RAPESEED RESEARCH AND UTILIZATION

About the article

A roundtable discussion on rapeseed research and utilization was held during November in Munster at the invitation of the Federal Center for Lipid Research in Munster. The following report on that meeting was prepared by Bernadette Hudalle, a nutritionist at that center.

More about Rapeseed

Since 1974 several new varieties of rapeseed are being cultivated in Germany. The availability of varieties which are virtually free of erucic acid and poor in glucosinolates may lead to an increase in the acreage for the production of this crop. These developments have raised various questions which were discussed in the fall of 1974 by an international group at the Federal Center for Lipid Research in Munster.

In response to an invitation by the Federal Center a new roundtable discussion on the status of rapeseed research and utilization took place on November 26, 1976, in Munster. The session was chaired by H.K. Mangold, who welcomed scientists from Egypt, India, Hungary, The Netherlands, and Poland to discuss with their German colleagues various topics of common interest. Several participants had reported about their work at the '75 meeting of the German Society of Fat Science (DGF), at Hamburg, and their papers have since appeared in *Fette Seifen Anstrichm.* The DGF has published a symposium issue "Low Erucic Acid Rapeseed, Their Oils and Proteins," which contains twelve articles, seven of which are in English.

The following topics were treated at the roundtable discussion: agronomical aspects of new rapeseed varieties, analytical methods, nutritional properties of oils and proteins from new varieties of rapeseed, and the economic significance of this crop in the world and in the European Community.

Agronomical Aspects

G. Röbbelen from the Univesrity of Göttingen, who played a decisive role in the breeding and introduction of new rapeseed varieties in Germany, opened the discussion. He pointed out that, on a worldwide basis, rapeseed occupies the fifth position among oil-producing crops, and he ventured to predict that rapeseed will gain in importance during the next decade. He emphasized that in Central Europe as well as in Scandinavia, rape is the only major crop that can be used for the production of vegetable fats and oils. Thus, it is no surprise that the Federal Republic of Germany, for example, covers by domestic production only about 8 percent of the vegetable oil consumed. Domestic production of rapeseed amounts to about 180,000 tons, annually. The vegetable oil consumed in this country is derived mainly from soybean, most of which is imported from the United States. In 1975, the Federal Republic imported (in 1,000 tons) a total of 3,463 soybean, 413 copra, 126 sunflower, 116 rapeseed, and 226 other oilseeds.

In Central Europe the yields of rapeseed, on a per acre basis, are remarkably high. In fact, 1,000 kg of rapeseed oil and 590 kg of protein can be produced per ha. On the average, rapeseed contains about 40 percent oil and 24 percent protein; whereas the values for soybean are 20 and 42 percent, respectively.

It can be expected that throughout Europe the acreage used for the production of rapeseed will be increased in the years to come by possibly about 50 percent or even more. Yet, at locations which are most suited for rapeseed production, its density frequently is already more than 25 percent of the acreage. A more even distribution of this crop over the total available acreage should be attempted. In general, expansion of rapeseed acreage is not only a matter of stable and healthy rotations but also a question of price relations in the market between the different competitive crops.

The conventional varieties of rapeseed contain an oil characterized by an erucic acid level of as much as 50 percent. Since it has been suggested that high levels of dietary erucic acid may be detrimental to human health, effort has been made in several countries to breed rapeseed whose seeds are practically free of erucic acid. Since the first "zero erucic" variety of winter type, called 'Lesira', was licensed for commercial production in the Federal Republic of Germany, two more "generations" of cultivars were developed. The first to follow 'Lesira' were the varieties 'Expander' and 'Erra,' while recently 'Rapora' and 'Quinta' were released. With each step, considerable genetic increases were achieved not only in yield capacity but also in winter hardiness and other characteristics of reliable productivity.

The seeds of new varieties of rapeseed, as grown in Germany, contain an oil with less than 1.0 percent erucic acid, almost 60 percent oleic, 20 percent linoleic, 10 percent linolenic, and less than 10 percent of saturated fatty acids. In addition, varieties having reduced levels of glucosinolates are at present being efficiently developed in the nurseries of German plant breeders. The first "double-low" cultivar 'Erglu,' which was released for production in Germany already in 1973, was of the spring type. Because

of much higher yields, per hectar, for rapeseed production in Germany, more than 95 percent of the acreage is sown with winter type varieties. For large scale production, according to Röbbelen, productive winter varieties will be on the market only after about another 5 years. These varieties then are expected to be virtually free of erucic acid and glucosinolates.

