RAPESEED IN A CHANGING WORLD: PROCESSING AND UTILIZATION

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The cultivar development of high erucic acid C22:1 (HEAR) rapeseed has been traced back to early Europe, India and Asia, prior to the advent of electrical power. The main thrust of subsequent improvement programs was primarily directed to increasing yield. However, by 1970, nutritional concerns for rapeseed initiated a program in Canada, which resulted in the rapid development of new varieties (Canola) with low erucic acid content (LEAR). Additional varieties were then developed in Europe and Australia, resulting in the complete commercial conversion to LEAR production in EC-12 (European 12 countries) by 1990. These changes have allowed rapeseed (LEAR) to meet the increasing quality and nutrition demands in our rapidly changing world.

UTILIZATION

Since the early 1960's, a rapidly increasing world population, plus a gradually improving economic standard, have stimulated the utilization, or disappearance of products from the oilseed industry. As a result, total oil crops and their products have become the second most valuable commodity in world trade. Despite the fact that the soybean has served as the major oilseed around the world, combined rapeseed/canola utilization enjoyed the highest percentage annual growth of all the oilseeds over the period 1957-1986, with an average increase of 6.2 percent per year. As a result, the oilseeds Brassicas, (rapeseed, canola and mustard) contributed over 13.2% of the world's edible oil available for utilization.

World Fats and Oils

The classical concept for supply and demand is that demand is the leader and supply will increase or decrease to satisfy the demand. An example of the production and disappearance figures over the last 10 years, as supplied by Oil World September 1989, indicates that the world will consume more fats and oils when more has been produced. This of course assumes that all other factors, such as economic and political, remain the same. Thus, utilization is directly linked to the availability of oilseed products.

In 1980/81, both production and disappearance were reasonably close at approximately (ca.) 155 million metric tonnes (Mt) (T. Mielke 1989). Disappearance exceeded production by a gap of 3.9 Mt (Figure 1). Since that time, usually there was an excess in production vs. disappearance for a particular year, followed by a gap when disappearance was greater than production. In 1988/89, production fell below 200 Mt and disappearance fell accordingly to result in a gap of 1.4 Mt. It appears that 1989/90 global supply/utilization will be closely balanced at approximately 210 Mt. There is already a strong unsatisfied per capita consumption demand for edible oils in the highly populated countries of Asia and Africa, as well as in the developing countries, such as the USSR and Eastern Europe. In these areas, when the price goes up, the utilization goes down and utilization goes up when the price goes down.

S. Mielke (1989) informs us that world availability of oil crops for utilization has increased by 172% over the last three decades. By decade, there have been increases of 10.4 Mt during the 1960's, 18.4 Mt in the 1970's and ca. 21.2 Mt during the 1980's. As a result, the quantity of the 17 major oils and fats available was ca. 79.1 Mt for 1990. In 1960, world availability of fats and oils was 29.0 Mt. By 1970, This had grown by 36% to 39.4 Mt. In 1980, supply rose to 57.9 Mt, an increase of 47%. By 1990, an additional increase of 37% was achieved, to exceed 79 Mt utilized for the first time in history.

During this period there was also a major change in the utilization, or disappearance of fats and oils around the world. Non-vegetable fats and oils, such as butter, lard, tallow and fish oil dropped from a 39% share of the market in 1960, to 26% in 1990. Major seed oils, such as soybean, rapeseed/canola and sunflower, increased from a 22% share in 1960, to 39% in 1990. However, palm oil achieved the most rapid rate of increase from a 4% share in 1960 to 14% in 1990. Other oils, such as lauric, cotton and specialty oils, fell from a combined 35% share of the market in 1960 to 20% in 1990.

With regard to the average world utilization of fats and oils, total world availability was 13.09 Mt during the period 1909-1913 (Figure 2). This compares to 70.86 Mt during 1985/86, for an increase of 441%. In the meantime, world population (10^9) grew from 1.7 to 4.9 over this same period, for a growth of 188%. Similarly, per capita consumption (kg) increased from 7.7 to 14.8, or +92%. Thus, the huge increase in world availability of fats and oils has been readily consumed by a rapidly increasing world population, combined with a major increase in per capita consumption.

Two-thirds of the world's fat and oil consumption is from oilseeds. Three annual crops, soybean, sunflower, rapeseed/canola, and one tree crop, palm, provide ca. 73% of all vegetable oil consumed around the world. Soybean oil supplies approximately 25% of the total. Since the beginning of the century, the percentage of total fat consumption through vegetable oils rather than animal fats has increased from ca. 24% to 70%. However, there are considerable differences in fat consumption among the world's regions and countries, due primarily to the differences in the purchasing powers.

