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Vienna, Austria, 8 - 12 October 1973

SOME INDIVIDUAL EXPERIENCES IN SCP PRODUCTION FROM N-PARAFFINS1/

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SUMMARY

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P. Peri*

Up to now two semi-industrial pilot scale SCP production processes have been developed.

In the first, the yeast, generally Candida species, utilizes the normal paraffin content of gasoil; in the second pure normal paraffin extracted from gasoil or kero-gasoil fractions is fed as C source for the yeast.

We shortly discuss production problems and product characteristics. We also discuss the advantages of the second process and the normal paraffin extraction technology is explained. Great attention is given to the purification system in order to obtain highly purificated n-paraffins.

Industrial production of SCP needs some bioengineering considerations for the selection of shape and dimensions of fermentor. These decisions also involve fermentation problems such as mass transfer of oxygen and paraffins, heat removal and mechanical problems with a fermentor construction.

Some results of continuous fermentation experiments are described such as Biomass concentration, cell yield, productivity and the general composition of SCP recovered is illustrated.

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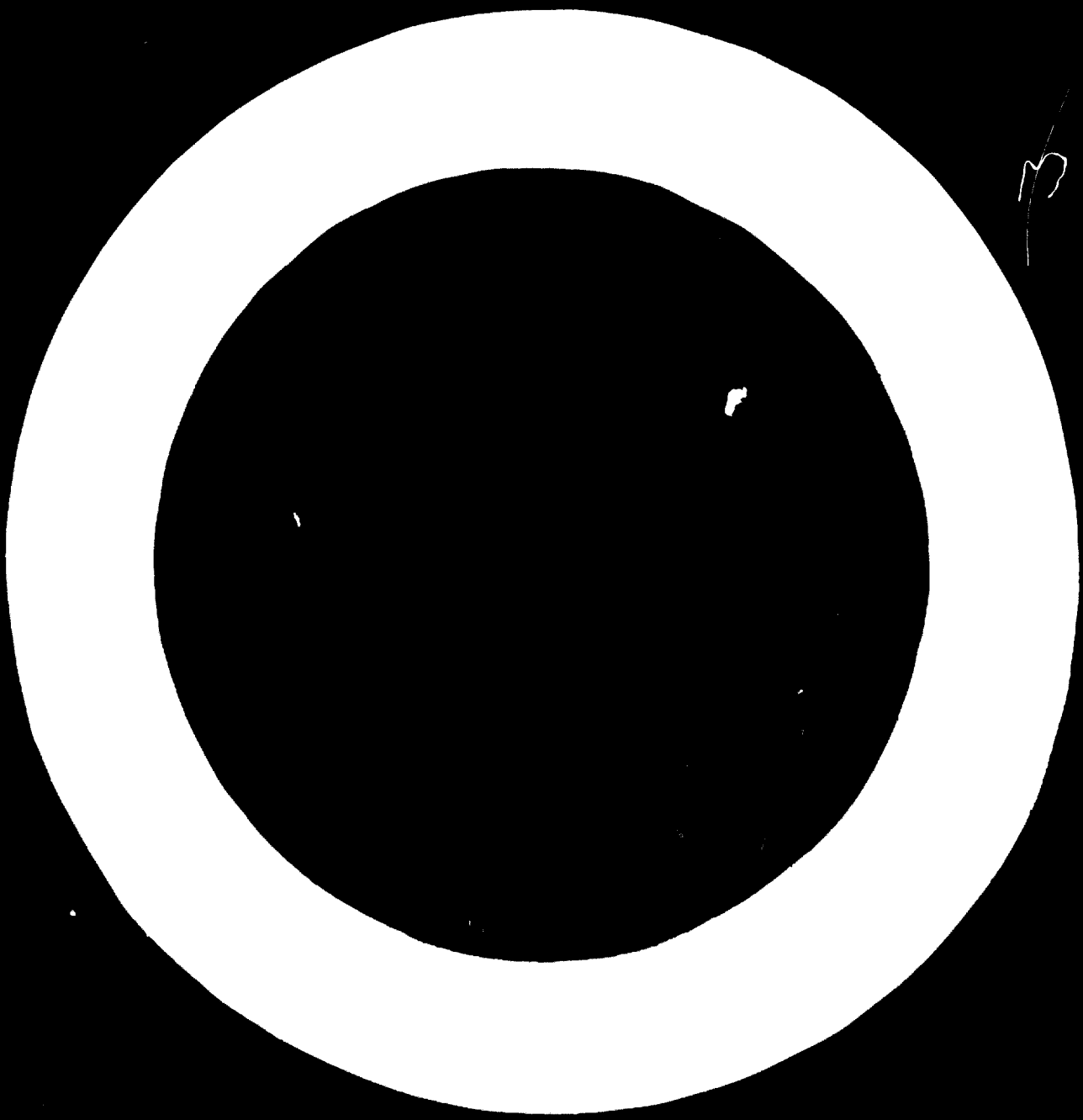


