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VALUE OF CROPS: QUANTITY, QUALITY AND COST PRICE

C. Meyer

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16. Abstract
Possibilities of using algae as a nutritional supplement are discussed. The nutritional value and protein content of spirulines of blue algae are discussed and the cost of growing them artifically is estimated.

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VALUE OF CROPS: QUANTITY, QUALITY AND COST PRICE

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I will end this series of conferences by discussing the possibilities of utilizing this algae and the problems created by such utilization. I think it is necessary to briefly review production values. /041

In the laboratory, it is normal to obtain growth rates which, under the best conditions, can reach 20 g of dry algae/m^2/ day. This, naturally, occurs when all climatic conditions, basically temperature and light conditions, are under control.

In the case of an outdoor culture, as it has been shown, these are parameters which cannot be completely controlled.

For example, in the case of cultures grown in Antibes, when in the morning there was enough light for photosynthesis, the temperature of the culture was about 25°; the temperature later reached a maximum of 33°, then it diminished slowly.

As far as spirulines are concerned, optimal growth conditions are around 30°, between 30 and 35°. It will be, therefore, advisable to introduce the culture in regions where, at sunrise, a temperature greater than 25° will have been reached in the basins. This presents a culture introduction problem.

We can hope to effect the temperature parameter on the one

hand through the greenhouse effect, which we discussed earlier, by operating with a closed basin which makes it possible to limit evaporation, cooling and night radiation and, on the other hand, through the thermal inertia of the culture, that is to say, the volume of the culture, with the limitations that this implies.

The tests we are going to conduct in Algeria will help us establish these points.

Under the present condition of our testing, we can speak of /042 these production rates.

We have worked in Antibes with actual crops for a period of two months, July and August, 1966. It was a more or less normal summer with a stormy period lasting a few days toward the fifteenth of August.

We obtained an average production rate of 10 g /m^2/day with peaks of 14 g /m^2/day.

In Mexico, we obtained the same rates. Temperature conditions in the basin are very similar to those we had in Antibes.

To estimate cost price, we have taken as a basis a growth rate of 12 g /m^2/day. We started from technological data we had accumulated in Antibes and which made it possible , by means of an extrapolation which for now remains quite theoretical, to establish a pre-project for algae culture corresponding to a production of 10,000 t/year. The culture should be introduced in a region where there are favorable climactic conditions and where it can operate 340 days/year; this leads us to consider a culture surface of 230 hectares.

These 240 hectares of cultures will be divided in four 60 hectare basins. These basins will be made up by the juxtaposition

of the elements discussed by M. Van Landeghem, and each one will measure 600 m by 1 km.

Why did we choose such size? It is because this size corresponds to optimal conditions, in particular in regard to the atomizer which will be used to dry the algae. There will be, in fact, an atomizer which will operate continuously and will be capable of drying the whole production; harvesting will be done with drum filters, of the same type you have just seen, at a rate of one filter per basin.

We have made certain hypotheses in regard to the water used for the culture, in regard to its quality and evaporation, which have shown it to be on the order of 3mm/day. The chemical products necessary for a culture are essentially sodium bicarbonate and sodium nitrate, as well as a certain number of mineral elements needed for all plant cultures. These are technical chemical products which are found in industry.

The carbon gas necessary for the culture is supplied by motors which operate the installation. The motors are basically diesel motors, generating sets and the gas turbine which serves to supply energy for the atomizer. The combustion gases of these different motors are recovered and sent into the culture. In other words, the fuel discharge serves to supply both the energy and the carbon.

Under these conditions, we obtained a cost price of 1.36 fr. /043 per Kg of dry algae.

I can detail for you the different components which make up the cost price.

	% of cost price
-fuel	14.5
-chemical products	15
-labor	8.5

-legal depreciation	33
-interest	11.5
-maintenance	14.5
-taxes - insurance	3

On the basis of all this, it is interesting to see where the algae fits within the market.

It is necessary to speak of the market for a product of this kind, although one would first consider the utilization of this algae in order to contribute to resolving the problem of hunger in developing countries. However, even in these countries, there is competition with other products and the algae will not be utilizable if it is too expensive.

On the other hand, to reach a sufficiently high level of development, substantial financial means are needed. It is, therefore, necessary to interest both international organizations and industry. Presently international organizations devote most of their financial resources to the improvement of classical methods of animal and plant production. The portion of these resources used for new protein sources, oil yeasts or algae, is extremely small.

