CHAPTER - IV

SUMMARY AND CONCLUSION

Man has for long been a prisoner of his environment - the victim of hunger and disease.

It is therefore a worthy tribute to the progress of man's knowledge that he has not only significantly overcome hunger and disease - his natural enemies- but is now endeavoring to use microbes as a source of health and food.

IV. SUMMARY AND CONCLUSION

Food clothing and shelter are the three basic needs for civilized life. Almost all living systems continue to depend exclusively on land and water resources for food. Science has not so far been able to find an acceptable and economic alternative to plant and animal life for feeding the hungry millions of the world.

With ever increasing population all over the world, particularly in developing countries, meeting the food need is causing anxiety. The tremendous rise in world prices for grain, pulses and animal feed, over the past few years is an indication of the serious food shortage that can overtake civilization.

The main incentive for the widespread research on the utilization of microorganisms as food and fodder is provided by authoritative prognoses concerning world food supply and population increase.

The general advantages of microbes over plants and animals as protein producers can be summarized as follows:

1. Microorganisms have a very short generation time and can thus provide rapid mass increase. Bacteria and yeast under the most favourable conditions have generation times of about 0.5 - 2 hr and 1 - 3 hr respectively.

2. The protein content of microorganisms is high. Most organisms contain between 7 to 12% nitrogen on a dry weight basis which even after substration for nitrogen from purines pyrimidenes etc. indicate a true protein content which is higher than that for most common food stuffs.

3. The production of SCP can be based upon raw materials which are locally available in large quantities such as cellulose, coal, petroleum, natural gas or industrial wastes which will be available for a long time to come.

4. The production of SCP can be carried out in continuous culture independent of climatic changes and with only a small land area and water requirements. The waste disposal problems are small compared with those encountered in most processes for food production.

Single Cell Proteins can be used to significantly augment food production supply for animal feeding and also for direct human feeding. This would greatly help to relieve pressure on land.

For the utilization of n.paraffinic hydrocarbons processes developed could be broadly classified under :

(1) Oxidation (2) Chlorination (3) Nitration
(4) Sulphochlorination and Sulphoxidation (5) Fermentation.

From the bibilographic data collected it is evident that first four processes are quite old and enough work has been carried out since the beginning of this century.

However utilization of n.paraffinic hydrocarbons by fermentation to produce Single Cell Proteins is of recent origin.

Today fermentation applies to both aerobic and the unaerobic metabolic activities of microorganisms in which specific chemical changes are brought about in an organic substrate by which a product of economic value accrues.

Having realised the importance of Single Cell Proteins and the possibility of producing the same from n.paraffinic hydrocarbons by fermentation techniques, attention is diverted to this new field.

From the present study the following observations have been made :

- The yeast strain "IIP-4" which has been isolated from the soil collected from the bottom of one of the storage tanks situated in Gujarat Refinery premises belongs to the species " Candida tropicalis " and can grow on n.paraffinic hydrocarbon above C_{12}. Lower n.paraffinic hydrocarbon C_7, C_8 disturbs the growth, depending upon its concentration in the feed the lag phase gets affected. On pure tetradecane, pentadecane, hexadecane as well as on $C_{14} - C_{18}$ cut n.paraffinic hydrocarbon it has a specific growth rate 0.38 h^{-1} at temperature 34 $\pm$ 1 °C and at pH 4 $\pm$ 0.05.
- This yeast strain can grow at temperature ranging between 26°C and 40°C with a specific growth rate

gradually increasing from 0.2 at 26°C, attaining the maximum specific growth rate at 0.38 h^{-1} at 34 ± 1°C then it gradually decreases and at temperature 40°C it has a specific growth rate of 0.125 h^{-1}. From the Arrehenius plot the energy of activation value obtained is 14 K. Cal/mole and deactivation energy is 24 K. Cal/mole.

- This yeast strain could grow at pH as low as 2.5 and at pH 4 long duration fermentation experiments could be carried out without maintaining strict sterile conditions.

- The stability of the yeast strain to grow on a simple nutrient medium containing commercial grade salts for long duration continuous operation has been checked in a 2.5 litre capacity bench scale fermentor, for over 20000 hours with C_{14} - C_{18} cut pure n.paraffinic hydrocarbons and three runs ranging between 1000 to 3000 hours on gas oil fractions and several runs in m^3 pilot fermentor ranging between 700 - 1000 hours.

- The presence of non normal paraffinic hydrocarbons, i.e. naphthenic hydrocarbons and aromatic hydrocarbons do not interfere with specific growth rate of the strain. This fact has been tried successfully to conduct microbial dewaxing of both kerosine and light diesel fractions. Dewaxed oil, recovered from the biomass collected from the fermentor after suitable solvent wash has better flow properties i.e. the pour point of the dewaxed kerosine fraction is considerably lowered.

- Continuous fermentation studies carried out with pure n.paraffinic hydrocarbons as well as with gas oil fraction indicate that the cell concentration in the fermentor could be maintained constant by carefully controlling the hydrocarbon feed rate to the fermentor and the dilution rate. In the case of gas oil fermentation beyond a dilution rate of 0.18 h^{-1} the cell concentration started decreasing and at dilution rate 0.38 h^{-1} complete washing out took place. However in the case of n.paraffinic hydrocarbon fermentation

even though the washing out took place at dilution rate 0.38 h^{-1} the cell concentration could remain constant up to a dilution rate 0.22 h^{-1}.

- With pure hexadecane as well as with C_{14} - C_{18} cut n.paraffinic hydrocarbons yield co-efficient obtained is 0.85 gms of dry cells per gram hydrocarbon feed. Both in bench scale fermentor as well as in pilot fermentor the maximum cell concentration obtained is around 10 g/L beyond which perhaps there is oxygen limitation.

  Lipid content increased from nearly 5 wt % to 17 % as the dilution rate increased whereas the variation in Nitrogen content is not that predominant and it decreased from 10 to 8%.

- When high purity n.paraffinic hydrocarbons are used as feed for fermentation, water washings, centrifugation and spray drying of the cream yielded a product free from residual hydrocarbons. Biomass obtained from gas oil fermentation needs solvent treatment and the method developed using solvent isopropanol

gave better results when compared to the one produced using the solvent mixture Acetone and Petroleum ether.

Single Cell Protein produced in pilot plant has undergone acceptability tests and field trial experiments. It contains 58% protein with fairly well balanced amino acid pattern. By supplementing with the amino acid methionine the protein efficiency ratio and Biological value increased considerably.

It can be used successfully as protein supplement in animal and poultry feed to increase the milk and egg yield respectively.

As long as it is dealt with the aim of finding a solution to scientific problem the question of economics is of secondary importance. However when a scientific discovery is to be industrialised and when a synthetic product enters the competition with natural subst-ances the cost is a decisive factor.

A direct cost comparison with soya bean protein or other vegetable sources of protein is not fair, because the SCP derived from n.alkanes differ in its protein make up.

When peanut cake is compared with SCP on the basis of quality taking into account the protein content, lysine content, biological value and digestibility one kilo of SCP provides the same nutritive value as around 2.5 kilos of peanut cake.

As the relevant technology improves, it appears SCP will become the least expensive protein source for food and feed application. The successful attempt made in cultivating the yeast strain without maintaining strict sterile conditions using simple nutrient medium made up of commercial grade salts, saves considerable steam requirement. Similarly products preparation costs (both for equipment and utilities) are significantly reduced when centrifugation is avoided.