CONTENTS

INTRODUCTION

Aim of our presence at this meeting is to introduce Liquichimica, particularly the "industrial biosynthetic section" to other Companies, International agencies and persons involved in SCP development.

Liquichimica, although actually engaged in a medium term plan of investiments in the N-paraffins and petroproteins productions, until 1976, has already launched a long term plan up to 1983. In this plan, Liquichimica has taken into consideration the likely changes which will take place in the producing countries with reference to the ever-growing need for proteins and has selected the areas where N-paraffins may be produced at the most economic conditions. Furthermore Liquichimica has carried out a social economical study and has tried to determine the areas which offer the greatest advantages for the production of single cell proteins and their derivatives foodstuffs.

The medium term plan makes of Liquichimica the first Italian Company developping an industrial programm in the fermentation sector from N-paraffins not only for the production of single cell proteins but also of other derivatives in the nutritional field and industrial field.

In my report I deal only with technical considerations and experiences.

I - N-PARAFFINS AS RAW MATERIAL FOR SCP

As referred by J. Hutchinsons of FAO during recent discussion on SCP, 28 March 1973, for the production of petroproteins two processes have been developed: in one the feedstock is gasoil from which the yeast (normally Candida species) selects the fermentable normal paraffin component of the gasoil; in the second one the feedstock is the fermentable pure normal paraffins separated in advance by molecular sieve extraction.

Almost all industrial firms which are planning today processes for the manufacture of hydrocarbon yeast, use n-paraffins isolated from kero and or gasoil fractions.

The second and alternative process the so called "gasoil process" is losing most of its interest for many reasons:

- the fermentation plant must be attached to a refinery because only 10% of the gasoil is fermented and the residual has to be returned to the refinery for recycling
- at the end of the fermentation cycle we have three phases to separate i.e : SCP, gasoil and spent water medium.

Since the cells attract oil during the process, a solvent extraction is necessary; this removes the fats thereby raising the relative protein content in the remaining material. It has however the disadvantage of lovering the metabolic energy of the protein when used for feeding.

In the normal-paraffin process, on the contrary, the conditions are such that at the end of the fermentation only the cells and the spent medium are left.

Even if a pretreatment of gasoil is necessary for the extraction and refining of the n-paraffins, it can be said that this process is the more advantageous because :

1) only a small volume of fermentor is needed
2) separation of cells and medium is easier
3) solvent treatment is not necessary because impurities can be removed by water-washing of the yeast cream which has been previouly separated from the medium. In this way the quality of the product is better.
4) the purity of the substrate reduces substantially the safety problems of the product
5) the investiments costs are lower.

Liquichimica is building at Saline, Reggio Calabria - Italy a 100.000 tons/y SCP plant, which will get in to production August 1974. It will use normal-paraffins as carbon source.

Before the SCP plant flow sheet is explained and show, we would like to stress that Liquichimica has placed considerable attention to the extraction of n-paraffins as raw material for fermentation.