In 1989, for example, the average world per capita consumption for fats and oils was 10.4 kg. For developed countries, the per capita consumption ranged from 16.4 kg in Japan to 47.2 in the Netherlands. In developing countries, the consumption ranged from 4.3 kg per capita in Bangladesh to 14.0 kg in the USSR, while China was 4.7, India 5.9, and Nigeria 7.2. China had a huge compounded growth rate of 12.2% during 1979-1984 and an 8.0% estimated growth rate over the 1984-1989 period.

Fats and oils consumption has been growing at a slower rate in the higher income countries of Europe, Japan, and the United States. Over all, the developed countries had a strong increase in consumption during 1979-1984, followed by a slowing growth trend during 1984-1989. The latter was partially due to the reduction in purchasing power during the world debt crisis.

In general, oilseed surplus areas have been North America (with crops such as soybean, cottonseed, peanut, sunflower, rapeseed/canola), South America (soybean, sunflower) and Australia/South East Asia (palm oil, coconut, cotton, sunflower). Primary deficit areas have been Europe (rapeseed, sunflower, soybean) Soviet Union (sunflower, cotton, rapeseed), China (ground nut, soybean, rapeseed, cotton) and Africa (ground nut, oil palm, cotton).

Rapeseed/Canola Availability

Focusing in on our rapeseed/canola industry, the November 30, 1990, Oil World Summary Report indicates that the world rapeseed/canola availability will reach a new record of ca. 24.0 Mt for 1990/91. This level is 21% higher than the 19.82 Mt available for consumption from the 1986/87 crop year. As previously discussed, there is a direct connection among production, availability, pricing and utilization.

In recent history, the most dramatic growth continues to be in the historically large oilseed producing countries. On a world basis, the 1989/90 average rapeseed/canola seed supply increased by 12% over the four year average period of 1985/86 - 1989/90. For comparison, West Germany increased production by 48%, Denmark by 41%, India 21%, UK 18% and China 15%. Other major suppliers such as Canada, France and Poland were below this average. The Soviet Union may also become a significant rapeseed supplier, climbing from its 288 Mt average base to 550 Mt in 1990/91. USA interest in rapeseed/canola production has also increased over recent years. It is estimated that 40 Mt were produced in 1990/91 vs. the 12 Mt figure for the average base period.

Of the 5.79 Mt available from the EC-12, France, West Germany, UK and Denmark account for approximately 98% of this total. All four countries increased their production over their average base levels. Eastern European countries contribute ca. 11% of the world's supply of rapeseed/canola. Only six of the eight countries in Eastern Europe produced rapeseed in any significant amount. They include Poland, with approximately 60% of Eastern Europe production, East Germany, Czechoslovakia, Hungary, Yugoslavia, and Rumania. The Eastern European rapeseed crop for 1990/91 is estimated to be ca. 2.22 Mt, down slightly from the 2.61 Mt in 1989/90.

In China, rapeseed is a major oilseed crop accounting for approximately 18% of total oilseed supply. Rapeseed production rose steadily from 1970-1987, peaking at 6.6 Mt. Production fell in 1988/89 to 5.04 Mt, but recovered somewhat in 1989/90 to an estimated 5.44 Mt. Improved weather has brought the production back to 6.58 Mt in 1990/91.

India's rapeseed production record of 4.412 Mt was achieved in 1988/89. Production fell off in 1989/90 due to reduced acreage, but recovered to 4.1 Mt in 1990/91.

Canadian canola production was 3.1 Mt in 1989/90, well below its average level of 3.7 Mt during the previous five years. The reduction was caused by reduced acreage due to a shift from oilseeds to wheat and reduced sales to Mexico, due to more attractive prices from Polish exports. The 1990/91 production of 3.325 Mt was greater than the previous year due to improved yields, as well as a slight increase in acreage.

Some countries supply more crops and products than they can utilize. Excess supplies are sold to countries in a deficit position. Canada has been the traditional leader in rapeseed/canola seed exports. In 1990/91, Canada exported 1.96 Mt, or 45% of the total. EC-12 exported 1.72 Mt of seed, 40% of the total. France with 0.913 Mt exported was the leader in the EC-12, followed by West Germany with 0.317 Mt. Poland exported 0.369 Mt, or 9% of the 1990/91 export totals.

