Chapter I

Introduction

1.1 Rubber and Processing of rubber

Rubber is a dicotyledon plant in the family Euphorbiaceae. The scientific name is *Hevea brasiliensis* (Department of Agricultural Extension, 1990).

In 2001, Thailand exported about 58,703 million baht of natural rubber, from which about 25,674 million baht (decrease 13.2%) was in the form of sheets rubber , 21,009 million baht (decrease 2.5%) as block rubber and 11,658 million baht (increase 24.5%) from latex concentrate (Krungthai Bank, 2002).

Hevea latex contains rubber hydrocarbon and a large number of non-rubber constituents present in relatively small amounts. Many of these are dissolved in the aqueous serum of the latex, others are adsorbed at the surface of the rubber particles and some are the non-rubber particles suspended in the latex. Being a natural product, the composition of fresh latex varies between wide limits. A typical composition of fresh latex is as follows (Fong, 1992):

	%
Total solids content	41.5
Rubber hydrocarbon	36.0
(Dry rubber content)	(39.0)
Proteinous substances	1.4
Neutral lipids	1.0
Phospholipids	0.6
Ash	0.5
Inositol & carbohydrates	1.6
Other nitrogen compounds	0.3
Water	58.5

The distribution of the major zones in the centrifuge tube, after high speed centrifugation in a fixed angle rotor, is illustrated in Fig. 1.1. The uppermost layer contains the rubber particles. Below this layer are the Frey Wyssling particles followed by the clear serum zone and finally the bottom fraction, which contains predominantly the lutoids.

Rubber Particles

In fresh latex rubber particles constitute 25%-45% of the volume of the latex. A complex film containing proteins and lipids protects the rubber particles in fresh latex. The rubber, contained in the particles, is non water-soluble and occurs as molecular aggregates. The rubber hydrocarbon is predominantly cis-1, 4-polyisoprene (at least 99%). The rubber particles are usually spherical with diameters ranging from 0.02 to 0.03 μm.

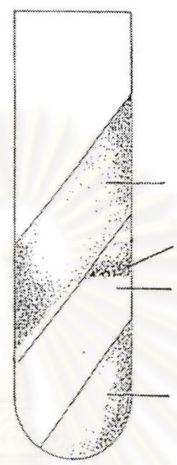

Figure 1.1 The distribution of the major zones of fresh latex after high speed centrifugation (Moir, 1959)

Lutoids

The most abundant non-rubber particles are the Lutoids. These are spherical membrane-bounded bodies typically 2-5 μm in diameter and are heavier than rubber particles. They form the bulk of the bottom fraction. The latter comprises 10%-20% (volume) of the whole latex and contain about 12% solids. Inside the lutoid is an aqueous solution (often called 'B-serum) which contains dissolved substances such as acids, mineral salts, proteins, sugars and a polyphenol oxidase.

Frey Wyssling Particles

The yellow color of the bottom fraction and indeed of some whole lattices is due predominantl to entrapped Frey Wyssling particles, and not to the color of the lutoids themselves. These particles are spherical and often bright yellow. The yellow color is due to the presence of carotenoid pigments. They are larger in size and have a slightly higher density than the rubber particles. These particles are mainly lipid in character and are not present in ammonia preserved concentrated latex. Apparently, they are either eliminated during centrifuging or they have dissolved in the serum when the latex is ammoniated.

1.2 Chemical composition of natural rubber latex

The most abundant non-rubber constituents (excluding water) in fresh latex are proteins, lipids, quebrachitol and inorganic salts, a large number of other substances are present in small amounts.

Protein

The total protein content of fresh latex is approximately 1%-1.5% of which about 20% is adsorbed on the rubber particles and a similar proportion is associated with the bottom fraction. The remainder is dissolved in the serum phase. The adsorbed proteins, together with adsorbed lipids, impart colloidal stability to the latex and remain associated with the rubber phase when the latex is coagulated by acid during the manufacture of dry rubber. About half of the serum and bottom fraction proteins are also coagulated and remain associated with the rubber in the process.

Amino Acids

Free amino acids comprise about 0.1% of the whole latex. The predominant amino acids are glutamic acid and its amide, alanine and aspartic acid which together account for about 81% of the total amino acid content.

Lipids

Lipids are water-insoluble and are concentrated mainly in the rubber phase with smaller quantities in the bottom fraction and in the Frey Wyssling particles. The total lipids on rubber particles varies from 1.4% to 3.2%.

