

## THE IMPORTANCE OF CHEMICAL ENGINEERING AND THE CHEMICAL INDUSTRY IN THE ECONOMY OF SRI LANKA

W.J.N. Fernando

*This evaluation of the requirement and demand for chemical engineers and the extent of involvement of chemical engineering in Sri Lankan Industries was carried out by Dr. W.J.N. Fernando, Head of the Department of Chemical Engineering, University of Peradeniya.*

*His survey reveals that at least 45 percent of chemical engineering operations are presently carried out by teams of chemists and mechanical engineers. This situation which has arisen as a result of the shortage of chemical engineers is shown to be unsatisfactory. Capacity under-utilization of Sri Lanka's chemical and allied industries is partly attributed to the lack of chemical engineering expertise in such industries. Contributions which could have been made to the national economy by way of improvement of capacity utilization and saving of power and fuel of the existing chemical and allied industries if the necessary chemical engineering expertise were available is shown to be substantial.*

*The important role of the chemical industry within and outside the Greater Colombo Economic Commission; and the potential of participation of the chemical industry and the chemical engineering profession in the future development of Sri Lanka is also discussed.*

### INTRODUCTION

During the inception of the profession of Chemical Engineering in the developed world, Chemical Engineering has been defined as the combination of disciplines of Chemistry and Mechanical Engineering. Consequently, Chemists and Mechanical Engineers are regarded as a sufficient substitute for Chemical Engineers. However this has been proved to be a fallacy long time back in industrialised countries. (1)

A commonly known process of manufacturing sugar from sugar cane can be taken as one of the examples to illustrate this fallacy. A Chemist, whose work is usually confined to a laboratory in a research/teaching organisation or in an industry obtains sugar juice by crushing and squeezing a few pieces of sugar cane. Sugar is then produced by evaporating sugar juice in a vessel. Under proper controlled conditions sugar crystallizes out. Study of molecular composition and crystal structure form part of

their work. For the Chemist, the energy for the evaporation which is usually obtained by a lighted bunsen burner or an electric element is quite abundant. He is not concerned of the efficiency or the economy of extraction of the juice.

However, industrial production of sugar needs much more skills and machinery than those mentioned above. A shredder or a crusher and several pressure mills are needed to extract the juice from the sugar cane. Conveying equipment for transport of sugar cane, pulp and syrup are needed. The juice which flows in large quantities is usually clarified by means of chemical treatment and settling in order to remove impurities and suspended matter. Settling is usually carried out in settling chambers.

The clarified liquor is then evaporated and crystallized. Some of the streams are recycled for better recovery of products and energy.

Mechanical Engineers are needed for this production process in order to design, operate and maintain mechanical equipments such as power drives, boilers, heat exchangers, coolers. The scope of a Mechanical Engineer usually does not embrace operations of equipment such as crystallizers, evaporators, clarifiers, settlers, extractors and also of recycle streams.

So it can be seen that a gap exists between the expertise needed for a sugar industry in addition to the expertise contributed by Chemists and Mechanical Engineers. This is the case in nearly all Chemical and allied industries. The gap can be termed as Chemical Engineering.

The definition of Chemical Engineering has varied from one institution to another and from one country to another. It would be appropriate if Chemical Engineering is defined as that part of Engineering other than Mechanical/Civil/Electrical/ Production or any other defined branch of Engineering encountered in Processing/Manufacturing industries in which physical and or chemical changes occur within the processes.

### CHEMICAL ENGINEERING IN RELATION TO SRI LANKA Present Position

Chemical Engineering embraces a wide range of engineering operations known as unit operations (1). A survey was carried out by the Department of Chemical Engineering of the University of Peradeniya in order to evaluate the importance of Chemical Engineering operations and their national importance. Table 1 shows a list of important Chemical Engineering operations and their relative national importance in Sri Lanka as evaluated by the survey.