EC-12 was the major importer of seed with ca. 2.146 Mt in 1990/91, required to fulfill utilization demands. Japan was second with ca. 1.825 Mt of imports, followed by Mexico and USA. Imports identify utilization needs above those fulfilled by domestic production.

Oil

Of the 8.318 Mt of rapeseed/canola oil available for utilization around the world, 2.337 Mt (28%) were supplied by the EC-12. Within these countries, West Germany led with 0.896 Mt produced. China produced 2.031 Mt (24%). They were followed by India, 1.299 Mt (16%), Japan 0.753 Mt (9%), and Canada 0.509 Mt (6)%. Since 1988/89, China has shown the largest increase, of 0.373 Mt (23%).

During 1990/91, 1.9 Mt of rapeseed/canola oil were imported by various countries. EC-12 was the major importer with 21% of the total, or 0.404 Mt. China imported 0.38 Mt 20%, followed by USA 0.2 Mt (10%) and Hong Kong with 0.13 Mt (7%).

Regarding recent rapeseed/canola oil disappearance, 8.406 Mt were consumed during 1990/91 vs. 7.872 Mt in 1988/89, an increase of 6.8%. Primary users were China 2.386 Mt, India 1.399, EC-12 1.294 and Japan 0.765.

Meal

Rapeseed/canola meal disappearance increased from 12.279 Mt in 1988/89 to 13.319 Mt in 1990/91. Major users were EC-12 3.790 Mt, China 3.237 Mt, India 1.801, and Japan 1.281, during 1990/91. Soybean meal is the leader in the world meal markets because it is an important component in hog and poultry feed. On a world basis, rapeseed and sunflower meals tend to be fed to ruminants; however, the low glucosinolate varieties such as LEAR/canola, are now being utilized in hog and poultry feed markets. Fish meal used to be an important competitor to oilseed cakes and meals; but, declining fish stocks have resulted in fish meal becoming less of a factor in the market place.

According to the American Soybean Association, the world supply of meal was ca. 119.36 Mt during 1988/89. Soybean meal production, ca. 65.3 Mt, contributed to over half of the world meal supply. Rapeseed/canola meal was in second place with 11.92 Mt of meal produced during this period.

1990/91 rapeseed/canola meal exports totaled 2.671 Mt, up 2.7% over 1989/90. The leading exporter was EC-12 with 0.992 Mt (37%). Following were China 0.52 Mt (19%), India 0.45 Mt (17%), and Canada 0.415 Mt (16%).

With regard to 1990/91 meal imports, EC-12 had the greatest need with 1.397 Mt, or 52% of the 2.693 Mt imported around the world. Within EC-12, the Netherlands was the largest importer with 0.43 Mt imported during 1990/91. South Korea was next with 0.380 Mt imported (14%), followed by USA 0.245 Mt (9%), and Japan 0.215 Mt (8%).

The use of these meals as ingredients in livestock ration formulations is primarily dependent upon availability, composition, price, digestability and palatability. In establishing the best-cost formulation, the digestability and palatability of ingredients become very significant.

With hulls, soybean has the highest protein content of ca. 44.6%, compared to cotton seed 41.2%, rapeseed/canola 37.0% and sunflower 23.3%. When hulls are removed, cotton seed meal protein increases to ca. 50.3%, soybean 49.7% and sunflower 46.3%. Thus, an economic dehulling operation for rapeseed/canola would be very beneficial for the marketability of meal destined for use as a feed supplement.

PROCESSING

In 1961 the world edible fat and oils supply was 18.4 Mt. By 1990 this output had increased to 60.0 Mt, an increase of 226%, or 7.8% per year. Rapeseed/canola comprised 12% of the total vegetable oil production by 1990. Over this period many new processing plants were built, but there have been no fundamental technology changes in processing oilseeds to make finished oil and meal products. Considerable effort has gone into upgrading processing techniques to improve the yield and quality during processing and to reduce operating costs. Major improvements have been obtained by converting from batch to semi-continuous or continuous systems, increasing equipment capacities and reliability, and incorporating automation.

There are three basic commercial processing alternatives for oilseeds; full pressing, solvent extraction, and prepress/solvent extraction. Because rapeseed/canola has a high oil content of ca. 44% (dry basis), commercial processors usually use the prepress/solvent extraction method (Carr, 1988). The prepress step is designed to remove most of the oil content from the seed. Solvent extraction is then utilized to remove most of the remaining oil content from the cake.

