CO1978OPE05

ROLE OF RAPESEED OILS IN WORLD FOOD PRODUCTION AND THEIR NUTRITIONAL VALUE

By Arne Engström
National Swedish Food Administration, Uppsala

An introductory lecture is expected to be broad and integrated, therefore it is hardly justified to open with a detailed botanical-genetic discussion of the oil plants, especially as such a theme probably will be covered by the next speaker. But let me mention that this discussion includes rape (Brassica napus), turnip rape (Brassica campestris) and various types of mustard. My presentation therefore is a slight extension of the scope for the "Group Consultatif International de Recherche sur le Colza". It is interesting to note that in Webster's dictionary the English word colza is defined as "rapeseed especially when used as a source of rape oil", thus a more narrow definition than the French colza.

My presentation is divided into four parts, first some historical comments, then production, so nutritional aspects, and finally a few future outlooks. Let us therefore begin with some aspects of the history of man's use of rapeseed. Mustard and rape have been utilized by man for thousands of years. That the seeds of these plants really have been of interest to man very long ago appears from old sanskrit writings in India 2000-1500 B.C., as well as in Japanese literature from 2000 years ago. Particular mention should be made of the Harappan culture in India, that is the "Bronze Age Civilization" of the Indus Valley in about 2500-1500 B.C. It was a most interesting societal organization and to quote the Indian Academy of Science "One can see the picture of city centered prosperous cultural communities thriving on wheat, barley sesamum and mustard". In Europe cultivation of rape and turnip rape on a field scale started in the thirtheenth century although rapeseeds have been found in old German settlements together with mill stones.

In order to obtain some information of earlier uses of mustard and rape I found it interesting to consult the "Grosses vollständiges Universal-lexikon", printed in Leipzig and Halle in 1743 and consisting of 64 parts in 32 volumes each weighing about 10 pounds and beautifully printed. This gigantic encyclopedia is really a fantastic source of information of the knowledge at that time accepting that the various topics are somewhat disordered. Under the entry words Senf (mustard) and Rübsen some interesting notations are given. Under the entry Rapsen,however, the reader is referred to Rübsen. It may be natural to find that at that time more attention in the learned world was given to mustard seeds and mustard oil because of their wide spread medical uses. Therefore I may be excused if extending the discussion beyond rapeseed as such but I will be staying within the domain of Cruciferous oil plants. The well known allegory of the mustard seed in the Bible, Matheus XIII. 31, 32 is found in other connections. For example when discussing Pythagoras the old German text reads: "Der Senf-Saame hat den Vorzug unter den Saamen, quorum in sublime vis feratur; welches von einigen von der Krafft dieses Saamens in Hoch-Aufwachsen verstanden wird; von andern aber der Krafft des Senfes zugeeignet wird, welche in die Nase oder in das Gehirne aufsteiget".

A number of interesting piquant and sometimes equivocal uses of mustard are given but generally it seems that it was highly appreciated as an antifever agent. It was also used for prophylactic measures especially at times when plague was a threat. The well known anatomist Bartholin, who i.a. gave the serous vessels the name lymph ducts, is said successfully to have treated splenic maladies with a mixture of mustard and wine, spiced with urine. That Bartholin emphasized the role of the spleen is interesting because he was active in detronizing the importance of the liver.

Mustard as a spice to food has a long history and is for example mentioned by Charles the Great in a trade ordonance in 812. To give another example, the Pope Clement VII, weak and devious by nature, is said to have eaten mustard with every meal. When reading all the fantastic descriptions in the old text I could not help wonder if this habit could have had an effect upon his involvement and his actions or perhaps delayed actions in connection with Henry VIII:s divorce process with Catherine of Aragon in order to marry Anne Boleyn. But of course this is mere speculation, without any documentation, but it is easy to be carried away when reading contemporary texts.

The description of rapeseed is equally long and detailed in the German text from 1743. Exact cultivation procedures are given for Winterrübsen and Sommerrübsen. It is especially pointed out that the flowering fields are suitable for the keeping of bees. A problem seems to have been to scare birds away from the fields when the seeds were ripening.

The oil from Rübsen was at that time mainly used as burning oil in lamps but processes were developed to manufacture edible oils, although these in general were recommended to people in poor economic circumstances. In the latter part of the Middle ages rapeseed oil was the most important lamp oil in Europe, north of the Alps.

In this year 1978 when we celebrate the 200th anniversary of the death of Carolus Linnaeus it is timely to reread his botanical and ethnological descriptions issued as books describing his travels to various Swedish counties.

From the reports by Linnaeus it is known that there was a small cultivation of rapeseed in Sweden in the 1740's. In his "Västgöta Resa" that is travels to West Gothia, he tells us that a test cultivation of rapeseed was made by Mr Jonas Alströmer, who is famous for having introduced the potatoe in Sweden. In his "Skånska Resa" that is his travels in Scania, where we now are assembled, Linnaeus describes an oil mill used for processing linseed and rapeseed.

To move somewhat forward in time. In the nineteenth centure, the cultivation of rapeseed declined in western Europe, probably due to the appearance of mineral oil instead of rapeseed oil for illumination. On the other hand the cultivation of rapeseed extended into new areas - eastwards into Switzerland, Poland and Russia, northwards into Denmark and Sweden. Now let us travel rapidly in time to present days.

