EXECUTIVE SUMMARY

0.1 HFCS, THE PRODUCT

High fructose corn syrup (HFCS) also known as isomerase syrup, isoglucose or synthetic honey is manufactured from starch obtained from grains like maize, jowar, rice and tubers like tapioca, potatoes, sorghum etc. HFCS is a concentrated solution containing primarily fructose and dextrose, with little quantities of higher molecular weight saccharides. High fructose corn syrup, as the name suggests, is the product obtained from corn starch specifically, which has proved to be an ideal substitute for cane-sugar in many applications, particularly for industrial uses. It can be used as a partial or complete replacement of cane-sugar or invert sugar in almost all food applications. It imparts sweetness, enhanced flavour, fermentable and humectant properties. Its various applications include soft drinks, bakery products, dairy products, confectioneries, processed foods, pharmaceutical products, table syrups and wines etc. HFCS is superior to sucrose in nutritive value and hence can be regarded as an ideal substitute for cane-sugar.

Presently, two normal grades i.e. 42 wt % HFCS and 55 Wt. % HFCS and an enriched grade 90 Wt. % HFCS are commercially available. 42 Wt. % HFCS has the same sweetness as sucrose, 55 Wt. % HFCS is 5-10 % sweeter than cane-sugar, while 90 Wt. % HFCS 25-30% is much more sweeter than cane-sugar. Other favourable properties of HFCS, include high solubility, resulting in its reduced tendency to crystallize out on standing. Its humectant properties allow increased shelf life and its high osmotic pressure prevents microbial growth.

0. 2 ARTIFICIAL SWEETENERS

Organic compounds other than Carbohydrates that taste sweet are known as artificial sweeteners. Artificial sweeteners pretend to be sugar-like as they satisfy the desire of sugar, but they do not change appreciably the blood glucose level. The list of such compounds is very long but only some of them have found use as sweeteners, while others have been discarded because of toxicological reasons. Some of the best known artificial sweeteners are saccharin, cyclamates, aspartame, stevioside, thoumatin and Acesulfam-k.

Unfortunately, none of these artificial sweeteners fulfils all the basic requirements of a good sweetener. All of them suffer from one or the other drawback. The most important functional limitations as judged by the consumer acceptance are bitter after-taste and poor stability.

In a recent study, a product 2,00,000 times sweeter than sucrose has been reported by two French researchers, who also believe that a compound sweeter than this may possibly not be developed in the near future.

In the present situation, there appear to be only two promising non-nutritive sweeteners viz. Saccharin and Aspartame, although there are controversial views regarding their carcinogenicity. It is felt that adequate studies for adaptability of Saccharin to Indian conditions yet remain to be conducted, especially with regard to mode of use in food. Similarly, in the case of Aspartame too, it is again emphasized that its safety evaluation has to be carried out after simulating Indian conditions.

0.3 DEMAND - SUPPLY GAP OF SUGAR

Indian tops the list sugar producing countries. A review of the status of sugar industries in India, indicates that the existing sugar mills are a typical mix of old and new plants. Per capita consumption of sugar and other products like Gur and Khandsari is going up and is expected to increase from 12.3 and 12.5 kg to 17.0 kg and 16.0 kg respectively by the end of this century. Studies on the raw material situation for the last 13 years reveal, that cane production has stagnated at about 60 tons per hectare with less than 1% increase per year from 1977-78 to 1989-90. Any scope of enhanced production of sugar-cane must come mainly from the development of high yielding varieties and improved farm practices. The limitation of traditional sources for meeting the ever increasing demand of sweeteners must be recognized. Therefore, manufacture of sweeteners based on starchy materials offers an attractive source to fill up the demand-supply gap of sugar as suggested by experts.