Inositols and Carbohydrates

Quebrachitol (methyl inositol) is the most concentrated single component in the serum phase, amounting to about 1% of the whole latex. Small amount of inositol isomers, sucrose, glucose, galactose, fructose and two pentoses have also been detected. In the absence of adequate preservation, the carbohydrates, but possibly not the inositols, are metabolized by bacteria and converted to volatile fatty acids.

Inorganic Constituents

The total concentration of inorganic ions in fresh latex is approximately 0.5% of which more than half normally consists of potassium (0.12%-0.25%) and phosphate ions (0.25%). Small amounts of magnesium, copper, iron, sodium and calcium are also present.

1.3 Latex concentrate production and properties of latex serum

To find ways of reducing the water content of the latex so as to avoid the high cost of shipping water in the form of low dry rubber content (d.r.c.) latex the production of latex concentrates of about 60 per cent d.r.c. could be done (Buakaew, 1998). According to Webster and Baulkwill (1989) the product made from this material worldwide now fall into eight categories, namely:

- dipped goods : gloves and balloons (36%)
- moulded foam (17%)
- adhesives (15%)
- thread (10%)
- carpet backing and underlays (9%)
- rubberized coir (5%)
- leather-board (3%)
- miscellaneous (5%)

Three methods are now used for concentrating latex-evaporation, creaming and centrifuging. Only the centrifuging was described in this chapter.

Field latex is collected as soon as possible after tapping. At the collection station the preservative such as ammonia is added in order to inhibit bacterial growth which would cause an increase in its content of volatile fatty acid (VFA), eventually leading to spontaneous coagulation in 6-12 hours. Magnesium was precipitated out by adding to the latex an appropriate amount of diammonium hydrogen phosphate (DAHP) to form magnesium ammonium phosphate, which settles in the tank with any natural sludge. The latex was then centrifuged. The centrifuged concentrates were preserved with ammonia, tetramethylthiuram disulphide (TMTD), and zinc oxide (ZnO) (Fig.1.2).

During the processing of rubber various amounts of water are used for washing, cleaning and dilution. The liquid effluent produced is about 22 litres per kg of dry rubber. The composition of the waste is dependent on the type of process employed in the factories, but generally it consists of processed water, small amounts of uncoagulated latex and latex serum containing substantial quantities of proteins, sugars, lipids, carotenoids, inorganic and organic salts (John, 1972)

In the processing of fresh latex to 60% concentrated latex, it generates large amount of wastewater. Waste water generated from water used for cleaning, dilution and sanitary washing. Skim latex serum is derived from the coagulation of skim latex, a by-product of latex concentrate production. After centrifuging fresh latex, it separated into three layer of rubber on the top, fairly clean serum in the middle and a bottom fraction. Many of the non-rubbers are dissolved in the serum, others are associated with the bottom fraction, and a few are absorbed by the rubber particles. The amount of non-rubbers in serum is approximately 4.0 %(w/w), which include proteins, lipids, carbohydrates, quebrachitol and inorganic ions. Effluent from latex concentrate producing factories gives the highest content of total solids, COD, BOD and nitrogen, because of the large amounts of non-rubbers presented and the chemicals added during its processing.