It is necessary then to turn to industry; therefore, competition problems arise.

Having made this point, what are the features of this algae? We have said that it is an algae rich in proteins; it contains 65% protein, and this makes it better than chlorella which generally contains between 50 and 55% protein.

In addition to protein, it contains glucides and some lipids; it also contains vitamins and some pigments, for example, xanthophyl which can be needed for certain uses.

It can be introduced in two different markets, that of animal /044 feeding and that of human feeding.

As far as animal feeding is concerned, presently the tendency is to feed animals industrially by giving them a balanced nutrition of proteins supplied essentially by soy flour or fish flour. The cost price of soy and fish flour expressed in francs per kg of protein varies between one franc to one franc, 30, according to their origin. The cost price of spirulines reaches 2.10 francs per kg of proteins. Therefore, on the basis of its protein content, spiruline cannot compete with these products. On the other hand, the fact that it possesses certain pigments such as xanthophyls enables it to compete in certain markets such as the poultry market, since xanthophyls tend to give a yellow color to poultry meat or egg yolks and these attributes are much in demand in certain countries.

As far as human nutrition is concerned, there is hope. Actually, prices for soy flour vary between 1.30 francs and 2.50 francs/kg of proteins and for fish meal between 2.50 francs and 3.50 francs. Spiruline can, therefore, become more competitive. On the commercial plane, this gives us a certain hope.

As far as nutrition is concerned, the quality of this algae is still to be explored. The protein value given by a chemical analysis is not sufficient. And it must still be established how these proteins are assimilated by the organism.

Preliminary tests were carried out with algae cultures obtained in Var and Antibes. These tests were limited to specialized laboratories. They consisted in feeding a group of animals, rats or chicks, on the one hand, with a controlled well balanced food ration and, on the other hand, with a ration identical to the controlled ration, specifically with the same amount of protein, but in which a portion of the protein of the control ration was substituted with the algae. Various criteria can be examined this

way, for example, the weight gain of the animal in relation to the amount of food it consumes. With more refined tests, we can determine the nitrogen balance, by measuring the amount of nitrogen retained by the organism .

I can give you some figures for some of the tests that have been completed. For example, with chicks, the nitrogen balance had a value of 50% for the nitrogen retained with spirulines, whereas with a control ration based on soy this value is 40%.

Testing on animals is a first stage. If we want to use these /045 proteins for human nutrition, it is obviously necessary to continue testing on humans.

In this case, we must carry out the two types of tests described above. These tests should be carried out in specialized centers such as hospitals and, generally, with infants.

Another kind of test which must be carried out is the acceptability test, since it is a well-known fact that, from the nutritional point of view, acceptability is an extremely important notion. We must be able, therefore, to introduce a new food product so that it is acceptable in the countries where it must be introduced.

You have just spoken of tests carried out in Chad. I believe that presently in Chad, tests are being carried out along these lines with the populations of Chad and with algae which has been obtained in natural waters.

Discussion

Mr. Robinet

We cannot say that there is anything new since the population /046

of the Kanem region has consumed these algae for a long time.

There are, however, two aspects, the side dish or nutritional supplement aspect, traditional and without determinable origin, and the famine aspect. Periodically, in Kanem, due to climatic reasons there have been times when the millet harvest was bad and it was necessary to supplement the food diet. We found that at these times the rich people's granaries were quite full of millet, whereas the poor had nothing but these algae which they obtained from the sea.

This is obviously the origin of the dual character, nutritional and supplementary, shown by the algae in the market. In the Kanem market, the nutritional aspect is dominant, whereas in the Fort Lamy market, the supplementary aspect is dominant.

Presently, I would like to speak about the diplomatic conflict which has originated between the Chad government on the one side and certain French organizations directly or indirectly represented in Chad. It seems that the Chad government does not want our help since it has never requested experts to assist it in resolving a nutritional problem.

Actually, there is no nutritional problem endemic to Chad, except for classic deficiencies which can be seen in children at the time of weaning. Their intestines do not adapt immediately to the large consumption of starchy foods of vegetable origin after a diet of maternal milk. There is a phase when illnesses develop, such as the appearance of certain edemas.