In the 1930's the production of rapeseed in Europe was only about 100-200 thousand metric tons per year. On the other hand the production in China, India and Pakistan at that time was more than 3 000 000 metric tons yearly. During the second World War when international trade for obvious reasons was reduced there was an increase in the rapeseed cultivation in

Europe and the commercial growing of rape in Canada started in the early 1940's. After the second World War rape has been an established crop also in Europe and Canada and today it ranks fifth among the major oilseeds of the world. In 1975 the world production of rapeseed was 8,1 mill metric tons.

Let us now take a look at the actual quantities of rapeseed and rapeseed oil produced. When studying the FAO-figures (The State of Food and Agriculture 1976) concerning the volume of the world production of vegetable oil and oil seeds (measured in oil equivalents) some interesting observations can be made. The total vegetable oils and oil seed equivalents have risen from about 27 mill metric tons in 1963 to about 42 mill tons in 1975, that is a factor of close to 1.6 in increase. In Western Europe the corresponding figures are 2 mill tons for 1963 and 2.5 mill tons in 1975, a factor of 1.25. The production of rape seed in Europe has risen from 0.4 mill tons in 1963 to 1.34 mill tons in 1975, a factor of nearly 3.4. It can also be observed that the production of olive oil diminished during that period in Western Europe.

In the North America the total vegetable oils and oil seed equivalents were 5.23 mill tons in 1963 and 9.76 in 1975, thus almost a doubling. In this total the main part are oils other than rapeseed but as said before Canada is an important producer of rapeseed. In 1975 the production of rapeseed in Canada was 1.64 (1.7) mill tons. But the largest production of rapeseed in the world still takes place in India, and China has a considerable production. The attached diagrams show the world production of edible oils and fats in the 1970's. A general comment to the figures in the diagrams and those previously given might be pertinent. The FAO-figures differ from those given in the publication "Oil World" but as said the FAO-figures are oils and oil equivalents. To the figures in Oil World the reservation is given that oil production is estimated on assumed extraction rates.

Anyway we are dealing with a world food commodity of considerable size.

Before discussion some human nutritional aspects of rapeseed and rapeseed oil I would like to mention the positive effect of rapeseed cultivations in agricultural practice. I refer to the breaking of a repetitions cultivation of for example wheat or barley with a cultivation of oil plants. The Swedish University for Agricultural Sciences reports that after a year of oil plants inserted into a continous agriculture of wheat or barley the yield of the latter can be increased up to 20 % as shown in the following table.

THE EFFECT OF THE YIELD OF BARLEY AND WHEAT WHEN THE PRECEEDING CROP WAS RAPESEED

Preceeding crop	Crop					
	Barley		Autumn wheat		Spring wheat	
	kg/ha	Rel	kg/ha	Rel	kg/ha	Rel
Barley/wheat	3090	100	4500	100	3540	100
Rapeseed	+300	111	+810	118	+730	121

In our country 60-70 % of the cultivated areas in the large agricultural districts are used for cereal productions, a production which is highly mechanized. The positive effect of an intervening oil plant cultivation cannot be compensated or replaced by an increase of the amount nitrogen fertilizers applied to the fields. The positive effect is probably to be sought in an diminishing or elimination in the soil of fungal parasites for cereals.

The economic yield from the oil seeds themselves and their positive effect on the yield of e.g. barley and wheat the following year thus make rapeseeds an important agricultural product in Sweden. In 1975, to give a figure comparable to those given earlier,the production in Sweden of rapeseed was 0.33 mill metric tons.

Unfortunately time does not permit me to enter a discussion on the role of rapeseed products in animal feeding so let me proceed to some comment on some aspects of rapeseed oils when used in human nutrition. This field is well covered by the report of an expert consultation on dietary fats and oils in human nutrition jointly organized by FAO and WHO in Rome in late September 1977. This report emphasizes two aspects, both the importance of fats in food, and the safety and health aspects. Dietary fat has the following important functions:

- as a source of energy, about 9 kcal per gram
- for cell structure and membrane functions
- as a source of essential fatty acids (EFA)
- as a vehicle for oil-soluable vitamines
- for control of blood lipids.

In addition one could mention:

- fat makes food palatable
- fat is important for food preparation i.e. cooking
- fat is important in food processing.

In the nutritional debate in the industrialized, wealthy nations two components are presently subject for a lively discussion, fat and sugar i.e. the common disaccaride. The opinion is that the average caloric intake of both components should be lowered. Concerning dietary fat is also pointed out by the expert group that the portion of unsaturated fatty acids should be increased. Now, favourably, most vegetable oils used for human consumption are relatively rich in polyunsaturated fatty acids, primarily linoleic acid (18:2, n- 6) but in some oils other variants are present. Such fatty acids are easily autooxidized if not protected. Inherently vegetable oils contain antioxidants. Vegetable oils contain vitamins of the E-family which are naturally stabilizing the oils. The modern oil industry has developed refined methods to produce vegetable oils as bland and colourless as possible. During heat treatment the fatty acids in vegetable oil could undergo structural modifications. This was already observed in a thesis "Planting of Oil Seeds in Sweden" from 1810. There it is said "If you do not want to spoil the oil such a heat should be avoided so that not the least burning takes place". Strangely enough this is a problem in the modern society and I am referring to the frying oil baths in road side eating places and restaurants. The quality of the frying oil used for example

in preparing pommes frites usually called French fried potatoes must be regularly checked with respect to formation of strange condensation products which are indigestible and badly tasting.