Oil Extraction

Cleaned seed is crushed by a series of flaking rolls and then "conditioned" in stack cookers with temperatures ranging from 80°C to 105°C (Figure 3). Cooked "meats" are pressed within expellers to separate two-thirds of the oil content from the remaining cake. In some cases, extruders are used to replace or augment the expellers to improve the performance of the subsequent extraction process.

The expeller/extruder cake is then contacted with solvent, such as hexane, to extract most of the remaining oil in the cake (Figure 4). Full miscella from the extractor, containing approximately 20% oil, passes through a multiple stage solvent recovery system to remove the solvent from the oil. This solvent-free oil is combined with the filtered expeller oil before the subsequent purification (refining) operation. The resultant solid meal fraction contains approximately 1% oil and is utilized as an animal feed protein supplement.

Oil Purification

Combined oils from the prepress and extraction operations proceed through a series of process steps before the final products are packaged (Figure 5). The first step is to purify the crude oil of impurities, such as free fatty acids (FFA) and phosphatides. Processors have three options for this purification step, with the majority using either a caustic soda chemical refining of the acid pretreated crude oil, or an acid/water degumming (super degumming) technique to remove sufficient phosphatides prior to a physical refining step.

Purified oil from the refining step is then contacted with a bleaching agent to reduce color pigments to an acceptable level, and to remove any remaining small quantities of soap from the refining step. Bleached oil destined for margarines and shortenings may be hydrogenated and/or interesterified to improve stability and obtain the desired melting characteristics. Formulated blends of either hydrogenated and/or liquid bleached oils are deodorized under a near perfect vacuum at ca. 265°C to obtain bland flavored oils with low FFA and peroxide values. Depending upon the final product type, the finished oils may be further blended to produce margarines, or are packaged as oils, shortenings and frying fats.

The present state-of-the-art processing technology produces an excellent quality LEAR/canola oil, more and more recognized for its excellent performance and nutritional properties. The quality level of the LEAR/canola meal fraction is not as well regarded, because of its relatively high fiber content and some palatability problems. Despite the high regard for the properties of LEAR/canola oil, there continue to be challenges to overcome, to improve our future competitive position.

Quality

Quality improvements are generally a combination of genetic improvements through breeding programs and biotechnology, combined with improvements in processing technology. Thus, ongoing research priorities for increasing yield, oil and protein contents, and disease resistance should also give high priority for reducing glucosinolates, color bodies such as chlorophyll and non-hydratable phosphatides contents in LEAR/canola components.

Process research is required for new expeller and expander designs, to allow lower processing temperatures for preserving oil quality factors during prepressing. New approaches are required to inactivate phospholipases without the use of high temperatures, to minimize the non-hydratable phosphatides and hence the need for acid degumming. Novel dewaxing process development is required for a low-cost system, perhaps in conjunction with degumming or refining, to make the finished oil more brilliant and acceptable after storage as finished product. Processes other than clay bleaching are required for chlorophyll removal, to improve oil appearance and stability, achieve processing economies, and reduce disposition environmental problems. Some projects in these areas are being tested on a plant scale and one patent application has been submitted.

The major meal concerns are the high content of fiber and a protein content lower than soybean meal. Research is required to enhance the essential amino acids, such as lysine, as well as to reduce the contents of glucosinolates, phenolics, phytates and dietary fiber in LEAR/canola meal. Various projects are underway utilizing enzymes for breaking down oilseeds. Enzymes may provide a partial breakdown of the hulls and meal, to result in improved digestability. It is possible that a markedly enhanced meal composition may be obtained, with respect to energy delivery and digestability. It is also possible that lower extraction plant capital and operating costs would result.

Dehulling of rapeseed has been investigated at the French technical research institute of CETIOM and commercialized at a crushing plant in Chalon, Bourgogne (Uzzan, 1989). Recent dehulling tests at the POS Pilot Plant Corporation, assisted by a new Crown Iron Works aspiration system, compared favorably with the Chalon commercial unit. For example, crude fiber content in the dehulled meal was 7% for the Chalon unit and 6.4% for Westar variety and 7.8% for Tobin with the POS system. Crude fiber content in the hull fraction was 24% for both the Chalon unit and the POS Westar and Tobin trial runs.

The French commercial operation includes two stages. Dehulling is first carried out in a centrifugal dehuller and is followed by a granulometric sorting in a fluidized bed sorter. Aldo Uzzan reported that kernels and hulls are separated according to their densities and the non-dehulled seeds are separated by suction and recycled back into the dehuller. The equipment is marketed by the French company Tecmachine. A report on the POS dehulling system has been submitted to the Canola Council of Canada, whose approval is required before details can be published.