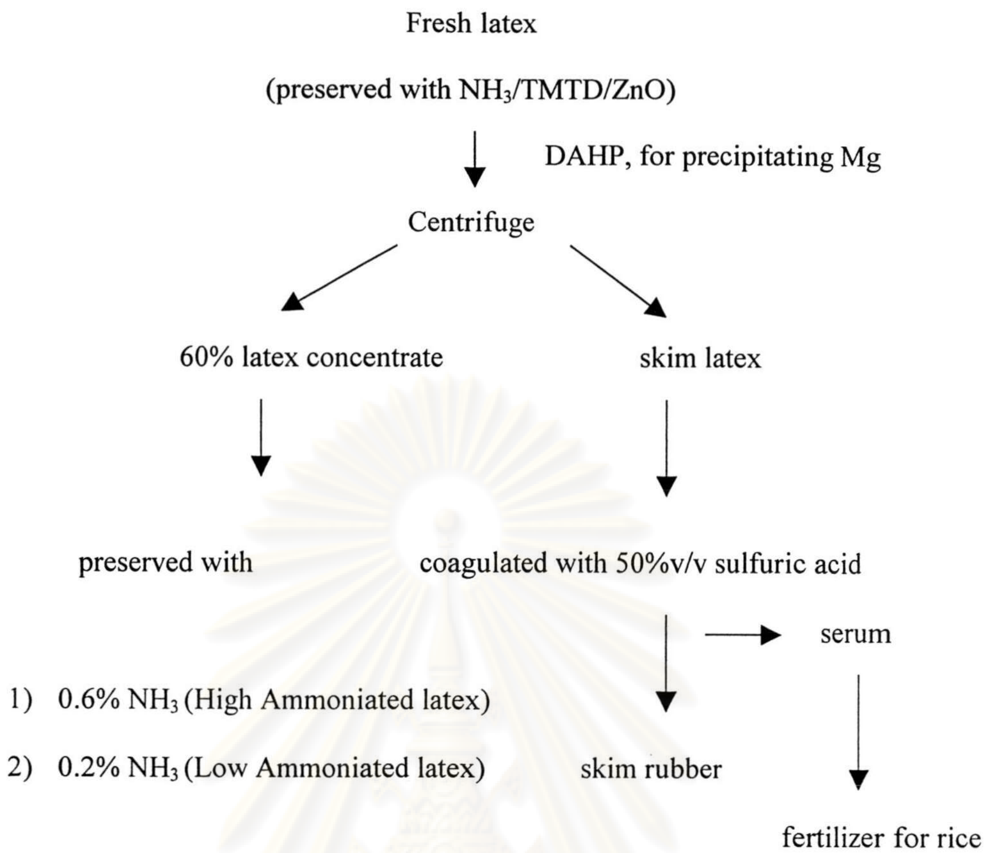

Figure 1.2 Latex concentrate production by centrifugation and serum from skim latex coagulation

Skim serum, an unwanted by-product of latex concentrate production, is normally disposed to the nearest stream. This procedure not only tends to aggravate stream pollution but also represents a direct loss to the land of valuable plant nutrients. Undiluted skim serum from the coagulating tank varies a little in composition, but usually contains about 4% total solids, including 0.26% ammoniacal nitrogen in the form of ammonium sulphate, 0.09% protein nitrogen, and some 0.2% potassium (Rubber Research Institute of Malaya [RRIM], 1959). Chemical composition of latex serum are shown in Table 1.1.

Since natural rubber serum contains various water-soluble materials, it will increase the biological oxygen demand (BOD) and the chemical oxygen demand (COD) content of a river if it is directly discharged into the river without any treatment. So far, effluent treatment ponds do not give a satisfactory solution to this pollution problem, therefore, an alternative approach is recovering the non-rubber substances from natural rubber serum and developing useful applications from them.

Utilization of the rubber serum to yield valuable substances can reduce the cost of effluent treatment or even generate additional revenue for rubber factories.

Table 1.1 Chemical composition of latex serum

Property	Average[a] (ppm)	Average[b] (ppm)
pH	4.77	-
Total Solids	42,550	-
Volatile Solids	36,410	-
Suspended Solids	2,850	-
Chemical Oxygen Demand	32,690	-
Biological Oxygen Demand	13,670	-
Total Nitrogen	4,620	5,700
Ammoniacal nitrogen	3,430	-
Albuminoid nitrogen	755	-
Nitrate nitrogen	3	-
Nitrite nitrogen	1	-
Total sugars	500	-
Reducing sugars	409	-
Al	1.6	-
Ca	6.0	2.15
Cu	4.0	0.04
Fe	2.0	1.45
K	618	1,070
Mg	61.0	2.74
Mn	0.6	0.07
Na	11.0	-
P	61.0	890

Source: a. RRIM , 1974 cited in RRIM training manual an analytical chemistry latex and rubber analysis: 201 b. Parasilp, 2000

Some proteins in natural rubber latex and products can cause allergy type I in hypersensitive users, which could be life threatening, thus there were many attempts to deproteinize protein in latex such as treatment of latex by enzymes. Deproteinized serum should contain more degraded peptides and amino acids comparing to conventional serum plus some stabilizing chemicals such as sodium dodecyl benzene sulfonate (SDBS) and Triton X 100, and therefore may be useful as fertilizer. The production of deprotenized latex concentrate (Boonjawat et al., 2000) is illustrated in Fig. 1.3.

