EXECUTIVE SUMMARY

0.1 PRODUCT AND APPLICATIONS

Vitamin C or L-ascorbic acid was first identified for its vigorous antiscorbutic activity which prevents and cures scurvy. Vitamin C was found to be present in citrus and other fresh fruits and vegetables. It was first isolated in 1928 by Szent Gyorgyi.

Vitamin C was first synthesized in a laboratory by Reichstein in 1932.

Vitamin C is being produced commercially since 1938, using basically the same Reichstein process, with some modifications over the years.

Sorbitol is the intermediate used in the manufacture of Vitamin C. It is fermented to sorbose. Sorbose is acetonized to diacetone sorbose. Diacetone sorbose is oxidised to diacetone 2 keto L gulonic acid, which is lactonized and enolized to get Vitamin C.

Sorbitol is manufactured by hydrogenation of dextrose solution. Dextrose solution is obtained by hydrolysis of starch.

Sorbitol is sold as 70% solution in water or as a powder. It has other applications in drugs and pharmaceuticals, food and cosmetics and manufacture of explosives, resins and varnishes.

Vitamin C is used in various pharmaceutical formulations, foods, agricultural applications and some industrial applications.

0.2 DEMAND - NATIONAL AND INTERNATIONAL

Demand for Vitamin C in the world went on increasing, first at a slow rate, and then at a high rate - upto 10% per year. At that time, it was claimed to be effective when taken in high doses, against common cold and in treating cancer, heart diseases, schizophrenia and in retarding aging. These claims are not yet fully accepted clinically and the present rise in demand per year in the world is about 3%.

The present world demand for Vitamin C is about 70,000 Tonnes per year and it is mainly met by the leading multinational, manufacturing companies such as M/s Hoffmann-La-Roche, M/s Pfizer and M/s Takeda. There are other comparatively small manufacturers in East European Countries, France, Italy, Denmark and The Netherlands. The average capacity utilization of Vitamin C plants in the world is about 70%.

In India, present demand for Vitamin C is of the order of 1,100 Tonnes per year and there are two manufacturers, namely M/s. Jayant Vitamins Ltd. Ratlam and M/s. Ambalal Sarabhai Enterprises Ltd. Baroda with respective plant capacities of 1,500 TPA and 430 TPA. However, the actual production of Vitamin C in 1991-92 was about 650 MT.

0.3 STATUS OF INDIAN INDUSTRY

The Indian manufacturers are operating at an overall efficiency (of conversion of sorbitol to Vitamin C) in the range of 44% to 48% which is only slightly lower than the world standard of 51%. However, their utility consumptions are on the higher side and the fixed cost is high due to lower production capacity.

0.4 INTERNATIONAL SCENARIO

The leading manufacturers of Vitamin C in the world are M/s. Hoffmann-La-Roche. M/s. Roche are not offering their technology to other countries. The overall efficiency of M/s. Roche is estimated to be about 60%. M/s. Takeda, Japan also are not offering their technology. Other manufacturers in Western Europe may offer their technology to Indian manufacturers. The technology generally available with these manufacturers is referred here as 'World Standard'. The overall efficiency is 50%. The manufacturers in East European Countries such as Czechoslovakia, Yugoslovakia, Romania and Russia are willing to offer their technologies. Two technologies available with Russia are presented in the report.

The world standard technology can be bought from Italy, France or Denmark. However, it will require huge investments and it will not be economical to import this technology for small capacity plants.

0.5 TECHNOLOGY GAPS

For setting up a large capacity plant India will have to export and compete with the world leaders such as M/s. Roche. Pfizer and Takeda. Though the present world price of Vitamin C is not very low,it will be very difficult for the Indian manufacturers to compete with the world leaders, with the available technology. Moreover, a breakthrough is expected in Vitamin C, as a result of concentrated research and development work on biochemical processes. This is likely to make the present technologies obsolete. It is understood that M/s. Pfizer have already implemented the biochemical route in their U.S. plant. Alternatives for ascorbic acid with similar antiscorbutic activity are also being explored.

It will be possible to upgrade the existing process, plant and utility generation, distribution and recovery system of Indian manufacturers to improve the efficiencies of some steps and to reduce energy consumption. This will reduce the cost of production considerably, with minimum additional investment.

In the long run, R & D efforts in the following areas will be useful:

(i) Electrochemical oxidation to diacetone keto gulonic acid.

(ii) Air oxidation of diacetone sorbose.

(iii) Biochemical process to get 2-keto-L-gulonic acid directly.

(iv) New applications of Vitamin C.