0.4 MANUFACTURE OF HFCS

Irrespective of the type of starch product used, the first step in the manufacture of HFCS is the production of aqueous starch slurry. For HFCS, the corn is cleaned, and soaked in hot water containing a preservative such as dissolved SO_2. Determination and consequent removal of oil bearing germs is achieved through partial grading of corn. The oil bearing germs are separated, dried and expelled to extract the oil, which is a by-product with high market value. Oil bearing germs free corn grains are ground and processed to remove fibrous materials, and proteins. The refined starch slurry is sent to a jet cooking unit wherein an appropriate does of enzyme alfa-amylase catalyses its conversion into meltodextrins which is a low DE oligosaccharide.

The next step is saccharification, where the low D.E., syrup is further

converted to dextrose by the action of glucoamylase enzyme. Most modern plants use continuous saccharifications process. It takes 65-75 hrs to obtain a 94-96% dextrose hydrolysate, which is then sent for isomerisation after proper refining. The above dextrose syrup (94-96% D.S.) is passed over columns packed with immobilized isomerase enzyme to obtain 42% HFCS. The degree of isomerisation can be controlled by the flow of the substrate. The enriched grade i.e. 90% HFCS is obtained form the 42% HFCS by chromatographic separation technique. 55% HFCS is obtained by blending 42% HFCS with the enriched HFCS.

0.5 FUTURE PROSPECTS

Production of High Fructose Corn Syrup seems to be a commercially feasible project. Maize, the main raw material for the HFCS is an agricultural produce like sugar cane, and hence will not disturb the agricultural economy. Besides this, 2 to 3 crop cycles can be taken from maize essentially using dry land farming technique as against sugar cane which is a 12-15 month crop, requiring a prime piece of land with assured irrigation facilities. Coarse gains like maize require much less input of nutrients, fertilizers and labour, hence, shift in favour of cultivation of these grains as against sugar cane is likely to strengthen the agricultural economy. The by-products of HFSC manufacture are also highly valuable products and are in good demand, and are thus helpful in bringing down the cost of the final products much below the cost of cane-sugar. United States, the major producer of HFCS in the world, produces a mix of cane, beet and starch sugars. Such a model should prove very healthy for developing countries like India, from the agricultural view point.

So far, the cost of corn or cassava starch in India in nearly equal to that of cane sugar in the international market, which in turn results in higher cost of production of HFCS. As a result, only two units have come forward to produce HFCS, though a total of six industrial units had intended to do so with a total capacity of 2.2 million tons.

Large scale production of HFCS will lower its prices to make them comparable to cane sugar. Thus there is need to establish 5-6 plants each, producing about 90,000 MT of HFCS per annum - a capacity which has been worked out for economic viability. Nearly 1.5 million tons of corn or equivalent amounts of other starchly materials are required to produce about 0.5 million MT HFCS. Apart from coarse grains and tubers, HFCS can also be produced from broken rice, damaged grains and spoilt potatoes. Taking into consideration the production of raw materials for HFCS like corn, wheat rice etc. vis-a-vis sugar cane this factor will not be constraint for producing HFCS in the country. Hence, it may worthwhile to set up large scale starch based plants, initially in those parts of the country where sugar-cane is not a principal crop.

HFCS is commercially produced throughout the world using refined starch which is costly in India and thus, it necessitates the recovery of starch from other cheaper raw materials. The pulverised cassava chips as such, without isolating starch from them, seem to offer advantages in reducing the cost of production of HFCS though no references are available in literature for the production of HFCS directly from cassava chips or cassava flour.

The basic requirement for promoting the use of HFCS in the Indian market is to bring down the cost of HFCS below the cost of sugar.

Most commercial plants in the world use enzymatic technology for the production of HFCS using glucose isomerase enzyme to effect the conversion of d-glucose to fructose. Soluble enzymes employed give poor conversions, while immobilized enzymes give very high conversion levels. Immobilized enzyme is not manufactured in India and has to be imported at high cost, which significantly effects the ultimate product cost. Therefore, to promote the use of HFCS in India, R&D institutions should preferably develop indigenous technology for the production of immobilized enzymes

It is expected that if the prices of HFSC are brought down below the price of sugar, it will reduce the industrial consumption of sugar, giving a boost to the starch manufacturing units to go for HFCS production expansion.