The representative of one of Germany's leading seed-producers, G. Rakow, related the characteristics of a number of new rapeseed varieties which are being offered at present. He confirmed that a great number of additional varieties, including 'double-zero' varieties are being tested by the Federal Bureau of Variety Registration.

The plant breeders and agronomists participating in the discussion agreed that, due to the climatic conditions prevailing in Central and Northern Europe, neither sunflower nor soybean could be grown in larger scale.

Analytical Methods

W. Thies from the University of Göttingen reported on problems concerning the analysis of glucosinolates. Hitherto, these substances were quantitated by gas chromatography as their trimethylsilyl derivatives. In autumn 1976 it was found impossible to use this method for the analysis of about one third of the seed samples which were supplied by the plant breeders. Clearly, one reason was the very low glucosinolate content (<10 μmole/1g defatted seed meal) of the new genotypes. Additional factors, such as the higher sugar contents of the seeds interfered with the derivative formation. Trials to adapt a method proposed by Thies [*Fette Seifen Anstrichm.* 78:231 (1976)] i.e. enrichment of the glucosinolates by ion exchange failed until now. The glucosinolates were converted into different salts (K^+, Ba^{++}, Pb^{++}, pyridine, trimethylammonia) but all of them had unsatisfactory properties. Meanwhile the glucosinolates are analyzed as nitriles after thermolysis (Thies, *Proc. Intern. Rapeseed Conf. 1974*, p. 257).

Nutritional Effects of Rapeseed Oils

One of the leading experts in this field, R. Vles of the Unilever Research Laboratories in Vlaardingen, The Netherlands, presented a thorough and detailed survey of present knowledge on the pathogenic effects of erucic acid and other monounsaturated long chain fatty acids. Working with rats, he studied the nutritional properties of various rapeseed oils over a period of six months. Of particular interest to all those working on nutritional aspects was his histomorphometric method for determining the incidence and severity of myocardial damage in various animals. Vles and his colleagues have recently described this method [*Fette Seifen Anstrichm.* 78:128 (1976)]. The very significant finding of the group working in Vlaardingen is that rapeseed oils with 2 percent erucic acid exhibit nutritional properties similar to those of soybean oil.

J. Pucsok from the Institute of Pathophysiology, Medical University, Budapest, Hungary reported on some biochemical and histological studies in conjunction with an investigation of the effects of various cardiopathic diets. In short, the Hungarian group made the following observations: in long-term as well as in short-term feeding experiments myocardial lesions were found which correlated with an accumulation of free fatty acids and triglycerides both in the myocardium and the serum of "minipigs." These findings were supplemented by ECG-studies, which showed typical "infarct curves." Analyses of the lipoproteins in serum as well as electron microscopy of mitochondria were also carried out. All of these methods revealed that the accumulation of lipids, the incorporation of long chain monoenoic fatty acids into various lipid classes, the weak binding of lipids to serum albumin, and the strong binding of fatty acids to mitochondrial membranes have an influence on the metabolism of heart mitochondria. All of these factors exert an influence on the function of the heart muscle The Hungarian group suggested that cardiopathogenetic diets, both those with high and those with low concentrations of conventional rapeseed oil, accentuate the various biochemical and histological changes observed.

It appears surprising that in almost all investigations concerned with the nutritional properties or erucic acid and oils containing this fatty acids, the lipids in various tissues have been studied extensively whereas the lipoproteins in the sera of the experimental animals were neglected. Irene Reichwald-Hacker reported about pertinent work at the section "Nutrition and Nutritional Biochemistry" of the Federal Center's Institute of Biochemistry and Technology. The lipoprotein patterns in the sera of rats fed various oils were determined by electrophoresis. The low density lipoprotein (LDL), very low density lipoprotein (VLDL), and high density lipoprotein (HDL) fractions were separated by ultracentrifugation. The lipid composition of these fractions is being determined.

An investigation regarding the influence of hydrogenation on the nutritional properties of low-erucic acid rapeseed oils, which Irene Reichwald-Hacker carried out in cooperation with K. Ilsemann and K.D. Mukherjee, has recently been published [(*Fette Seifen Anstrichm.* 78:181 (1976)]. In groups of rats fed 'Lesira' oil and hydrogenated 'Lesira' oil, half of the animals exhibited myocardial lesions of light degree, whereas in groups fed soybean oil and hydrogenated soybean oil only one-eighth of the animals examined showed such effect. The occurence and severity of the myocardial lesions are known to be much higher in rats fed conventional rapeseed oils.