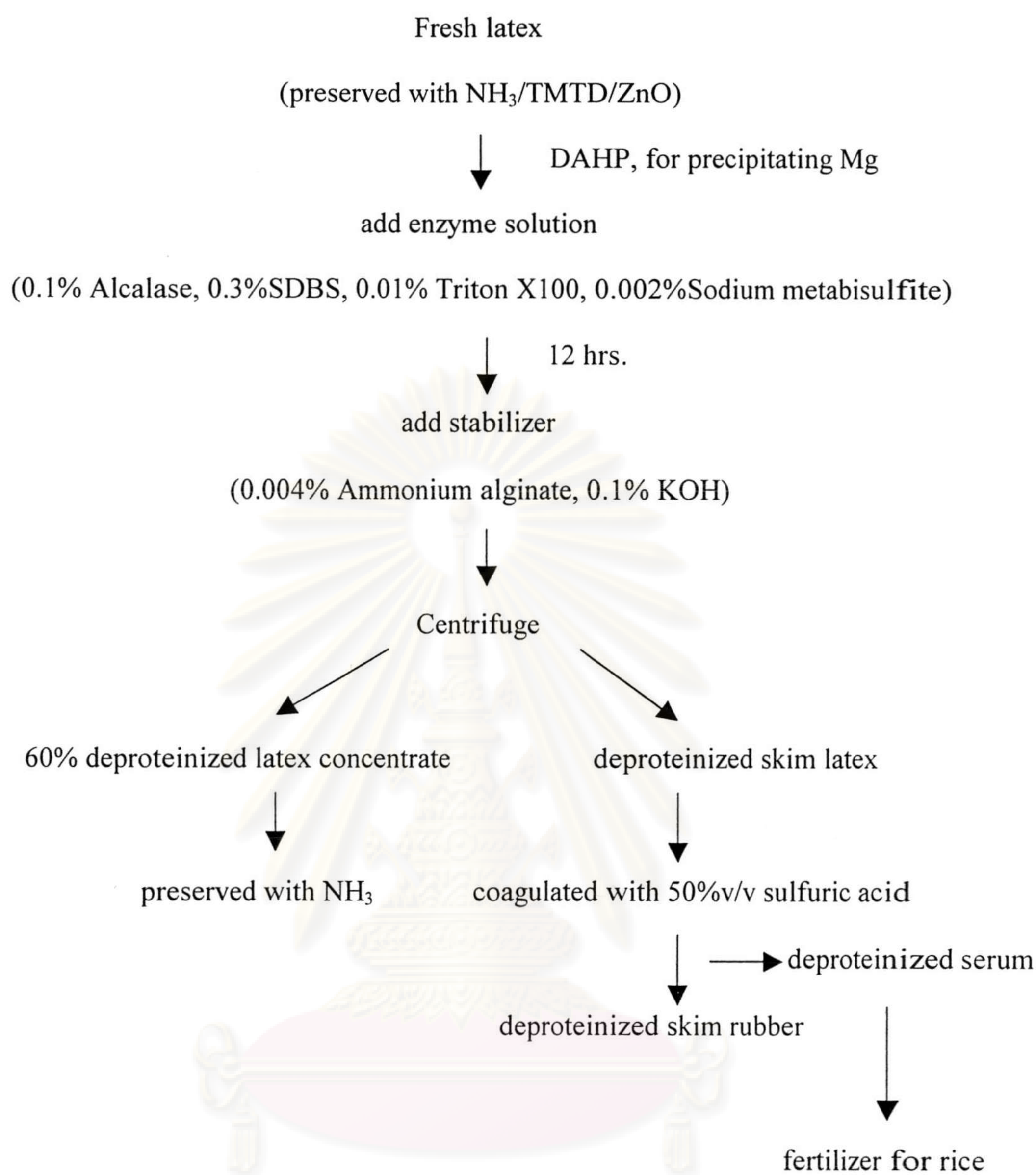

Figure 1.3 Deproteinized latex concentrate production by centrifugation and deproteinized serum from skim latex coagulation

1.4 Application of natural rubber serum and effluent from rubber factory

1.4.1 Fertilizer application

RRIM (1975) reported that if effluent from latex concentrate factories is properly diluted, it could be a useful source of nitrogen for irrigated paddy fields. Hence, appropriate adjustments on nitrogen manuring of paddy fields using water containing rubber effluent can be beneficial to the farmer in cost savings in terms of nitrogenous fertilizer may be achieved. However, balanced phosphorus, potassium and magnesium fertilizer would be essential.

In 1977 John et al. reported the results of utilization of effluent from natural rubber processing factories in irrigated rice. The initial investigation showed that where the irrigation water mixed with the effluent was continually changed at weekly intervals, high concentration was found to be detrimental. In the two soil media tested, i.e. sand and Selangor series, dilution of the effluent to 25% strength gave the best results. In a subsequent investigation, 5% serum in 95% water gave almost similar dry matter production as complete nutrient solution though the number of tillers was somewhat lower. However, there was a definite increase in the number of tillers and the total dry weight by increasing the concentration of serum applied from 1 to 5%.

Karim and Bachik (1989) reported that there was no significant difference in latex yield produced by the effluent-treated rubber seedlings and the fertilizer-treated seedlings. Soils treated with rubber effluent had higher nutrient contents than fertilizer-treated soils but rubber seedlings grown on fertilizer-treated soils had higher leaf nitrogen contents than those grown on effluent-treated soils.