The survey showed that approximately 45% of the Chemical Engineering operations in Sri Lanka are being carried out at present by teams of Chemists and Mechanical Engineers. As a result,

TABLE 1

**RELATIVE IMPORTANCE OF  
SOME CHEMICAL ENGINEERING  
OPERATIONS**

Operation	Estimate as a Percentage
1. Cooling/Air Conditioning	9.49
2. Feed/Effluent treatment	9.31
3. Solids treatment	8.58
4. Heat transfer	8.17
5. Drying	7.21
6. Filtration	6.91
7. Evaporation	6.22
8. Mixing/Agitation	5.87
9. Conveying	5.37
10. Centrifugation	5.01
11. Fluidisation	4.27
12. Chemical reaction	3.41
13. Boiling	2.92
14. Ion exchange	2.20
15. Sedimentation	2.17
16. Thickening	2.12
17. Absorption	2.10
18. Distillation	2.00
19. Bio-chemical reactions	1.96
20. Crystallization	1.88
21. Extraction	1.54
22. Adsorption	0.64
23. Flotation	0.35
24. Osmosis	0.30

malfunctioning of equipment without proper care and maintenance, underutilization of equipment, wastage of energy and other resources due to unawareness or incapacities could be expected from our Chemical and allied industries.

**Production Aspects**

Table 2 shows the percentage utilization of capacities of our industries for years 1976 to 1982 (both years inclusive).

Out of these, industries belonging to categories 1, 4, 5 and 6 could be regarded as industries of Chemical and allied nature.

The value of industrial production for these four categories of industries over the above period are shown in Table 3.

Table 4 shows the additional production capabilities of our Chemical and allied industries for each of the years 1976 to 1982. This analysis shows that products of Chemical and allied nature worth Rs. 22,313 million which could have been produced in Sri Lanka for the seven year period 1976-1982 (inclusive) had not been produced due to under-utilization of our Chemical and allied industries. In 1982 alone this amounts to Rs. 5,954 million this is 5.9 percent of the gross domestic product of Sri Lanka in 1982.

The capacity under-utilization of Chemical and allied industries can be attributed to the following reasons.

1. Unavailability of raw materials and energy.
2. Short of markets for products.
3. Malfunctioning of machinery or deterioration of machinery to production rates lower than designed values.
4. Lack of expertise for proper care, maintenance and development of machinery.

If factors (3) and (4) are assumed to be equally responsible for under-utilization as much as factors (1) and (2) then it could be argued that an extra production of at least Rs. 2977 million (i.e. 50% of Rs.

5954 million) could have been achieved in 1982 if the necessary expertise were available for the existing Chemical and allied industries. The figure could be of the same order or of larger magnitude in 1983. The overall figure for the seven year period 1976-1982 (inclusive) is Rs. 11,156.5 million.

Table 5 shows the values of industrial production of Sri Lanka for the seven years 1976 to 1982. Items 1, 4, 5, and 6 being Chemical and allied industries represent 76.1, 77.7, 77.5, 79.0, 81.6, 79.9 and 78.9 percent of the gross industrial production in each of the years 1976 to 1982 respectively.

**Energy Aspects**

Equipment associated with chemical industries usually consume large quantities of energies compared with other industries.

To demonstrate this fact, take the single unit operation of drying. Table 6 shows the production rates of six selected industries of Sri Lanka in 1983.

Products of these industries usually have to be dried through moisture contents of at least 40 - 60%. If 50% moisture content is taken as an average figure, amount of moisture evaporated by the six industries in 1983 estimates to at least 397,525.5 metric tonnes of water (i.e. 50 per cent of 795,051 metric tonnes).

If the latent heat of evaporation of moisture is assumed to be 2256.7 kJ/kg, the total energy requirement by the industries for evaporation alone amounts to at least 8.97 x 10<sup>11</sup> kJ. This amounts to 249 million kWh of energy. The power generated in 1983 by thermal power stations of the stations of the Sri Lanka Electricity Board amounts to 897.2 million kWh.

It is therefore seen that the energy consumed for the unit operation of drying for these six

**TABLE 2**  
**CAPACITY UTILIZATION IN INDUSTRY 1976 - 1982**

		% Utilization of capacity						
	Category	1976	1977	1978	1979	1980	1981	1982
1.	Food, beverages and tobacco	75	69	70	72	70	66	77
2.	Textile, wearing apparel and leather products	56	55	62	67	70	87	94
3.	Wood and wood products (including furniture)	45	71	78	84	89	81	92
4.	Paper and paper products	58	70	72	70	68	75	70
5.	Chemicals, petroleum coal, rubber and plastic products	66	61	67	65	79	76	77
6.	Non metallic mineral products (except petroleum and coal)	76	61	77	80	82	83	85
7.	Basic metal products	39	40	63	68	62	53	33
8.	Fabricated metal products, machinery and transport equipment	53	54	64	60	58	68	83
9.	Manufactured products n.e.s.	45	57	79	74	70	69	73