In the developed countries the average energy intake from fat is relatively high, 35-45 energy percent. The nutritionists are mentioning about 30 % or slightly thereabove as a suitable average intake. In many developing countries the caloric intake from fat is low, 10-20 per cent. Thus FAO-WHO states that on a global basis there could be an approximately sixfold difference in the fraction of energy that is derived from fat by various populations. From that point of view there is certainly room for an expansion of the edible oil industry in the world.

Mention should be made of the dietary fat deficiency syndrome described in 1930. The syndrome developed because of lack of linoleic acid in food. It is now well established that linoleic acid and possibly α-linoleic acid are essential fatty acids in human nutrition. The physiological function of these fatty acids are closely interrelated with prostaglandins, tromboxanes and prostacyclin. I will not enter this exciting research field in detail but only make a reference to the FAO-expert group,which states that for human adults a dietary intake of 3 % of essential fatty acids is to be recommended. For populations having a high incidence of atherosclerosis higher amounts may be required. What one has in mind is about 30 % energy intake from fat with a ratio of saturated to poly-unsaturated fatty acids of 1:1. Further research work is going on and we have not yet seen the end of the dietary fat debate.

In Sweden the main domestic source of polyunsaturated fatty acids are the Brassica oils, rapeseed oils. For this reason and the previously mentioned positive effect of oilseed cultivation on the yield of sub-sequent cereal crops, the cultivation of rapeseed is an important part of the Swedish agricultural economy.

There is one aspect of rapeseed oil intended for human consumption which merits somewhat further discussion. That is the physiological role of fatty acids with more than 18 carbon atoms in the chain and occurring in vegetable oils. Long chain fatty acids also occur in marine oils. Particularly the erucic acid (CIS-Δ13-docosenoic acid, 22:1, n-9) has attracted considerable attention after animal feeding experiments showing its effect on the heart muscle. It is not surprising that those long chain fatty acids attract interest as they are not normally occurring in the human organism. If such acids are incorporated in the cellular membrane systems via food intake the question arises if the molecular properties of membranes are changed. That this is a vital question, scientifically and practically, is evident from the fact that the membrane systems are essential elements, in energy converting organelles in the cell, in signal transmission e.g. in the nerves, the reception of light in the eye, in the upkeeping of concentration gradients between cellular compartments, and in absorption, transport and excretion phenomena,only to mention a few vital functions where membraneous structures are involved.

Regarding the effect of erucic acid on the mammalian organism, it has, as is well known, been demonstrated in animals, that if the calory or energy intake is above about two percent there appear damages to the heart tissue in the form of fat inclusions, which later develope into small scars. Controversial results have been presented, some of which are

claiming that there is another factor present in rapeseed causing the changes. In humans, however, no direct evidence has been found of such effects of erucic acid although scars of similar nature in the heart tissue are found at post mortem studies. The etiology of these scars are unknown, vital infections could be one source. It is therefore of interest to read the following statement from the FAO-WHO expert group "In the light of present knowledge from animal studies, it seems prudent to recommend, for populations in which fat constitutes a high proportion of dietary energy, (a) the reduction of the erucic acid (22:1, n-9) in brassica oils and/or (b) the blending or use of brassica oils with other fats and oils. This recommendation, which may be of special importance for children, may have to be modified in the light of further data from human studies". As an additional information it is worth mentioning that the Codex Alimentarius Commission is developing standards for oils with a low content of erucic acid.

In order to meet the demands for a lower content of long fatty acids, especially erucic acid, in rape, the plant breeders have been successful in bringing out new varieties with a very low content of erucic acid. In order to act to the best scientific knowledge the National Swedish Food Administration developed in cooperation with the edible oil and margarine industry a scheme for trapping down the content of erucic acid in margarine. It is now very low. That this is adhered, too, the National Swedish Food Administration has been able to establish by repeated analyses. The attached extract from the recent Nutrition Tables from our Food Administration shows the low content of erucic acid in the margarine on the Swedish market. As we are not living of margarine alone at least in our country the average caloric intake due to erucic acid in Sweden is at least 10 to 100 times below the smallest doses which have been demonstrated to cause myocardial damage in animals. In relation to present knowledge and present state of research the situation in our country therefore is satisfactory in this respect. But surely we will hear more about these problems in the future. New knowledge, however, has to be scrutinized carefully because in a field of such an economic size as food production, competition between various products is strong and sometimes even science becomes biased. Let me here quote the cyclamate-sugar interests. Be how it is with this, the discussion should be taken calmly and seen in the light that we are and have been consuming food from various sources. Therefore my nutritional message is very simple, eat little of everything, control your total caloric intake and exercise regularly. In addition enjoy a well prepared meat, the stress of always being a puritan can also that cause disturbances for example of a psychosomatic nature.