The extraction and purification process is based on the Isoviv process realized by Union Carbide.

The n-paraffins are separated from isomers, naphtens and aromatics by a selective adsorbtion on molecular sieves.

This process is a cyclic one and the desorbtion of n-paraffins is obtained by a light hydrocarbon in an equicurrent washing for removing last isomers traces and a countercurrent washing for the recovery of n-paraffins.

After these operations and recovery the isolated n-paraffins are again desulphurized and dearomatized in order to eliminate aromatic hydrocarbons.

As results, n-paraffins employed for the yeast production have a high purity (99%) and a low contents of aromatic policyclic hydrocarbons.

N-PARAFFIN	:	99%
3-4 BENZPYRENE	:	0,5 p.p. bilions max
1-2-5-6 DIBENZANTHRACENE	:	0,7 p.p. bilions max
20 METHYL-CHOLANTHRENE	:	0,9 p.p. bilions max

BIOCHEMICAL AND ENGINEERING ASPECTS IN SCP DEVELOPMENT

As regards the our experiences in the development of Petroprotein, as first I will show you the flow sheet of our technology. (Figure 1) -
Single cell Proteins are produced via fermentation of n-paraffins using a strains of Candida species.
The process is characterized by the following processing steps:

a) two stages submerged batch fermentation for preparation of the inoculum of the main fermenters. Standard type fermenters provided with mechanical agitator and refrigeration coil are used
b) separation and washing of the yeast with water in three stages process. Specialyzed centrifugal yeast separators are provided.
d) final drying and sterilization of the yeast before bagging and storage. The drying is performed by using the waste heat from the incineration of the exhaust from fermenters.
e) incineration of exhaust air from the fermentation plant before releasing it to atmosphere for environmental control.

FERMENTOR TYPE

The production of yeast from n-paraffins on a very large scale requires specially suitable fermentor. There is a problem of size and, moreover, there are some other problems such as: mass transfer of oxygen and paraffins, heat removal, and mechanical problems are involved with the fermentor construction.
We have developed an air-lift type fermentor, whose simplified schema is shown in figure 2.
The primary body of the air-lift fermentor is equipped with a device for the aeration of the broth. The air, blown into the fermentor through the injectors system, takes the form of micro-bubbles, thereby increasing the oxygen transfer rate. The broth in the fermentor is forced to circulate at a high speed between the primary body and the circulatory body by the air lift effect, resulting in a high micronization of air bubbles and paraffin

droplets. Furthermore, the diameter of the upper part of the fermentor is larger than that of the main body, thereby reducing the ascending velocity of the air.

B) OXYGEN TRANSFER RATE

We have measured the oxygen transfer rates in our bench-scale air-lift and in a conventional agitated fermentor by the sodium sulphite oxidation method. From figure 3) showing the comparison of Kd values, expressed in terms of g-mol O_2/ml. min., as affected by the difference in the fermentor types, you can see that there is no significant difference between the air-lift type and the agitated fermentor when compared on the basis of aeration rate. However, when compared by the viewpoint of power consumption, the agitated type seems less advantageous because it requires power for mechanical agitation as well as power from the aeration.

This means that the power requirements for the air-lift type are considerably lower than those for the agitated one.

As for as the problem of the removal af a large amounts of heat developed during metabolism is concerned, we have performed a specialyzed heat removal system on the circulatory body of the fermentor.

The experimental values of heat to be removed are: 4640 Kcal/kg yeast if the fermentation yield is 1,25 or 6000 Kcal/kg yeast with the fermentation yield of 1,03.

This experimental data agree with the values referred by K.R. Guenther.

As conclusion of my brief report, I would like to show some results of Fermentation experiments in pilot plant.

III - RESULTS OF FERMENTATION EXPERIMENTS IN PILOT PLANT

Some results of continuous fermentation experiments conduced in our pilot plant are in Table 4 and 5.