Hildegard Kaiser and Bernadette Hudalla are trying to find whether or not different varieties of rapeseed contain constituents other than erucic acid and glucosinolates, which show detrimental effects in rats. They are studying the nutritional properties of the surface lipids of rapeseed, of the nonsaponifiable fraction of rapeseed oil, and of the total lipids of cell cultures. These cultures are known to be rich in sterylglycolipids and other unusual compounds, which are found in much smaller proportions in the seeds and in various other parts of the rape plant.

Before entering the discussion on proteins H.K. Mangold related plans on studying the nutritional effects of rapeseed oils in nonhuman primates. At the outskirts of Munster, just a few miles from the Federal Center for Lipid Research, a Primate Center was established a few years ago. Working with the center, the nutritionists of the H.P. Kaufmann Institute are going to investigate the effect of vegetable oils on the functions of various organs, on the patterns of lipoproteins in the serum, and on the composition of subcellular particles in the heart of rhesus monkeys. This rather ambitious and fairly expensive study will be supported by several government agencies. In addition to Irene Reichwald-Hacker, Hildegard Kaiser, and Bernadette Hudalla, two guest scientists, a biochemist, and a veterinarian are expected to participate in this venture.

Nutritional Effects of Rapeseed Proteins

It is well known that rapeseed meal can be used as animal feed to a very limited extent, although its amino acid pattern is quite favorable. This is due to the presence of glucosinolates, whose degradation products exhibit toxic effects in many animal species. Since plant breeders have so far not been entirely successful in getting varieties free of glucosinolates it appears desirable to evolve technical processes for the easy and inexpensive removal of these substances and their degradation products. K.D. Mukherjee, who is heading the section "Technology" of the Federal Center of Lipid Research, discussed two methods for the production of low glucosinolate rapeseed meals, which he developed in cooperation with A.B. Afzalpurkar and A.S.

El Nockrashy. In the first method, successive extraction or countercurrent extraction of myrosinase-deactivated ground rapeseed with 70% aqueous acetone for the removal of glucosinolate is followed by defatting using pure acetone. In the second process, autolysis of ground rapeseed by the action of heat, moisture, and myrosinase for the decomposition of glucosinolates is followed by defatting using hexane with simultaneous removal of the decomposition products of glucosinolates. Both processes yield low-glucosinolate rapeseed meals having favorable nutritional properties. Especially the process involving autolysis is simple and inexpensive and practically none of the proteins is lost. This process can be easily adapted to the conventional processing of rapeseed. Studies with rats were carried out to determine the nutritive properties of meal, obtained by the aforementioned methods. The techniques developed by K.D. Mukherjee, A.B. Afzalpurkar, A.S. El Nockrashy were described in *Fette Seifen Anstrichm.* 78:306 (1976); the results of nutritional studies will be published elsewhere.

K.D. Mukherjee also referred to a process for the preparation of protein isolates from new varieties of rapeseed. This process, which was developed by A.S. El Nockrashy, a guest scientist from the Research Center at Cairo-Dokki, Egypt, in cooperation with scientists of the Federal Center in Munster, has just been published in *J. Agr. Food Chem.* Rapeseed meals and proteins prepared therefrom were fed to chicks as well as to rats. These studies revealed better performance of the protein isolates as compared to the corresponding meals.

Nutritional studies with rapeseed meals have been carried out also at the Institute for Animal Nutrition of the Federal Center for Agriculture in Braunschweig-Völkenrode. U. Petersen, who carried out this work together with E. Schulz, reported that, in pigs, extracted meal derived from the rapeseed variety 'Erglu' had no effect on the meat quality of slaughtered animals, though a linear increase in the size of liver and thyroid was still found with increasing proportions of such rapeseed meals in the rations.

H. Henkel, University of Kiel, emphasized that broilers, pigs, and other domestic animals respond to dietary rapeseed meal with a slackening of the rate of growth. This effect is most pronounced in broilers. In his opinion it cannot be due solely to the presence of glucosinolates in the meals. Of all the rapeseed meals tests, 'Erglu' meal exhibited the most favorable nutritional properties.

In the countries of the European community about 500,000 ha of land are being cultivated with rapeseed. As a consequence, analytical standards for low-erucic rapeseed oils have to be developed in conjunction with the *Codex Alimentarius* standards for fats and oils. In view of the results of nutritional studies it is planned to set a limit of 10% erucic acid for low erucic acid oils, beginning in 1977. A year or two later, this limit is expected to be reduced to a level of 5% within the EC-region.

One fact emerges clearly from the foregoing discussion: the seeds of new varieties of rapeseed will play a considerable role in contributing to the demand for edible oils and proteinous food for the world's increasing population.