We know that the government of Chad has, nevertheless, been sensitized to this question of the algae and that it has delegated to the F.A.O. and to local experts, some sent by F.A.O., others belonging to Chad organizations, the responsibility for collection and improvment of the product. Basically, this involves improvement of the drying process; since production is normally from the sea, the drying

process is not carried out any longer on the sand as we have seen in the film, but rather in baskets, on beds of leaves, or according to other procedures which make it possible to eliminate the high amount of sand which lowers the nutritional value of the product.

Tests have also been carried out on animals. /047

To my knowledge, they are not to be carried out on man. They have been done, they are known, they are constant.

During periods of famine, poor people have resorted to this product that we call "dié", while the rich use it in classical manner as a condiment, as a sauce, since these algae, due to their gelatin content, when oiled with meat or other food products, constitute a normal side dish with a certain nutritional value.

This is all I can concretely say on the subject.

I want to pose the following question. In comparing the prices that you have given us and adding that ruminants, which are the essential source of protein in these countries, are not its consumers it does not seem advisable to give them this food product, since they are cellulose transformers. We cannot transform cellulose and find it transformed in consumable animal protein. Under these conditions, the chances of utilizing these algae proteins in the underdeveloped Sahel countries where cattle raising is practiced are extremely low. They are infinitely greater, more encouraging and realistic, perhaps, in the countries where it is more possible to raise cattle or ruminants; this is the case of the coastal countries where tripanosodiasis prevents all extensive animal raising but does not prevent intensive raising of cattle which consumes the industrial sub-products of agriculture. We can imagine, in the Ivory Coast, the consumption of bananas which are not exported in the south of Chad, the consumption of cotton meal on the condition that we can eliminate gossipol.

We can consider peanut consumption. There is an interminable list of classical sources presently wasted and sub-products of agricultural or industrial food product origin which can be made the object of an extremely economic transformation for cattle and ruminants, in the form of a stock farming which is not extensive as in the Sahel but which is semi-intensive, both traditionally in free range land, as in Madagascar, and industrially. All these projects are based on ensilage, and the recovery of these sub-products on corn culture, on penicetol culture, etc.

Ms. Meyer

The culture of algae does not pretend obviously to take the place of all these traditional sources. It is an alternative possibility which can be suitable for certain areas.

Mr. Robinet /048

I understand that. In the case of Chad, it is certain that the physiological and sociological aspects of the use of these products do not come up, since it is not new.

However, in Niger, where I have lived for a long time, I have never seen the inhabitants consume such algae or import them from Chad, because the standard of living of the population did not require resorting to this product. On the other hand, we must not lose sight of the fact that in this is a product of famine, that it is consumed when the famine creates a physiological need, a protein deficiency visible in the adult. It is also a supplement which complements a more or less balanced nutrition, but which the inhabitant of Chad does not necessarily need.

Ms. Meyer

It is clear as Mr. Moyse just explained, that the algae is not

a particularly appetizing product. If one must choose between the algae and another more appealing food product, he will choose the latter.

Mr. Robinet

The taste of the algae is not unappreciated, on the contrary, when the algae is dried in these countries and consumed dry, its taste is not bad, since, given the long exposure to the sun, it does not deteriorate.

This is one of its advantages. In periods of famine, those who can store the algae can use them as a nutritional product instead of a supplement.

This is all I can say regarding this question.

Ms. Clement

I would like to add that we are in contact with Mr. Autret, whom you certainly know, he is the director of the nutrition division of F.A.O. and he keeps us informed of all the new work and testing.

Mr. Robinet

Based on this report, it does not seem that he anticipates a great future.

Ms. Clement /049

For the present, he does not anticipate any industrial utilization. Based on what he has said, he will not invest much money. For now, he is content with carrying out tests among populations of different ages, adults and young people, and of different social origins. In the middle of December, 5,000 to 6,000 meals had already been

served. The algae were sold in 250 g bags and it seems they were easily marketed.

Mr. Robinet

Yes, there is a market problem. As long as the market is not saturated and prices remain within certain limits, namely within the possibilities of the family budget, there is not doubt that in Chad there will be no problem in placing this product on the market. The same cannot be said as far as the taste appeal of the product is concerned, when it is transported in the countries where there are great deficiencies, namely Congo Brazzaville, Minchasa, in those corners where there is a nutritional problem far greater than that of Chad, but where this product has not been tested.

Ms. Clement

In Asia or Latin America for example.