Table 4. Results of continuous fermentations

Experiment n.	Biomass Concentration (%)	Cell Yield (%)	Productivity (Kg/m3 Hr)
1	1.01	112	2.97
2	1.28	113	3.07
3	1.58	106	3.22
4	2.04	114	2.66
5	1.17	109	3.00
6	1.43	118	3.24
7	1.52	114	3.20
8	1.37	104	3.11

Fermentation conditions :
Temperature : 30° C
Ph : 5,0

During these experiments we have also collected the experimental values for the calculation of the expected utilities consumption per 1 ton of SCP. These data are shown in Table 5.

Table 5 -

EXPECTED UTILITIES CONSUMPTION PER 1 TON OF SCP

M.P. steam, kg	10,000
L.P. steam, kg	500
Cooling water, m^3	1,200
Chilled water, m^3	15
Raw water, m^3	45
Process water	1
Electric power, kwh	500
Fuel gas, MMKcal	5

PRODUCT CHARACTERISTICS

The Single Cell Protein product is suitable for direct use for feed for:

- Poultry

  For chicks, broilers and layers, the best formula ratio has been found to be 5 - 10%.

- Pigs

  For pigs the best SCP formula ratio was found to be 10-20%.

  As a protein source for piglets and swine, the SCP by itself, showed excellent experimental results.

- Cultured fish

  The SCP ratios for cultured fish are as follows:

Carp	40-50%
Eel	about 30%
Rainbow trout	" 30%

The SCP presents the following quality features:

- there is no change whatsoever when stored for a long period of time.
- the amino acid pattern is similar to that of animal protein and its lysine content is particularly high.
- rich in B-vitamins
- high caloric value
- excellent digestibility and palatability.

The following data clearly indicate that it can be easily digested by poultry, livestock and fish. In fact its digestibility is very similar to those of fish and soybean meals. (Table 6) -

Protein Digestion Rate	%
Poultry	84.8-88.0
Pig	88.3-89.3
Carp	85.4
Eel	81.6
Pepsine digestion rate	86.4-91.2
Metabolizable Energy	**Cal/g**
Chick	3.15-3.38
Layer	3.48-4.08
Digestible Energy	**Cal/g**
Piglet	4.16
Swine	4.55

Table 7. Example of analytical data on our yeast produced in the pilot plant.

GENERAL COMPOSITION (%)

Moisture	4-6%
Crude Protein	60-63
Crude Fat	2-4%
Crude Fiber	3-5%
Crude Ash	6-11%
N.F.E.	21%

VITAMINS (as dry matter)

Vitamin B1	12 mg/Kg
Vitamin B2	160 mg/Kg
Vitamin B6	8 mg/Kg
Vitamin B12	8 mg/Kg
Niacin	372 mg/Kg
Biotin	0.4 mg/Kg
Folic acid	1,8 mg/Kg
Pantothenic acid	167 mg/Kg

MINERALS (as dry matter) (%)

Phosphorus	(P)	2.74
Potassium	(K)	2.2
Magnesium	(Mg)	0.30
Calcium	(Ca)	0.10
Sodium	(Na)	0.06
Zinc	(Zn)	0.05
Iron	(Fe)	0.05

AMINO ACIDS COMPOSITION (%) (on total amino acids)

Aspartic	11	Alanine	6,5	Tyrosine	3.0
Threonine	6	Cystine	2.0	Phenylalanine	4.5
Serine	5	Valine	6.0	Tryptophan	1.2
Glutamic acid	15	Methionine	1.5	Lysine	9.0
Proline	4	Isoleucine	5.0	Histidine	2.3
Glycine	5	Leucine	8.0	Arginine	5.0

CONCLUSIONS

This is a short biography of LQ with regard to its presence in this sector, emphasizing in particular the integrated programm involving n-paraffins and single cell proteins.

The basic elements required to put proteins on the markets at competitive prices are already avaiable to LQ.

As regards the problem of investment in the field of the single cell proteins, LQ are at your disposition to give you any further explanation you may require within the limits of a preliminary discussion.