Finally I would like to discuss briefly the protein portion of rapeseeds and its use for human food. Much developmental work is taking place all over the world to make this protein source useful to man. One can not say that there is an increased tendency to add vegetable proteins to products classically made from animal proteins. Also textured vegetable proteins are finding an increased application. This is a development which must be welcomed but some warning signals have to be raised. As some people are allergic to certain vegetable proteins it may be necessary to label the food products properly, so that the consumers are fully informed.

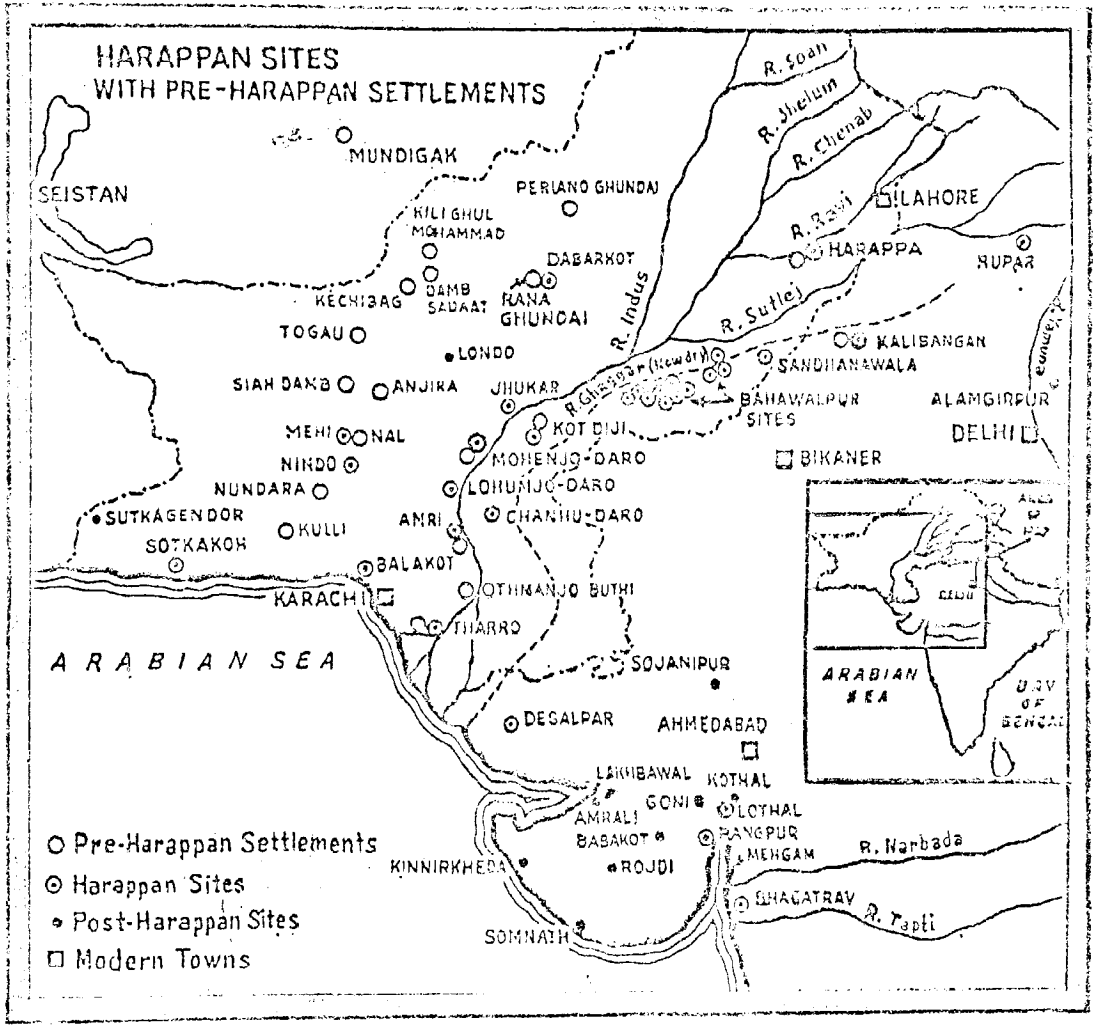
In other cases like that of rapeseed protein it may be difficult to obtain it so pure that undesirable components are not contained in the final product. Plant seeds contain the anion phytate which is known to