Lau, Subramaniam and Tajima (1989) reported the results of using concentrated natural rubber serum, a formulation with a $N:P_2O_5:K_2O$ content of 8%:8%:8% as a fertilizer on a variety of vegetables. It was found that the natural rubber serum fertilizer had good potential for use on leafy vegetables such as spinach (bayam), where higher yields (of as much as 76%) were sustained by the natural rubber serum fertilizer compared with those of the compound NPK fertilizer. The plants grown on the natural rubber serum fertilizer were also noticeably healthier and bigger.

Malaysian Agriculture Research and Development (MARDI) also determined the efficacy of NRS fertilizer as a nutrient source for vegetables grown on various types of soils in Malaysia and concluded that NRS fertilizer when applied at the same equivalent nutrient level as the inorganic NPK control, and used in combination with chicken dung gave the highest yields for sawi (*Brassica juncea*) tested on both sandy soil and inland mineral clay-loam soil. MARDI has tentatively agreed that 1500 kg/ha of NRS fertilizer with 3 tons/ha of chicken dung can be used for sawi on inland mineral soil.

Kadir (1994) reported that besides nitrogen, phosphorus and potassium, natural rubber serum fertilizers contain special saccharides and proteins, which have been found to promote the absorption of not only nitrogen and phosphorus but also potassium by plants. They also stimulate the production of sugar in fruits thereby giving them a better taste (Lau, Subramaniam and Tajima, 1989). The fertilizers are also totally environment friendly and have been well-accepted for use on golf courses in Japan.

1.4.2 Nutrient for various micro-organisms

Taysum (1966) found that good growth of straw mushroom (*Volvaria esculents*) and button mushroom (*Psalliota campestris*) was obtained in four days when grown in SMR block rubber waste serum at ambient temperature. Similar growth was also obtained from an unidentified Australian edible muchroom.

Phang (1990) reported that utilization of the effluents for algal production could transform the nutrients into a beneficial product. Algae generated in high-rate algal ponds can be used as protein and vitamin-rich animal feed. Valuable chemicals like lipids and carotenoid can be extracted from the algae.

Hunpongkittikul (1991) reported that *Chlorella*, *Scenedesmus* and *Spirulina* could grow in the effluent from rubber processing and could rapidly reduce BOD and COD.

Bakti and Karim (1992) studied the aerobic growth of *Schizosaccharomyces sp.* on skim latex serum. The maximum yeast concentration of about 7 g/litre serum was reached after 30 h of cultivation on sulphuric acid coagulated serum and after 48 h on formic and sulphuric acid coagulated serum. The average specific growth rates for the yeast grown on formic and sulphuric acid coagulated sera were 0.027 h^{-1} and 0.056 h^{-1}, respectively. Irrespective of the type of skim latex serum used, the chemical oxygen demand reduction after four days of batch cultivation was about 80%, indicating yeast cultivation can be used to treat rubber effluent.

Kadir (1994) reported that natural rubber serum powder (NRSP) which contains 16.5 wt.% soluble organic nitrogenous compounds, 28 wt.% soluble non-nitrogenous compounds, 18.5 wt.% ash materials, and 2 wt.% water promoted growth of a wide variety of bacteria and yeasts, and provided a nutrient capacity equivalent to that of yeast extract. Also, when NRSP was used alone or as an enzymatic decomposition product, it could function as a part of the fermentation medium and supported the culture of both aerobic and anaerobic bacteria. Fermentation studies have therefore shown that NRSP is a unique culture medium for microbial studies and has an effectiveness almost equivalent to that of yeast extract.

1.4.3 Pharmaceutical-grade chemicals

Hevea latex normally contains 1 to 5% (w/w) of non-rubbers. The largest single component of water-soluble substances is a carbohydrate of the cyclitol family called quebrachitol. Comprising about 23% by weight of the total non-rubbers, quebrachitol which is also chemically called 1L-(-)-2-O-methyl-chiro-inositol, occurs naturally in *Hevea* latex. quebrachitol offers great potential as a chemical feedstock for the synthesis of a range of bio-active materials. Being a carbohydrate and possessing a unique and chiral structure, quebrachitol has several advantages that can make it attractively useful to pharmaceutical drug manufacturers, particularly those who are using carbohydrate chemistry and are contemplating on the switch to chiral drugs (Mun, 1996). Inositol derivatives are connected to the mechanism for the transmission of information between living cell, a process which is referred to as "cell-signalling". For example, it has been disclosed recently that inositol-

1,4,5-triphosphate, which is a decomposition product from inositol phospholipid and diacylglycerol plays an important role as "second messengers" in the cell-signalling mechanism. It is thought that by suitable chemical modifications, some inositol derivatives might be able to function as an anti-cancer drug, antibiotic or as an enzyme-inhibitor (Ozaki and Watanabe, 1989).