**TABLE 3**  
**VALUE OF INDUSTRIAL PRODUCTION OF CHEMICAL AND ALLIED INDUSTRIES**  
**(RS. MILLION) 1976 TO 1982**

	Category	1976	1977	1978	1979	1980	1981	1982
1.	Food, beverages and tobacco	1715	2295	2609	2856	3899	4496	5246
4.	Paper and paper products	203	270	376	445	476	626	725
5.	Chemicals, petroleum, coal, rubber and plastic products	2336	2469	3279	4508	9416	12105	13099
6.	Non metallic mineral products except petroleum and coal	360	411	592	710	1156	1250	1370

industries alone is about twenty eight percent of the energy generated by thermal power generating units of the Ceylon Electricity Board in 1983.

**TABLE 4**  
**ADDITIONAL PRODUCTION CAPABILITIES OF CHEMICAL AND ALLIED INDUSTRIES**  
**(RS. MILLION) 1976 TO 1982**

Table 7 shows the cost of power and fuel used by industries in 1982. It can be seen that a major portion of the fuels amounting to Rs. 1714 million have been used by Chemical and allied industries. This amounts to approximately 79 percent of the cost of the total energy consumed in 1982. The figure for the year 1983 should not be too different.

Modern researches and developments of unit operations have shown possibilities to reduce the energy requirements in respective operations. Savings up to 10-15% have been shown to be possible compared with the older unit operation equipment (6). As a result energy saving techniques if employed in existing operating could have yielded a national saving of around Rs. 170-250 million in 1982 alone.

Table 8 shows the estimated national saving which could have been made if proper expertise for Chemical and allied industries were available.

#### Overall Considerations

Therefore a national contribution of at least Rs. 300 million could have been made available in 1982, by way of increase of production and fuel saving if proper expertise in Chemical Engineering were employed in our Chemical and allied industries.

As a comparison of the magnitude of this figure, it represents approximately 11% of the total production in 1982. These figures should not deviate much for the years 1983 and 1984.

#### FUTURE TRENDS

##### Forthcoming Industries

In addition to the factors discussed earlier, other contributions which the Chemical Engineering profession could make available

Category	1976	1977	1978	1980	1981	1982	1983
1. Food, beverages and tobacco	426	711	783	800	1170	1529	1207
4. Paper and paper products	85	81	105	134	152	157	218
5. Chemical, petroleum, coal rubber and plastic products	794	963	1082	1578	1977	2884	4323
6. Non metallic mineral products except petroleum and coal	86	160	136	142	208	213	206
<b>Total</b>	<b>1394</b>	<b>1915</b>	<b>2106</b>	<b>2654</b>	<b>3507</b>	<b>4783</b>	<b>5954</b>

Grand Total : 22313 Rs. Million

**TABLE 5**  
**VALUE OF INDUSTRIAL PRODUCTION 1976 - 1982**

Category	1976	1977	1978	1979	1980	1981	1982
1. Food, beverages and tobacco	1715	2295	2609	2856	3899	4496	5246
2. Textile, wearing apparel and leather products	680	698	1008	1128	1923	3040	3863
3. Wood and wood products (including furniture)	129	127	124	166	289	315	361
4. Paper and paper products	203	270	376	445	476	626	725
5. Chemicals, petroleum, coal/rubber and plastic products	2336	2469	3279	4508	9416	12015	13099
6. Non-metallic products (except petroleum and coal)	360	411	592	710	1156	1250	1370
7. Basic metal products	138	132	219	349	478	428	262
8. Fabricated metal products, machinery and transport equipment	474	671	590	569	620	782	904
9. Manufactured products (n.e.s)	26	34	55	50	54	58	74
<b>Total</b>	<b>6061</b>	<b>7007</b>	<b>8852</b>	<b>10781</b>	<b>18311</b>	<b>23010</b>	<b>25904</b>

to the national development of the future depend on the forthcoming expansion and development schemes in the fields of Chemical and allied industries of Sri Lanka.