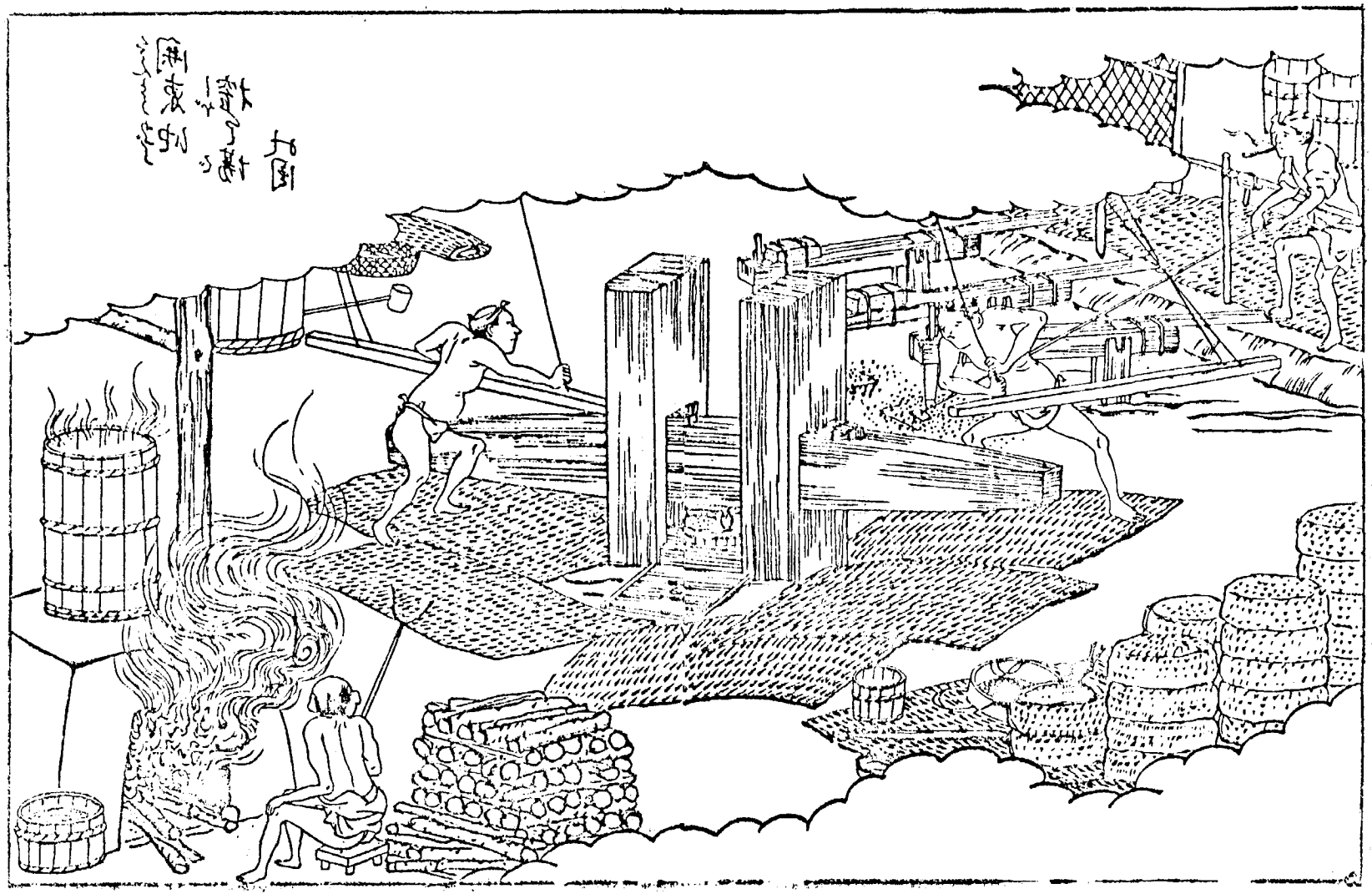
bind zinc and other minerals and concomitantly, zinc and other minerals have been demonstrated to improve the utilization of protein. Meat is a valuable source of zinc and other trace elements. Therefore the phytate content of a plant protein being used as meat additive or substitute must be kept low and an assessment of phytate on the bioavailability of zinc and other minerals must be made. In this connection it may be of interest to follow the research on the enzyme phytase which hydrolyses phytic acid to inositol and phosphoric acid. Rape seeds contain according the sources I have consulted little of this enzyme. If the oil plant breeders by some molecular engineering which by a more complicated terminology is called recombinant DNA-research could introduce a gene for an inherent increased phytase content to be active in the processing of oils a great step forward would be made. Or a gene depressing the content of phytate.

The content of glycosinolates in rape seed meal have lessened its use as animal feed. Though plant breeding the glucosinolate content is reduced. This achievement increases the possibilities to use rape seed protein for animal feeding and by adequate technological processes it is possible to use this protein as human food.

At last it may be worth mentioning that rapeseed oil has and probably will have to greater extent industrial applications. I am not thinking of its old use as burning oil but rather as lubricating products in advanced machineries and high speed mechanical production. Strangely the long chain fatty acids will here be of an advantage. From an agricultural point of view this presents problems of persisting seeds in the soil if one alternately wants to grow rape with a high and a low erucic acid content. Climatic conditions also determine the type of crop to be grown. Mention should also be made about possible future uses of these oils in the advanced chemical and drug industry.

My presentation may appear to many of you as not having brought any new scientific discoveries or theories but I took it as my duty in this introductory lectury to paint a broad panorama in connection with rapeseed oil. As a medical molecular biologist and crystallographer I would have liked to have treated in detail the structure and function of membraneous structure and their connection with different lipids. But rather, let me, as I have used the time allocated for my presentation to express that both as scientist and administrator I am convinced that the proceedings of this conference will yield results of great value for a further understanding of our important nutrient, rapeseed. I wish you all luck.