Recently, a process of concentrating and recovering the non-rubber solids present in the serum was developed. The process of concentrating the serum and converting it into a powder is energy intensive. If the serum can be directly utilized without the need to concentrate and/or convert it into a powder, the processing cost can be lower. A promising approach to the direct utilization of skim latex serum is in the using as rice fertilizer in the form of liquid.

1.4.4 Medium for fish culture

John (1975) reported that the stabilization pond used in treating effluent from the block rubber factory is suitable for the propagation of a variety of freshwater fish. They derive their food mainly by feeding on green algae, which thrive well under Malaysian climatic conditions. *Tricipodus leeri* starting from only a few grams, grew to about 35 g in six months. *Clarias* sp. grew from about 10 to 85g in four months

1.5 Rice (*Oryza sativa* L.)

Rice is an importance staple food as leading food sources for humankind. It has been estimated that half the world's population subsists wholly or partially on rice. Although rice is grown in 112 countries, about 95 percent of the crop is grown and consumed in Asia. Rice provides fully 60 percent of the food intake in Southeast Asia and about 35 percent in East Asia and South Asia. Rice is the only major cereal crop that is primarily consumed by humans directly as harvested.

Rice is an annual grass belonging to the family Graminae, the same family as barley, oats, rye and wheat and sharing many of their characteristics. The rice genus is *Oryza*. Its origins go so far back into antiquity that they will probably never be traced with certainty. The two cultivated rices are *O.sativa* of Asia and *O.glaberrima* of West Africa. *Oryza* also includes 20 wild species, which are scattered in Asia, Africa, Australia and Central and South America.

Rice can be grown in various environments. It originated in the hot, humid tropics, where monsoon rains and floodwater create and aquatic environment for at least part of the year. Rice is cultivated in cool climates high in the mountains of Nepal and India and in the hot deserts of Pakistan, Iran and Egypt. It is grown as a dry-land drop in parts of Asia, Africa and Latin America. At the other extreme of cultivation are floating rice, which thrive in floodwaters three meters deep in parts of Bangladesh, Burma, eastern India, Thailand and Vietnam. Rice adapts well to diverse growing conditions and performs better than other grain crops in areas with unfavorable saline, alkali and acid sulfate soils. On the basis of this characteristic, the Food and Agriculture Organization has predicted (in *Land Resources for Populations of the Future*) that in coming decades rice culture will expand in several countries.

Over the millenniums the cultivated species of Asia (*O.sativa*) differentiated into three subspecies based on geographic conditions. They are indica, japonica and javanica (Tatsongchan, 1999). A further classification, which emphasizes the habitat in terms of soil and water, is rainfed lowland and upland rice and irrigated and deep-water rice. Indica rices were originally confined to the humid regions of the Asian Tropics and subtropics. Japonicas type were cultivated in subtropical temperate zone regions. Javanicas type flourished in the equatorial region of Indonesia.

The production of rice in the world is 591.01 million tons, crop year 2000/2001. (Supawan and Pattanapan, 2002). Thailand has the total land area about 51.4 million ha. Rice is regarded as the main crop occupying 9.6 million ha. Available statistics suggest that domestic rice production of Thailand has expanded over the past ten years. The production of major and second rice in Thailand is about 25.608 million tons, crop year 2000/2001. (Office of Agricultural Economics [OAE], 2001).

The lowland soil in Thailand, which comprises 60% of the total arable land, has been used for growing paddy rice for centuries with only slight replenishment by fertilizers. Furthermore, a vast area of the paddy field in Thailand is covered with problem soils, which are poor in fertility, such as acid sulfate soils, red-yellow podzolic soil (Utisol). Consequently, the soil fertility status is relatively low, and the yield per hectare of paddy is the lowest among the ASEAN countries (Vacharotayan and Takai, 1983). Rice production conventionally increases by proper use of fertilizer and introduction of new improved varieties, which highly respond to nitrogen fertilizer. Chemical fertilizer is necessary and widely used by the Thai farmer. Nitrogen and phosphorus are two important macronutrients normally found limiting the production of good rice yield. The application of fertilizers should increase the yield of paddy. However, rate of chemical fertilizers applied by the farmer is still lower than the rate of recommendation due to the high cost of fertilizers that farmer cannot afford. So, the nation average paddy yield is rather low compared with other rice producing countries.