0.6 CONCLUSIONS

The Indian scene of HFCS industry is at a nascent stage. One or two units engaged in this field are either in the establishment stage or had stopped producing HFCS due its high cost of production and poor demand in the consumer sector. The production and consumption of this particular product is not only limited due to its high cost, but also due to a general non-awareness about HFCS in the society. So, promotion of HFCS industry also demands an intensive campaign, highlighting the important advantages of HFCS, especially its rapid metabolism process in the human body and independence of insulin.

The know-how for the manufacture of maize starch and its subsequent conversion to liquid glucose, meltodextrines, dextrose and sorbitol is indigenously available. Further research work for the development of the process know-how for making HFCS from starch, has been undertaken at Indian Institute of Technology, Kanpur.

Other related research work, like isolation of SCF culture, isomerisation of glucose to fructose, etc. is being entirely carried out at CFTRI, Mysore, Forest Research Institute, Dehradun and other institutes.

It is anticipated, that in the near future, a starch complex with HFCS as the principal product could be set up with indigenous technology and expertise.

0.7 RECOMMENDATIONS

HFCS is finding an increased use in soft drinks manufactured in the advanced countries. 50% to complete replacement of sugar with HFCS has been permitted in the U.S.A. Soft drink manufacturers in the country may also be persuaded to opt initially for at least 15-20% replacement. Gradually, other industries like bakery, processed foods, ice-creams etc., should also consider sugar replacement by HFCS. This move would encourage further outlets for HFCS for various applications and it could spare sufficient amounts of sugar for public consumption.

0.7.2 High fructose corn syrup has proved to be an ideal substitute for cane-sugar and can hopefully supplement additional requirement of sweeteners. In India currently, neither there is adequate production of HFCS, nor is there much demand for it in the consumer sector. Industries are not coming up for the production of HFCS because of its high cost, which is also a reason for its low demand. Besides, cost, a general unawareness about the advantages of HFCS also seems to be one of the reasons for its poor demand. Therefore, it is required to make intensive efforts to produce HFCS at reasonable cost.

0.7.3 It is necessary to create a general awareness in the society for the utilization of the same.

0.7.4 Establishment of large scale starch complexes with HFCS as the principal product seems to be commercially attractive. Large scale HFCS plants may be established in those parts of the country, where sugar cane is not a principal crop. Gradually, the number of these starch complexes may be increased. These measures may provide a long term stabilizing effect on the sugar availability and prices.

Initially, 5-6 starch complexes with a maize crushing capacity of 500 tons/day at an investment of about Rs. 300 crores may be set up. These units would then produce about 5,00,000 tons of HFCS annually, which would help tide over sugar shortages.

0.7.5 The know-how for the conversion of starch to liquid glucose, maltodexrins, dextrose and sorbitol is indigenously available, while further research work for the development of the process know-how for making HFCS is in progress at both the national research institutes and industry. If the tempo is maintained, then in the near future, complete technology for the production of HFCS from starch will be available indigenously.

0.7.6 Immobilized Glucose isomerase, an enzyme which is used for the production of HFS, is a proprietary product of for manufacturers. It is imported at exorbitant cost resulting in a significant increase in the production cost of HFCS. Prices of HFCS can be brought down, if this particular enzyme is made available in the country. Concerted efforts by the industry as well as research institutions are required, to develop this enzyme catalyst, for the production of HFSC.

0.7.7 Though many organic compounds, known as artificial sweeteners, are known to provide sweetness even at considerably low concentrations in comparison to sugar, they suffer from one or the other drawback. Based on the knowledge so far gained from literature, they cannot be regarded as totally safe for human consumption. Hence, it is very much essential had safety evaluation simulating Indian conditions be performed on such sweeteners and safety norms for consumption established.

0.7.8 In view of the fact that sweeteners of plant origin have great relevance research institutes need initiate effort in the direction of developing plant based sweeteners. Locally used plant need be explored.

0.7.9 Protein band sweetners and piptide sweetneres need be developed.

0.7.10 Use of alpha amylase as a sweetening agent at high temperatures needs to be explored.