HARAPPAN SITES
WITH PRE-HARAPPAN SETTLEMENTS
MUNDIGAK
SEISTAN
PERIANO GHUNDAI
KILI GHUL MOHAMMAD
DABARKOT
KECHIBAG
DAMB SADAAT
RANA GHUNDAI
TOGAU
LONDO
SIAH DAMB
ANJIRA
JHUKAR
MEHI
NAL
KOT DIJI
NINDO
MOHENJO-DARO
NUNDARA
LOHUNJO-DARO
SUTKAGENDOR
KULLI
AMRI
CHANHU-DARO
SOTKAKOH
BALAKOT
KARACHI
OTHMANJO BUTHI
THARRO
ARABIAN SEA
SOJANIPUR
DESALPAR
AHMEDABAD
LAKHIBAWAL
KOTHAL
AMRALI
GONI
LOTHAL
BABAKOT
RANGPUR
KINNIRKHEDA
ROJDI
MEHGAM
R. Narbada
SOMNATH
BHAGATRAV
R. Tapti
R. Indus
R. Sutlej
R. Jhelum
R. Chenab
R. Ravi
LAHORE
HARAPPA
RUPAR
KALIBANGAN
SANDHANAWALA
BAHAWALPUR SITES
ALAMGIRPUR
DELHI
BIKANER
R. Ghaggar (Hakra)
Pre-Harappan Settlements
Harappan Sites
Post-Harappan Sites
Modern Towns



Några Anmärkningar

om

Oljevåxters Plantering i Sverige,

Med

Philoſophiſka Facultetens bifall

under inſeende

af

M. ANDERS JAH. RETZIUS

Hiſtor. Natur. Oecon. och Chem. Profeſſor, Phyſiogr. Sällſk. Secr. Ledamot af K. Sv. Vet. Acad. K. Sv. Patriot. K. Finſka Hushålln. Kejſ. Ryſka Oecon. K. Danſka Vetenſkaps och Medicinſka Sällſk. Linn. Soc. i Lond. Vet. Acad. i Padua och Mantua, Acad. Natur. Curioſor. Berlinſka och Danſka Natur Hiſt. Sällſk. Phyſiſka Sällſk. i Jena och Göttingen. Phytogr. Sällſk. i Göttingen. Götheb. Vet. och Vitt. Sällſk. Heſſen-Homb. Patriot. Svenſka Uppſoſtr. Sällſk. ſamt Correſp. af K. Turinſka Vet. Acad. och Leipziger Oecon. Sällſk.

För GRADEN

förſvarade

af

H. M. RÖNNOW

Skåning,

d. 21 Junii 1810.

Lund, 1810.

Tryckt hos Directeuren CARL FR. BERLING.

The effect on the yield of barley and wheat when the preceeding crop was oil plants

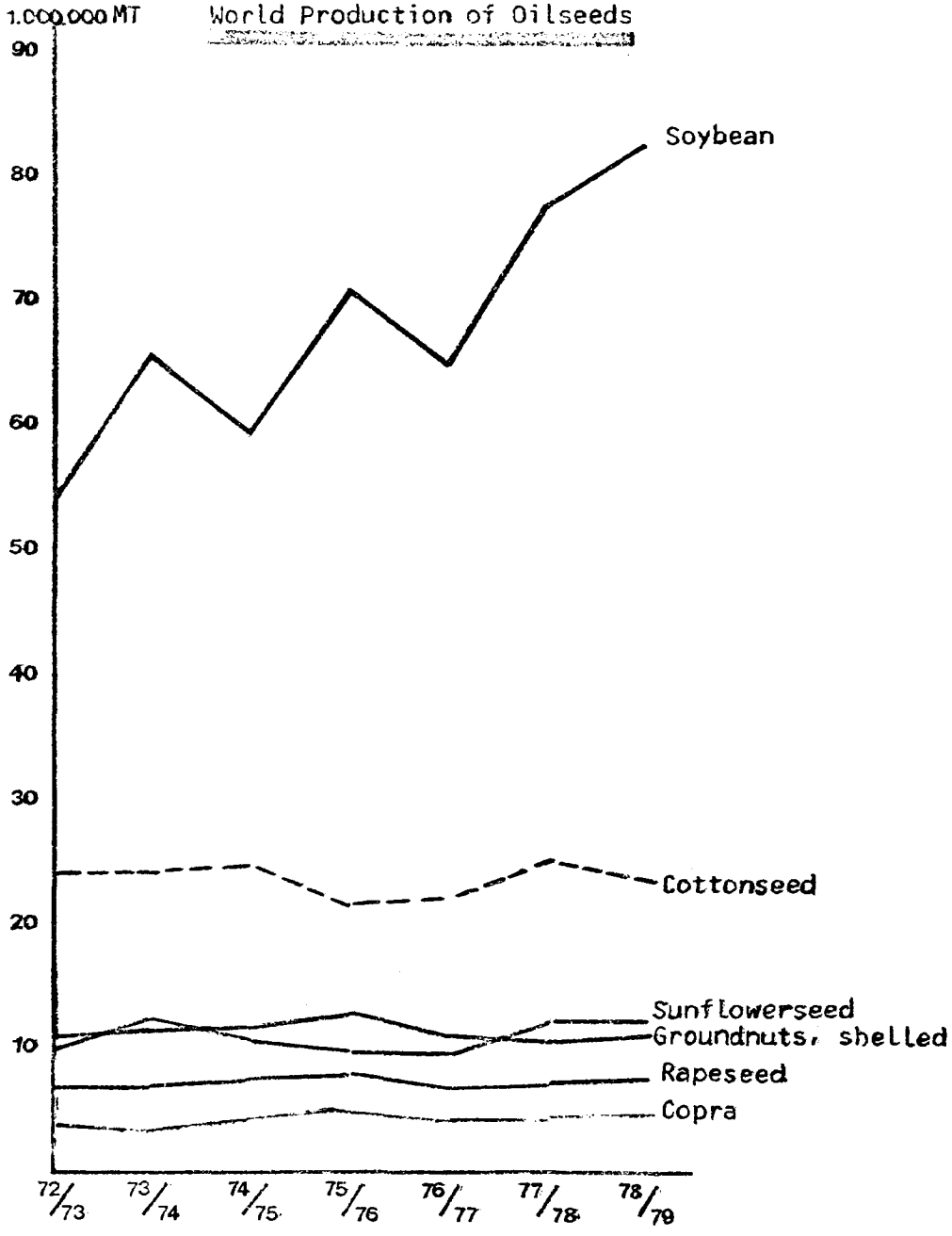
Preceeding crop	Crop					
	Barley 29 experim.		Autumn wheat 31 experim.		Spring wheat 33 experim.	
	kg/ha	Rel	kg/ha	Rel	kg/ha	Rel
Barley/wheat	3090	100	4500	100	3540	100
Rape	+300	111	+810	118	+730	121