Fertilizers cannot be produced to meet local demand and must be imported; besides, supplies are unreliable and subject to a shortage at any future time due to the depletion of the world's fossil deposits. The organic fertilizer also plays vital role for better production and becomes the alternative source of essential plant nutrients. Therefore, the need for increase paddy yield by using combination of chemical fertilizer and organic fertilizer were recommended.

Normally, there are two types of rice variety, photoperiod-sensitive and the photoperiod-insensitive cultivars. The characteristic of the photoperiod-sensitive cultivars are generally tall in excess of 150 cm, vigorous growing, leafy, profuse tillering, sensitive to photo period to initiate flowers, lodging susceptible and poorly responsive to nitrogen fertilizer. It can be grown only in traditional wet season rice system and most of them are limited yield potential. However, they still have ability to produce a moderate but stable yield under adverse conditions such as relatively drought, in saline soil, deep water and intense weed competition. Photoperiod-insensitive varieties are mostly high yielding and nitrogen responsive. They have early vegetative vigor, relatively high tillering ability, erect growing leaves, short sturdy stems that resist lodging. These varieties are also possible for increasing the total rice production by double cropping in the dry season under irrigation.

A large quantity of rice is produced in many areas worldwide to meet the demand of consumers. In fact, aromatic rice varieties are very popular in Southeast Asia. Recently, they have gained a wide acceptance in Europe and the U.S.A. One of the major aromatic varieties, Khao Dawk Mali 105, is mainly produced in Northeast Thailand. It is the most popular photosensitive cultivar of Thailand. The demand for this variety is increasing in both domestic and international markets due to the recognition of its good cooking quality, i.e. pleasant aroma. SPR 1 is the non-photosensitive cultivar, which is mainly planted in central part of Thailand. The prominent characteristics are high tillering ability, highly response to fertilizer and resistant to many diseases such as blast disease, yellow orange leaf disease, bacterial leaf blight disease and brown plant hopper. Major characteristics of the two rice varieties used in this experiment are compared in Table 1.2.

Table 1.2 Characteristics of Suphan Buri 1 (SPR 1) and Khao Dawk Mali 105 (KDML 105).

Characteristics	SPR 1	KDML 105
Photoperiod sensitivity	non sensitive	sensitive
Aroma	non aromatic	aromatic
Height	125 cm	140-150 cm
Maturity	120-125 days after transplanting	ripening date Nov.20
Average yield/rai	806	515
Response to fertilizer	high	low

1.6 Fertilizer

Fertilizer means organic substance, synthetic organic substance, inorganic substance or microorganism either from natural resources or production that used for plant nutrient. Fertilizer makes chemical, physical or biological changes in soil to promote plant growth. It can be separated in two groups; chemical fertilizer and organic fertilizer.

World fertilizer production has increased by over 60 times in the course of the 20[th] century. In the last 35 years alone, it has increased by 4 times to reach 136 million tones of nutrients. All fertilizers used in Thailand in the past have been imported both in the form of formulated compound fertilizers (NP and NPK) and straight fertilizers. In January 2002, total chemical fertilizer import of Thailand was 125,798 metric tons (OAE, 2002). Generally, Thai farmers cannot afford to use the recommended fertilizer rates, due primarily to high fertilizer cost and low crop prices. (Osotsapar, 1995).

After a downturn in 1997/98 (refer to 1997) due to the economic crisis and El-Nino-related drought, fertilizer consumption in Thailand recovered strongly in 1998/99 (refer to 1998) and reached a new record level of 1.7 million tons nutrients (Fig. 1.4). A similar trend could be observed in fertilizer imports, which grew by 8.4 per cent during the same period. The recovery of fertilizer use could be attributed to improved weather conditions, higher prices of agricultural products partly due to the Thai devaluation and strong export demand, renewed government support for agriculture as the driver of economic growth, and increased local fertilizer production due to the commissioning of several new NPK plants.

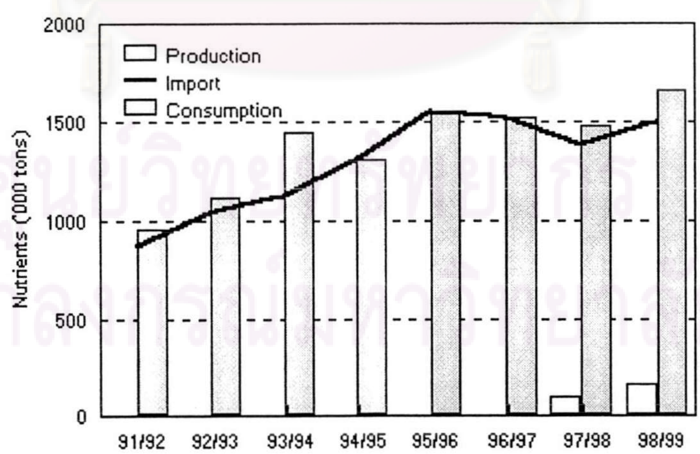

Figure 1.4 Fertilizer trend in Thailand

Source: FADINAP's Agro-chemicals News in Brief, Special Issue, December 2000 cited in http://www.fadinap.org/Thailand/indicators.htm.