Table 9 shows the investment approvals contracted within the GCEC (Greater Colombo Economic Commission) for various categories of industries from 1979-1983. The investments made on already contracted Chemical and allied industries as a percentage of the total investment have been 21.6 percent for the whole five year period (1979-1983) and 28.2 percent for 1983 alone. The total investments approved and contracted was 3662 million rupees for the five year period. 790 million rupees have been allocated for Chemical and allied industries. Major Chemical industries for which agreements were signed in 1982 are the manufacturing project for phosphate fertilizer using Eppawala rock phosphate deposits. This is with the collaboration of Agrico Group of Companies of USA and the State Mining and Mineral Development Corporation of Sri Lanka. Another is the Sevaganala sugar development project with the collaboration of KCP Ltd of India and Sri Lanka Government. The annual capacity of the project was to be 27,000 t/y.

Other projects such as activated Carbon, P V C blown containers and oil palm have already taken off the ground prior to 1982.

The investments on Chemical and allied industries outside the GCEC have been substantial over the last five year.

Table 10 shows the total investments outside the greater Colombo Economic Commission approved by the foreign investments advisory committee for the five years 1979-1983. 43.5 percent of total investments for the five years up to 1983 and 44.9 percent of the total investment in 1983 have been for Chemical and allied industries. The total investment

**TABLE 6**  
**PRODUCTION RATES OF EIGHT SELECTED INDUSTRIES**  
**OF SRI LANKA IN 1983 (3)**

		Metric Tonnes
1.	Sri Lanka Sugar Corporation	22044
2.	National Paper Corporation	22262
3.	Ceylon Ceramic Corporation	44498
4.	Sri Lanka Cement Corporation	479568
5.	Tea	179300
6.	Desiccated Coconut	43529 (4)
	Copra	3850 (4)
	Total	795051

**TABLE 7**  
**COST OF POWER AND FUEL USED IN INDUSTRY 1982 (5)**

Category	Rs. Million
1. Food, beverages and tobacco	307
2. Textile, wearing apparel and leather products	314
3. Wood and wood products (including furniture)	26
4. Paper and paper products	232
5. Chemicals, petroleum, coal, rubber and plastic products	814
6. Non-metallic mineral products (except petroleum and coal)	361
7. Basic metal products	57
8. Fabricated metal products, machinery and transport equipment	41
9. Products n.e.s.	5
Total	2157

TABLE 8

ANTICIPATED APPROXIMATE NATIONAL SAVING IN 1982 IF PROPER  
CHEMICAL ENGINEERING EXPERTISE WERE AVAILABLE FOR  
EXISTING INDUSTRIES

	Rs. Million
1. Contribution with respect to proper utilization of capacity	2977
2. Contribution from saving power and fuel	170-250
<b>Total</b>	<b>3147-3227</b>

TABLE 9

INVESTMENT APPROVALS AND CONTRACTED WITHIN GCEC\* (RS. MILLION)

Category of Industry	Year				
	1979 <sup>(9)</sup>	1980 <sup>(9)</sup>	1981 <sup>(5)</sup>	1982 <sup>(4)</sup>	1983 <sup>(4)</sup>
1. Food, beverages and tobacco	-	45	-	-	-
2. Textiles, weaving apparel and leather products	180	934	153	128	91
3. Wood and wood products	-	2	-	-	-
4. Paper and paper products	-	-	-	-	-
5. Chemical, petroleum, coal, rubber and plastic products	-	86	55	79	20
6. Non metallic mineral products (except petroleum)	426	-	35	14	30
7. Basic metal products	-	-	-	-	-
8. Fabricated metal products, machinery and transport equipment	13	488	54	2	-
9. Other	-	134	196	461	36
<b>Total</b>	<b>619</b>	<b>1689</b>	<b>493</b>	<b>684</b>	<b>177</b>

\* Greater Colombo Economic Commission

being 5756 million rupees for four years and 1031 million rupees for 1983. Out of the 56 industrial projects approved in 1983, 29 projects have been in the Chemical and allied industries (4).

Table 11 shows the approvals by the local investment advisory committee for industries outside the Greater Colombo Economic Commission. 44.5 percent of the total investment for the five

year period and 58.8 percent for 1983 have been for Chemical and allied industries. The total investments being 2112 million rupees for the five years and 415 million rupees for 1983.

The total investments approved and contracted by GCEC and approved by FIAC and LIAC for the establishment of Chemical and allied industries have been 4537 million rupees.

#### Other Opportunities

Suitability of a given chemical industry for a particular country is determined by numerous, complex and interdependent factors. Most important of all is the market for the products envisaged. The market could be either national, regional or export.