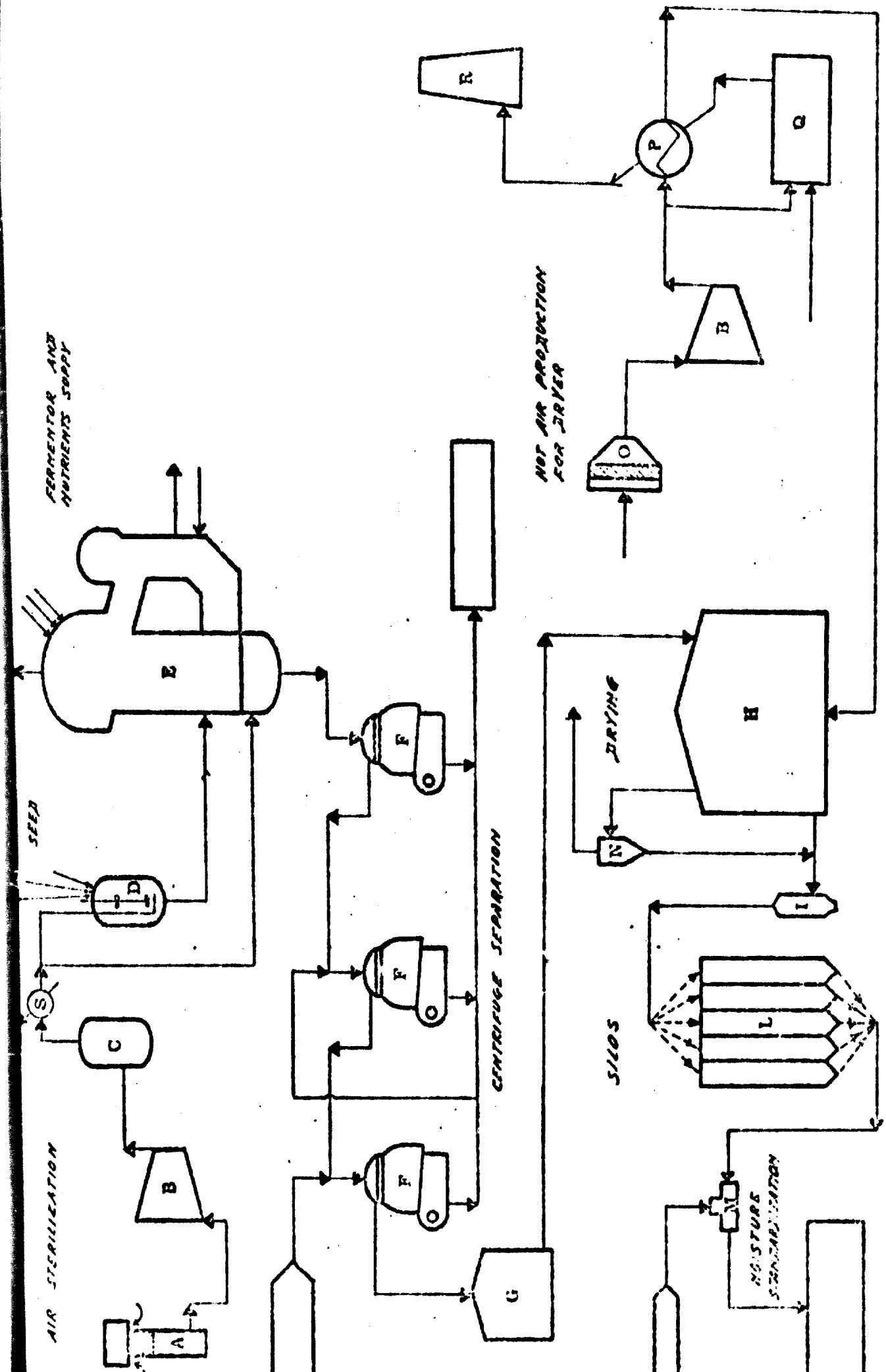


FIGURE 1. PRODUCTION SCP PROCESS

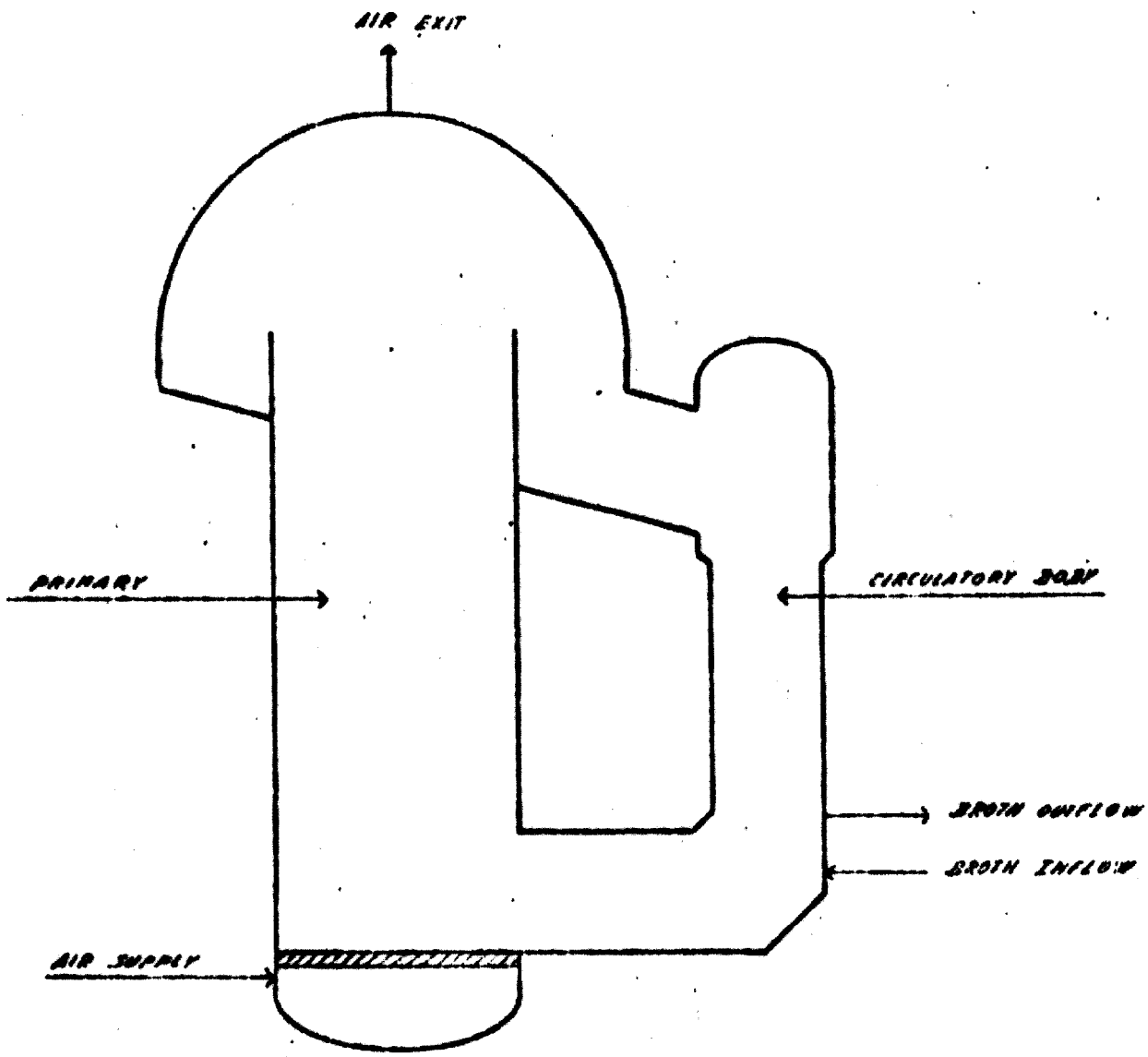