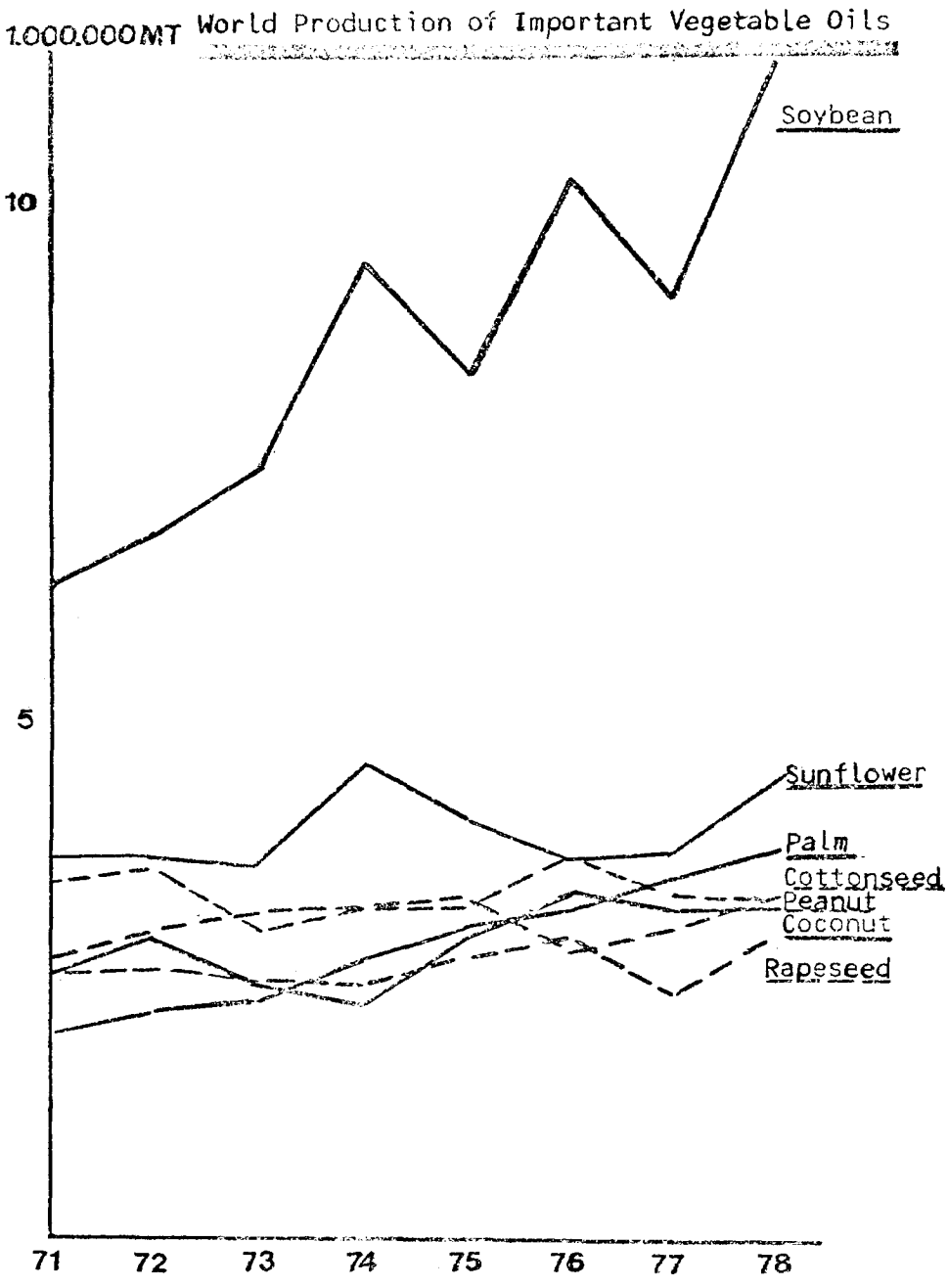
Dietary fat has the following important functions:

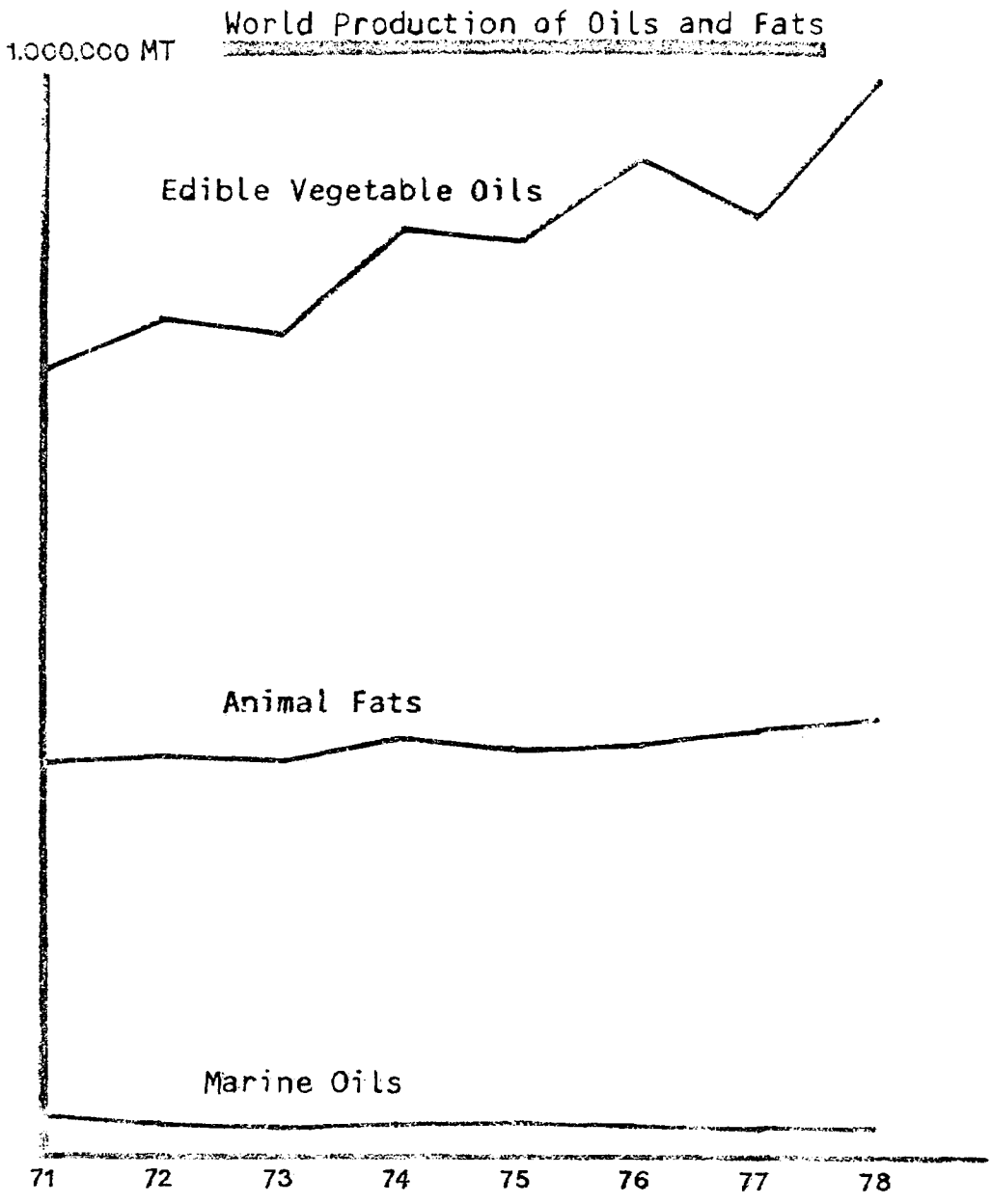
- as a source of energy, about 9 kcal per gram
- for cell structure and membrane functions
- as a source of essential fatty acids (EFA)
- as a vehicle for oil-soluable vitamines
- for control of blood lipids.

In addition one could mention:

- fat makes food palatable
- fat is important for food preparation i.e. cooking
- fat is importent in food processing.


1.000.000 MT
World Production of Oilseeds
90
80
70
60
50
40
30
20
10
Soybean
Cottonseed
Sunflowerseed
Groundnuts, shelled
Rapeseed
Copra
72/73
73/74
74/75
75/76
76/77
77/78
78/79


1.000.000MT
World Production of Important Vegetable Oils
10
5
Soybean
Sunflower
Palm
Cottonseed
Peanut
Coconut
Rapeseed
71
72
73
74
75
76
77
78


World Production of Oils and Fats
1.000.000 MT
Edible Vegetable Oils
Animal Fats
Marine Oils
71
72
73
74
75
76
77
78