Mr. Robinet

I'd rather not leave the framework of Africa, since I don't know the other aspects of the question.

It is certain that in Africa, competitiveness between existing protein sources, available in short or medium term, that is to say intensive stock farming in cities such as Abidjan, Dakar, Lagos, Minchasa and the possibility of introducing algae as a food product do not favor the establishment of large African plants for the production of spirulines.

Mr. Moyse

I think that among the questions that have been presented, Mr. Remenieras has proposed: relative position of protein derived from

cultures of algae versus oil derivatives, technical and ecomonical points of view.

I don't know if very precise information is available regarding the cost price.

Ms. Meyer /050

From the economic point of view, we can cite the price announced by the B.P. society.

Mr. Van Landeghem

With reservations, however. Economic calculations made at I.F.P. regarding cost prices of yeast leave an extremely wide margin concerning the valorization of the oil gas derived from the procedure. The oil gas is dewaxed and proteins are produced. Based on the valorization rate given to the dewaxing, we can establish any cost price we want for the proteins. In other words, a high one, as long as we don't know too well how the decision has been made and what were its motives.

Mr. Delsol

This is the typical and frequent problem regarding the cost of products which are related and for which the establishment of cost price presents considerable difficulties.

I think that the price announced by the B.P. society is on the order of about 0.70 francs per kg (compared with 1.36 francs).

Mr. Van Landeghem

It is still the same factor 2. There is no doubt, based on our predictions, that since I.F.P. has developed a yeast procedure

the yeasts will be marketed better. How much better? We do not know exactly, because yeast production presents separation and drying problems which are not found with algae. Specifically, there is great reticence among possible consumers regarding aromatics, noted carcinogenic agents which will possibly remain in our product.

Mr. Moyse

Thank you very much Mr. Van Landeghem.

Do you want to pose other questions?

Mr. Lenain

I would like to ask a question regarding the nutritional medium you use for your cultures.

What is its basic chemical composition?

Ms. Meyer /05.

I cannot give you exact figures. It is a medium characterized by a high level of sodium bicarbonate. It is, therefore, an alkaline medium, with 9 to 9.5 pH.

Generally, the growth rate depends very little on the concentrations of the nutritional elements.

The nutritional medium can be composed more or less as we wish.

For a better industrial culture, we have used a medium not highly charged in salts, but controlled by continuous readjustment of the consumed salts. This method facilitates washing the algae when they are harvested.

The concentrations can be varied. These algae can withstand

very different salinities.

Mr. Lenain

Have you used urea?

Ms. Meyer

It would be quite interesting to utilize urea, which costs less than nitrates. However, it presents problems due to the discharge of ammonia.

Mr. Moyse

There are pH and temperature limits which can never be exceeded when using urea.

With pH8, in particular, if the temperature exceeds 40°, there is decomposition with formation of ammonia damage to the plants.

Mr. Delsol

I'd like to ask some technological questions.

Have you thought of using devices such as immersed combustion burners which make it possible to use liquid or gas fuels with high efficiency, since the bubbling of the combustion product makes it possible to stir directly the considered medium?

Mr. Van Landeghem /052

We have not considered this. There are certain aspects of the problem which have not been completely considered because the utilization of fuels that are very light or gaseous depends on how they are directed and the place where they must be introduced. This is why

the estimate mentioned by Ms. Meyer was made on a relatively neutral oil gas base, which can be found everywhere. Light fuels and gases involve heavy transportation. It is necessary to be situated near a gas depot or oil field.

For the present, we have put these solutions aside.

With established plants in Algiers we have tried to use other fuel sources with more efficient uses.

Mr. Delsol

It is true that in the case of Algeria or other African countries where there are substantial oil and gas deposits for example natural gas, methane, the combustion of this methane in underwater burners seems rational and economic.

On the other hand, as Professor Moyse just indicated, it is necessary to relate the productivity of the spirulines with insolation. Is it possible to measure the incidence of this insolation parameter and can we express productivity g /m^2/day as a function of light or insolation?

Mr. Moyse

I think that, given growth rates the crop values you have per m^2 and per day are more or less the same as those obtained with chlorella and correspond to efficiencies based only on the light fraction, on visible radiations. Efficiencies must be on the order of 4 to 6%, corresponding to quantitative requirements of about 100 quanta per molecule of assimilated carbon gas.

