23\%}$	$Pvif_{i=24\%}$	$NPV_{i=24\%}$
0	-13,680,000	1.000	-13,680,000	1.000	-13,680,000
1	2,782,000	0.8130	2,261,766	0.8065	2,243,683
2	3,016,500	0.6610	1,993,907	0.6504	1,961,932
3	3,068,467	0.5374	1,648,994	0.5245	1,609,411
4	3,207,720	0.4369	1,401,453	0.4230	1,356,866
5	3,343,892	0.3552	1,187,750	0.3411	1,140,602
6	5,477,430	0.2888	1,581,881	0.2751	1,506,840
7	5,407,880	0.2348	1,269,770	0.2218	1,199,468
8	5,335,110	0.1909	1,018,472	0.1789	954,451
9	5,258,966	0.1552	816,192	0.1443	758,869
10	5,179,289	0.1262	623,626	0.1164	602,869
	28,397,254		*123,811*		*-345,009*

$$IRR = 23 + (24-23)\left[\frac{123,811}{123,811 - (-345009)}\right] = 23.26\ \%$$

It can be seen that the sterilized bamboo shoot business gives the highest IRR of 31.89%, whereas vacuum deep-fried and freeze dried businesses show the IRR of 31.77, and 23.26%, respectively.

Payback Period Analysis

The payback analysis is the simplest method for looking at one or more major project ideas. The results would be explained how long it would take to earn back the money, which was spent on the project. The expression is:

$$\frac{\text{Cost of Project}}{\text{Project Cash flow}} = \text{Payback Period}$$

In this study, payback periods of three type projects during 10 years of business are show in Table 5.13.

Table 5.13 Payback period analysis.

Project	*Project cost (Baht)*	*Average Project cash flow (Baht)*	*Payback period (years)*
Sterilized project	4,678,000	1,965,925	*2.38*
Vacuum deep fried project	4,928,000	1,320,925	*3.73*
Freeze-dry project	13,680,000	2,839,725	*4.82*

Under the payback period analysis, project with shorter payback is more liquid, and less risky. It means that the investment can be recouped sooner, therefore money can be reinvested elsewhere. Moreover, there are a number of variables which grow increasingly fuzzy looking out in the future by many projects. With a shorter payback period, market conditions, interest rates, the economy, or other factors, which drastically change, will not affect the project.

Generally, a payback period of three years or less is preferred. Some advisors said that if the payback period is less than a year, the project should be considered essentialy. From this point of view, an establishment of sterilized product and new development products, i.e. freeze-dried bamboo shoot snack and vacuum deep-fried bamboo shoot, are recommended to be the most interesting business.

There is a couple of drawbacks by using the payback period method. For one thing, it ignores any benefits that occur after the payback period, so a project that returns 40 million Baht after a six-year payback period is ranked lower than a project that returns zero after a five-year payback. But probably the major criticism is that a straight payback method ignores the time value of money. To get around this problem, the net present value of the project should be considered, as well as its internal rate of return.

Table 5.14 Summarization of NPV, IRR, B/C, and payback period of three developed products.

Project	*NPV*	*IRR*	*B/C*	*Payback period (years)*
Sterilized product	8,976,289	31.89 %	1.13	2.38
Vacuum deep fried product	5,899,806	31.77 %	1.18	3.73
Freeze-dried product	10,423,116	23.26%	1.21	4.82

In conclusion, the data analysis shows that the best business is vacuum deep fried project, because it gives high benefit per cost (B/C), high internal rate of return (IRR) and also short payback period. Sterilized bamboo shoot project is the second one, which give the high IRR and very quick pay back period. However, B/C ratio is quite low. It means that NPV-benefit value is close to NPV-cost. The third business to be considered was freeze-dried project which gives high B/C ratio but lower IRR and longer payback period. However, from the discussion point of business competitor in Chapter II, we suggest that only vacuum deep-fried business and freeze-dried business are good for investment.

PD 56/99 Rev . 1 (I)
สำนักวิจัยเศรษฐกิจและผลิตผลป่าไม้ กรมป่าไม้
สนับสนุนโดย
องค์การไม้เขตร้อนระหว่างประเทศ
(International Tropical Timber Organization - ITTO)

กรมป่าไม้ 61 ถนนพหลโยธิน แขวงลาดยาว เขตจตุจักร กรุงเทพฯ 10900 โทร . 02 - 5799177