The situation changed very dramatically in 1999 as prices of agricultural products, particularly, rice and tapioca, fell significantly due to over production from the previous year and low prices on the international market. This occurred while prices of imported agricultural inputs, such as fertilizers and pesticides, soared as a result of the Baht devaluation. Consequently, Thai farmers and farm cooperatives suffered huge losses and became heavily indebted.

Investigation and research to increase rice yield in Thailand has been carried out since 1940. During this time most of the works have been academic in nature and detailed experiments have been conducted in the rice experiment stations. Between 1960 and 1970, these experiments were continued and large pilot demonstrations were also conducted in the selected fields. Ammonium phosphate (16-20-0), which was used in the pilot demonstrations, was found to be profitable to increase rice yields. The amount of 16-20-0 fertilizer imported into Thailand has therefore increased considerably since 1966. In January, 2002 Thailand imported 125,798.04 metricton of chemical fertilizer, which 6,600 metricton is in the form of ammonium phosphate 16-20-0.

Production of supplemental nitrogen by industrial techniques has relied heavily on fossil fuels since its inception. Rising costs of these fuels indicate that the cost of industrially fixed nitrogen will continue to increase. Despite their advantages, however, chemical fertilizers have serious drawbacks. The main side-effects are on soil life and water quality (Oelhaf, 1978). Use of organic sources of nitrogen is feasible where these materials are available in sufficient quantities. Nitrogen release for plant absorption from these nitrogen sources is not instantaneous and is dependent on bacterial action in the soil to convert the nitrogen to a usable form. Soil chemistry of nitrogen is strongly tied to soil microbiology and essentially all nitrogen oxidation-reduction reactions in the soil are a result of microbial action (Follett, Murphy and Donahue, 1981).

Although higher plants have the capacity to utilize organic N, the major sources for N acquisition by roots are considered to be NO_3^- and NH_4^+ (KronZucker, 1999; Lægreid, Bøckman and Kaarstad, 1999). The main forms of inorganic nitrogen absorbed and used by plants are ammonium nitrogen (NH_4-N) and nitrate nitrogen (NO_3-N). The nutritional effect of these two forms of nitrogen on plant growth greatly varies depending on plant species. Plant species can broadly be classified into two groups: those whose growth is promoted when using NH_4-N as a nitrogen source (ammonia plants), and those whose growth becomes vigorous when using NO_3-N as a nitrogen source (nitrate plants). Representative ammonia plants include paddy rice and tea, while tomato, tobacco, Chinese cabbage and spinach are typical nitrate plants. The influence of the two nitrogen forms on paddy rice varies according to its growth stage: NH_4-N is more effective at the vegetative stage, while NO_3-N displays a better effect at the reproductive stage (Chanh, 1981; Matsuo et al, 1995). De Datta and

Magnaye (1969) also surveyed nitrogen fertilizers for rice and concluded that those supplying ammonium nitrogen were about equally effective in terms of grain yield response but noted that nitrate sources were unsatisfactory for preplant treatments because of denitrification losses of nitrogen.

From the above data it can be seen that the latex serum is potentially a large source of several nutrient for plant. NH_4-N is the major element found in latex serum and is appropriate for rice plants, which is the ammonia plant. Investigation of the effect of latex serum on growth and yield of rice plants should be performed. If possible, it can reduce chemical fertilizer use and at the same time reduce wastewater from rubber factory.

The aim of this research is to evaluate the utilization of conventional serum or control serum and deproteinized serum as fertilizer in two rice cultivars: Suphan Buri 1 (SPR 1) which is highly responsive to fertilizer and Khao Dawk Mali 105 (KDML 105) which is an aroma rice with low responsive to fertilizer. The effects of latex serum on nutrients content of plant and soil were also investigated. Experiments were carried out with the following steps:

1. To study the effects of control serum (CS) and deproteinized serum (DS) on growth of rice cultivar Suphan Buri 1 and Khao Dawk Mali 105 at seedling stage in hydroponic culture.
2. To study the effects of CS and DS on growth and yield of rice cultivar Suphan Buri 1 and Khao Dawk Mali 105 under greenhouse experiment.
3. To investigate the effects of latex serum on chemical composition of rice plant and soil.