The size of Sri Lanka national market is small. The country had sometimes already witnessed low efficiency, poor quality control and high prices as a result of conflict between small size market and the need for an efficient scale production of some industries (11). Leaving aside the possibility of small scale chemical industries at appropriate level for local markets, planning for export markets therefore become very essential for many of the future chemical industries in Sri Lanka.

The second governing factor which determines the setting up of future chemical industries in Sri Lanka is the availability of resources. Apart from Capital and manpower resources, availability of raw materials is a prime factor of importance. Sri Lanka being a country surrounded by seas, raw materials for chemical industries could be tapped from and across the seas around, in addition to resources from the ground beneath and skies above.

Resources from the ground are available from two main sources: the agricultural resources and minerals resources.

**TABLE 10 INVESTMENTS APPROVED BY THE FIAC\*\*  
OUTSIDE THE GCEC \* (RS. MILLION)**

Category of Industry	Year				
	1979 <sup>(9)</sup>	1980 <sup>(10)</sup>	1981 <sup>(5)</sup>	1982 <sup>(4)</sup>	1983 <sup>(4)</sup> (p)
1. Food, beverages and tobacco	77	650	229	258	235
2. Textiles, weaving and leather products	688	38	55	162	140
3. Wood and wood products	-	-	20*	7	123
4. Paper and paper products	12	-	-	-	-
5. Chemicals, petroleum, coal, rubber and plastic products	75	60	210	151	64
6. Non metallic mineral products (except petroleum and coal)	12	4	235	70	164
7. Basic metal products	-	-	-	136	242
8. Fabricated metal products machinery and transport equipment	97	264	362	-	-
9. Other	10	776	50	17	63
<b>Total</b>	<b>971</b>	<b>1792</b>	<b>1161</b>	<b>801</b>	<b>1031</b>

\*\* Foreign Investment Advisory Committee  
\* Greater Colombo Economic Commission  
p provisional

Chemical and allied industries which could be based on agricultural resources are (12).

- (1) Food and beverages industries
- (2) Tea, rubber and coconut products industries
- (3) Pulp and paper industries
- (4) Essential Oils industries
- (5) Tans and Dyes industries
- (6) Oils and Fats industries

(7) Gums, resins and oleo-resins industries

(8) Sugar and Alcohol industries

(9) Indigenous medicine manufacture industries

(10) Industries based on agricultural wastes

The main chemical industry associated with food and beverages in Sri Lanka has been the processing and canning of fruit juices and canned fruits. It is anticipated that the exports of products of this industry would increase by 47.6

percent from 1983 to 1987 in value (11). The anticipated increase of exports of instant tea is 200 percent during the same period (11). The increased earnings from exports of desiccated coconut, and shell charcoal/activated carbon envisaged during the above period are 3 percent and 58.1 percent respectively.

Products from rubber which have good export potential has now been identified (11). Manufacture of household rubber gloves, non-industrial rubber footwear, bicycle tyres and tubes, rubber hose and rubber protective clothing and moulded products has been identified as viable export oriented rubber based chemical industries of the future (11).

It is anticipated (11) that a growth rate of 35 percent be maintained for export of essential oils. Such growth of the essential oil industry will be necessary as value added products such as extracts, tinctures and essential oils would enhance Sri Lanka's export earnings rather than by export of raw materials.

The export market of soap and allied products is expected to increase (11) from Rs. 10 million in 1983 to Rs. 40 million in 1987. The glycerine export market depends on the future improvements of technology of production of glycerine and the quality of production. However, with the increase in manufacture of soap, the exports of glycerine could be reduced.

During the years 1977 to 1983 sugar imports have risen by 703 percent by value (4). paper and paper products imports

have risen by 187 percent by value. It is therefore seen that additional sugar and paper industries could become worthwhile industries for the future.

Out of chemical industries based on Minerals, the joint venture project for the manufacture of phosphatic fertilizers envisages production of ammonium phosphate and triple superphosphate to the extent of 399,000 tonnes and 37,500 tonnes respectively in 1986 and 480,500 tonnes and 45,000 tonnes respectively in 1987. Production and export of wall tiles, porcelain and other products is to rise from 200 million rupees in 1983 to 473 million rupees in 1987. The total minerals exported from Sri Lanka in 1982 have been 48,893 mT of ilmenite, 1530 mT of Rutile, 3024 mT of graphite, 292 mT of mica and some metallic iron pyrites (5). It is a well known fact that beneficiated minerals are several folds valuable than the respective raw minerals. As a result, beneficiation projects for minerals will have to be given consideration. Such projects are basically chemical industries.