0.6 SORBITOL

The present Sorbitol production in the world is about 1.2 million tonnes per annum (TPA). The leading manufacturers are M/s. ICI, Archer Daniels Midland, Lonza, Hoffmann-La-Roche, Roquette, and Ethichem with total 2 million tonnes per annum capacity. In India the present demand is about 25,000 TPA, whereas the manufacturing capacity is 50,000 TPA. The small plants are not economically viable. At present there is no scope of export to the European countries, which was

thought of earlier, because of the low international price of sorbitol, levies etc. The prevailing international frice of sorbitol is much lower then the cost of production of Indian manufacturers.

There is scope to improve marginally on the catalyst, operating conditions, use of cheaper starting materials, efficiency of hydrogen generation/compression plant and drying of Sorbitol. A breakthrough is expected in sorbitol technology, employing direct hydrogenolysis of starch.

0.7 CONCLUSIONS

The demand for Vitamin C in the world is increasing at about 2% per year. This rate may not increase, unless new therapeutic or other applications of Vitamic C are invented. The manufacturing plants in the world, have excess capacity over the present demand.

In India, the present requirement is about 1,100 Tonnes per annum and the two manufacturing plants in operation have capacitites of 1,500 TPA and 430 TPA. The actual production of Vitamin C in the year 1991-92 was about 650 tonnes. The formulators of Vitamin C, were not getting the required quantity of Vitamin C, as the production was low. Moreover, manufacturers of Vitamin C were diverting their production to food grade Vitamin C.

The overall conversion efficiencies from sorbitol to Vitamin C of M/s. Jayant Vitamins Limited (JVL) and M/s. Ambalal Sarabhai Limited (ASEL) are 48.48% and 44.42% respectively, whereas the world standard is 50.85%. The efficiency of M/s. Roche is expected to be 60.60%. The overall efficiency of Indian manufacturers is lower only slightly than that of the world standard, but the consumptions of the utilities of Indian manufacturers are considerably higher.

The world leaders, such as M/s. Roche and M/s. Takeda, are not ready to offer their technologies as a policy. The technologies offered by East European Countries and Russia are not competitive. The world standard technology may be offered by European manufacturers. The plant

capacity of the present manufacturers is more than the indigenous demand. A new plant with new technology will have to aim for exports. However, it is necessary to have the best technology to compete in the international market. Hectic R & D work is pursued in the world, on direct bioconversion of glucose/sorbitol to 2 keto L gulonic acid - a precursor of Viitamin C. It is learnt that M/s. Pfizer have successfully implemented the biotechnology route in their California plant. This technology may make the prevailing technologies obsolete.

The immediate option available to Indian manufacturers will be to upgrade their process, plant and recovery systems, with minimum investment, so as to improve the overall conversion efficiency as compared to the world standard and also to reduce energy consumptions. These efforts can provide a good profit, at the present selling price.

R & D has to be initiated and pursued by Indian manufacturers and R & D institutes on possible R & D thrust areas, and biotechnology.

Small capacity sorbitol plants will not be economically viable. Higher capacity sorbitol plants can be marginally improved through indigenous efforts. The international price of sorbitol is much lower than the cost of production of Indian manufacturers. A breakthough in technology is needed, to enable the manufacturers compete in the world market.

0.8 RECOMMENDATIONS

1. There is no scope to have new sorbitol plants.

2. Indigenous sorbitol technology can be further improved by :

   (i) Developing better catalyst suitable for lower pressure and temperature conditions.

   (ii) Using cheaper starting material such as starch (or even maize or tapioca).

   (iii) Improving efficiency of hydrogen generation and compression.

(iv) Adopting sorbitol drying technology for better export possibility.

(v) Developing new applications of sorbitol.

3. Import of Vitamin C technology is not advisable at present.

Though import of available Vitamin C technologies from European manufacturers, seem to be economically attractive; it is not advisable, at present, as there is a possibility that these technologies may become obsolete after the emergence of the biotechnology route.

4. The Vitamin C plant should be upgraded by;

(i) Energy conservation measures.

(ii) Improving the catalyst for hydrogenation.

(iii) Designing better sorbose recovery system.

(iv) Replacing present enolisation-Lactonization process by the process employing sodium methylate solution.

(v) Improving solvent recovery systems.

(vi) Adopting better automation and process control.

5. R & D efforts are to be pursued on :

(i) Developing a catalyst and process to convert starch to sorbitol in a single step.

(ii) Recovery and reuse of catalyst in oxidation step.

(iii) Electrochemical oxidation of diacetone sorbose.

(iv) Air oxidation of diacetone sorbose.

(v) Biochemical process to get 2 keto-L-gulonic acid directly.

(vi) New applications of Vitamin C.