Mr. Trombe

I would like to ask Mr. Moyse what is the maximum CO^2 which

must be introduced for maximum efficiency?

Mr. Moyse

Considering only internal restrictions constituted by the organism's capacity for photosynthesis, it is on the order of 0.1% in air. In the liquid phase, taking into account the consumption rate and /053 the solubility factor, air injection is at about 1%, corresponding to an atmospheric equivalent of 0.1% since a substantial amount of gas does not dissolve.

Circulation time is not sufficient due to the shallowness of the cultures.

Mr. Delsol

As a result, the interest in underwater combustion burners.

Ms. Clement

The thermal problem is quite important. We had large basins, 30° is right.

Mr. Trombe

If you had 40°, how would that be?

Ms. Clement

No, 40° is too much if the temperature is maintained permanently.

Mr. Van Landeghem

The covering of water droplets constitutes already a filter against infrared rays.

Mr. Trombe

That alters the possible balance, especially in regard to polyethelene.

Mr. Moyse

Would you like to ask other questions?

If you allow me, I would like to draw some conclusions.

These cultures originated from the need to create new nutritional alternatives in regions with agricultural potential.

They originated also from a desire to utilize better a form of energy which is freely distributed and usually wasted.

The first problem which we encountered, as with all cultures, /054 was that of crop quality.

This problem of quality presents several aspects. First of all, there is composition. These unicellular organisms have shown to be good nutrients based on their high number of protein, greater in spirulines than in chlorella. They have also proved to be good supplements in those regions of the globe where food crops are products which are essentially carbohydrate. It is in the countries with rice that these cultures may be of the most interest, since in these countries, it is quite difficult to obtain protein and vitamin supplements.

It is not for regions where people consume the algae, as the Chad population, and where no deficiencies are manifested, as Ms. Brandily has shown. On the contrary, it is for those regions where there are protein deficiencies, the Indies, the Far East, Japan; it is not by chance that the Japanese are interested in

chlorella.

Another problem is that of taste. It is a personal business. As the I.F.P. engineers, I have gotten used to eating spirulines in Antibes; there isn't much to be said about it. It is not bad. Obviously, if we had to choose between steak and algae, we would not hesitate, but we must consider that not everybody can afford steak everyday.

It must be noted that these cultures have a certain "Jules Verne" character. This is not meant in a derogatory way, on the contrary. They are to be viewed within the framework of population growth, of the ever greater difficulty in finding usable surfaces and introducing economically feasible cultures on such surfaces or in the ground and, eventually, in water. The amount of lost water is partially recoverable and not as large as the amount of water lost with cultures produced in the ground in semi-arid countries, where infiltrations with evaporation constitute a very great source of waste.

In reviewing the history of these cultures, thinking back to 1948-49 to the first report in 1953 entitled "laboratory algae culture in pilot plant", we see that we have come a long way.

Estimates made in 1955 by Arthur D. Little were, if I remember correctly, ten times greater as far as cost price is concerned than those presently made.

Regarding taste, what occurred with the potato can occur here. Before Parmentier, the potato was already known in Europe. However, it was considered an inedible legume.

Nevertheless, it played a role in the lives of North Central /055
European countries. Among all the possible means which can be employed in fighting nutritional deficiencies, algae constitute one of the most interesting ones. The starting point is mixed, agriculture

and utilization of solar energy.

We still do not know the arrival point. What we can estimate is the progress within a period of 20 years.

The main progress has been made not through more powerful technology - the most powerful technology is that of Arthur D. Little and it led to failure - but through simplification by using organisms which are better adapted to readily available culture conditions and, probably, by combining, as you have done with spirulines, the technical problems of the cultures, the supplying of carbon gas and light.

For the present, it is essentially an economic and technological problem. The algae could serve as animal nutrition, although off hand this may seem a luxury (at least in my opinion). I think that the true use of the organism will be as direct supplement for people whose nutrition is unbalanced due to their high intake of carbohydrates.

In conclusion, I would like to thank everyone and in particular the individuals and engineers of Institut Francais du Pétrole, Mr. Balaceanu to whom I would like you to communicate our thanks, for having cooperated in this study session, Ms. Clement, Ms. Meyer, Mr. Van Landeghem, without forgetting those who are absent and thinking of Mr. Rebeller, Mr. Trambouze and all those who have carried out for a number of years these studies in Provence and Antibes, before continuing the project in Mexico and Algeria.