Out of the sea-based industries, it is reported that new ventures like the manufacture of refined salt and enhanced production of chlorine and caustic soda could be beneficial. The magnesium content of 0.13 percent of our sea waters is reported (7) to be promising for exploitation. Extraction of antibacterial agents from marine natural products could become viable.

Nitrogen based industries such as ammonia, nitric acid and ammonium nitrate can form part of the Chemical industries of the future.

One of the neglected areas in the development of chemical industries has been the field of manufacture of pharmaceuticals.

TABLE 11 INVESTMENTS APPROVED BY THE LIAC\*\* OUTSIDE  
GCEC\* (RS. MILLION)

Category of Industry	Year				
	1979 <sup>(9)</sup>	1980 <sup>(10)</sup>	1981 <sup>(5)</sup>	1982 <sup>(4)</sup>	1983 <sup>(4)</sup> (p)
1. Food, beverages and tobacco	103	34	32	15	61
2. Textile, wearing apparel and leather products	504	51	22	60	72
3. Wood and wood products	-	1	18	9	33
4. Paper and paper products	21	17			
5. Chemical, petroleum, coal, rubber and plastic	74	105	88	82	176
6. Non metallic minerals products (except petroleum and coal)	45	44	22	13	7
7. Basic metal products	-	3	-	52	66
8. Fabricated metal products machinery and transport equipment	123	64	69		
9. Other	5	18	3		
Total	875	337	254	231	415

\*\* Local Investment Advisory Committee  
\* Greater Colombo Economic Commission  
p - provisional

Manufacture of synthetic pharmaceuticals and pharmaceuticals from natural products are some possibilities. The import expenditures incurred by Sri Lanka for the four years 1979 to 1982 have been Rs. 135 million and approximately Rs. 34 million in each respective year (5). A large portion on this expenditure has been for the import of antibiotics. Since penicillin still holds the reputation of being a reliable antibiotic and since most other antibiotics can be manufactured with penicillin fermentation equipment with or without minor modifications and since capital investment in the antibiotic industry seems to be safe and markets stable (8), such industries could become worthwhile chemical industries in the future.

Use of alternate sources of fuel and utilization of energy saving techniques in chemical and

agricultural processing industries could be considered useful in order to curb the rising costs of production in such industries. Introduction of fluid bed drying techniques for tea is an example of an emergence of this trend in the agricultural sector.

#### CONCLUSION

From the above analysis it is seen that the chemical industry plays an important role in the overall production and economy of Sri Lanka at present. Approximately 79 percent of the industrial production accounts for production from chemical and allied industries. During the five year period 1979 to 1983, approximately 36.5 percent of the total investment within and outside GCEC has been envisaged for chemical and allied industries. It is also seen that possibilities for numerous chemical and allied industries exist for the future development of Sri Lanka. It is

also seen that the Chemical Engineering profession could play an active and important role in chemical and allied industries at present. However there exists a shortage of personnel in the field of Chemical Engineering.

#### REFERENCES

1. Ibl, N., 'Trends in Chemical Engineering' Eight Marchon Lecture, The University of Newcastle Upon Tyne, Ruari McLean. 1968.
2. Central Bank of Ceylon, Annual Report 1981.
3. Central Bank of Ceylon, The Bulletin June 1984.
4. Central Bank of Ceylon Annual Report 1983.
5. Central Bank of Ceylon, Review of the Economy 1982.
6. Potter, O.E., et al., Proc. 3rd Int. Symp. on Drying, 12-15 September 1982, Birmingham, U.K.
7. Herath, J.W., 'Mineral Resources of Sri Lanka' Economic Bulletin No. 2, Geological Survey Department, Colombo 1980.
8. Dryden, C.E., 'Outlines of Chemical Technology' Affiliated East-West Press, New Delhi, 1969.
9. Central Bank of Ceylon, Review of the Economy, 1980.
10. Central Bank of Ceylon, Review of the Economy, 1981.
11. Sri Lanka Export Development Board, 'National Export Development Plan 1983-1987' Vol. II, 1984.
12. Seneviratne, E.W., Proc. Int. Symp. on the Industrial Utilization of Tropical Products, Tsukuba 1980 pp. 156-220.