FIGURE 2 SCHEMATIC REPRESENTATION OF AIR-LIFT FERMENTOR

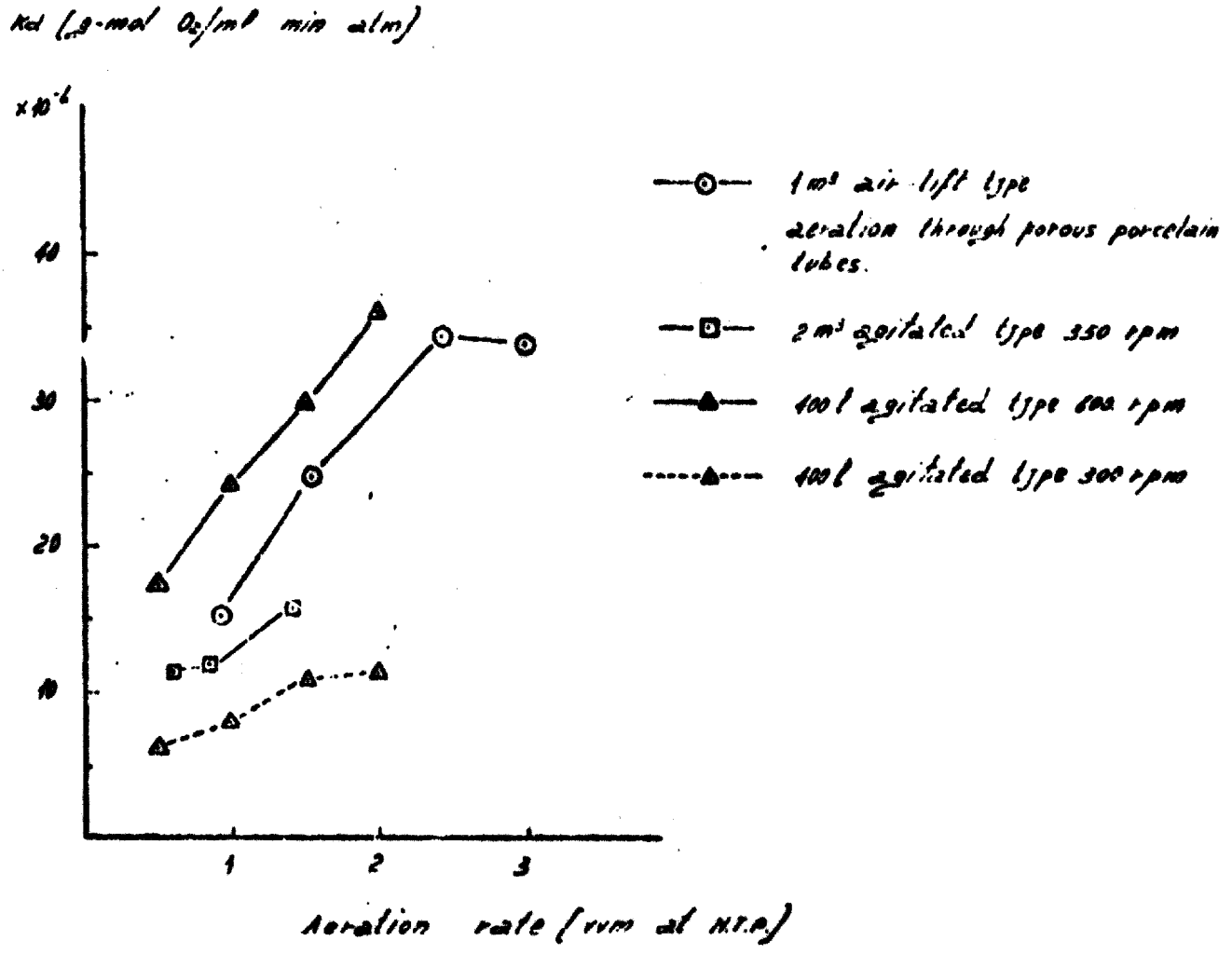
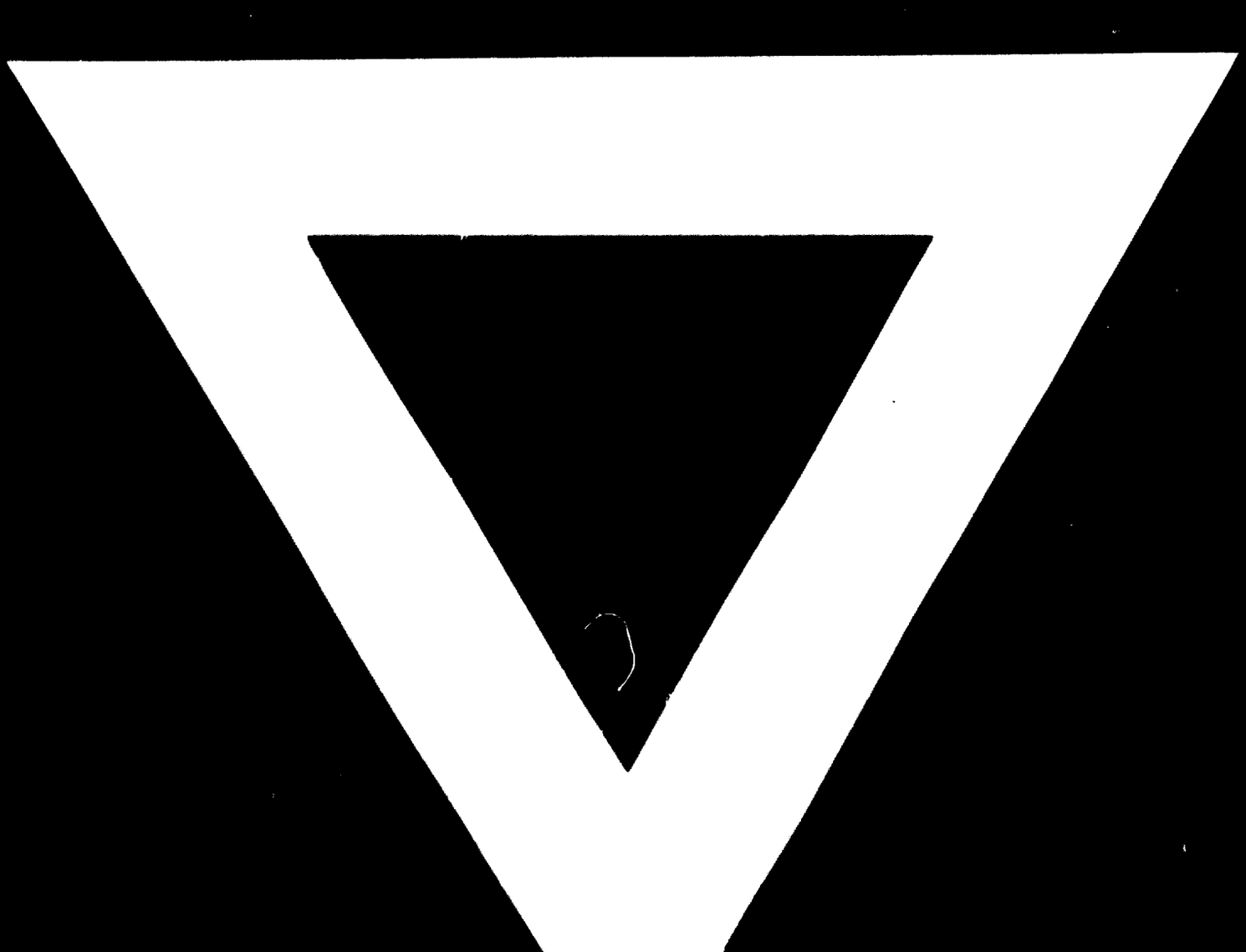


FIGURE 3 COMPARISON OF Kd AS AFFECTED BY THE DIFFERENCE IN FERMENTOR TYPES.



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