Consumerism demands are also a factor in process design trends. The growing demand for "natural and pure" products behooves us to strive to process with minimum reagents and additives, to preserve as much as possible, the original composition of micro-nutrients and antioxidants. One example is the willingness of some consumers to pay a premium for products not contacted by organic solvents and hence, described as "cold pressed" expeller oil. This is compatible with the recent increase in the use of high residual oil content "cake" materials. Recent deodorization/physical refining equipment designs such as the Johnson & Loft unit, tend to be based on minimizing residence time to reduce heat isomerization and leaving as much as possible of the original natural antioxidants in the oil. More selective removal systems, such as molecular distillation, may become available to eliminate the use of acids and alkalis, to replace present refining and deodorization techniques.

Nutritional concerns may stimulate the investigation of fixed bed hydrogenation reactors, using rare metal catalysts to minimize trans-isomer formation content in hardened oils. Such "brush", hydrogenation could allow the production of more stable low linolenic hydrogenated LEAR/canola oil, without any significant development of additional saturates or trans-isomers.

Growing environmental demands will force the investigation of a total agriculture processing technology. Processing plants will have to be designed so that they do not discharge waste water and solids disposal problems. Water will increasingly become a valuable resource and must be economically reclaimed and reused. All by-products such as gums, soapstock, spent clay, and deodorizer distillates will have to be recovered for maximum value, vitamin E production for example. Technologies such as ultrafiltration and fixed bed should be investigated for augmenting or replacing present refining, bleaching and hydrogenation unit operations.

In addition to the pacing technologies described above, increased efforts in automation and process control, will also be required. Further improvements are necessary in the area of super degumming and physical refining to improve product uniformity and minimize waste disposal problems. LEAR/canola has been found to be more compatible with the physical refining process than soybean oil. Extra research and development effort is required to build on the LEAR/canola advantages that already exist.

NUTRITION AND HEALTH

Because Dr. Bruce McDonald, Professor, Dept. of Foods and Nutrition, University of Manitoba, has contributed greatly to the understanding of the effects of edible oil fatty acid components on nutrition and health, he was requested to provide his overview for the subject in this section, Nutrition and Health.

Recent Developments

Several nutritional developments during the past five years have significant implications for the fats and oils industry and the rapeseed/canola industry in particular. Paramount among these developments was the report by Mattson and Grundy (1985), and its confirmation by Mensink and Katan (1989) in the Netherlands, McDonald et al (1989) in Canada and Wardlaw and Shook (1990) in the United States, that dietary monounsaturated fatty acids (MUFA: viz., oleic acid) are equally effective to polyunsaturated fatty acids (PUFA: viz., linoleic acid) in lowering blood total and low-density lipoprotein (LDL) cholesterol levels.

Equally significant was the recommendation that individuals in the United States (Consensus Conference, 1985), Europe (European Atherosclerosis Society, 1987) and Canada (Health & Welfare Canada, 1990) reduce total fat intake to no more than 30%. Saturated fat intake should be limited to no more than 10% of total energy.

The third major development during this period was the general acceptance that the n-3 family of PUFA (also known as omega-3 fatty acids) are essential dietary nutrients (Budowski, 1988) and the suggestion that the ratio of n-6 to n-3 fatty acids in the diet be between 4:1 and 10:1 (Health & Welfare Canada, 1990). These developments are of particular interest to the rapeseed/canola industry because of the chemical composition of LEAR/canola oil, namely; low saturated fatty acid (SFA) content (<4% palmitic acid); a high level of MUFA (55-60% oleic acid); and a relatively high level of α-linolenic acid (8-10%) with a favorable n-6 and n-3 ratio (approx. 2.5:1).

Blood Lipid Effects

The demonstration of a hypocholesterolemic effect for dietary MUFA helped explain the observation by McDonald et al (1974) that dietary canola oil was as effective as dietary soybean oil in lowering blood total cholesterol levels in male subjects with normal blood lipid patterns. The group at the University of Manitoba has confirmed this earlier observation and has shown that the decrease in plasma total cholesterol in response to dietary canola oil was due primarily to a decrease in detrimental LDL-cholesterol (McDonald et al, 1989; Chan et al, 1991). Replacement of a mixed fat diet by one containing either canola oil or sunflower oil resulted in a similar decrease in plasma total (20% and 15% resp.) and LDL (25% and 21% resp.) cholesterol.

Unlike the findings of Mattson and Grundy (1985), who reported a decrease in beneficial high-density lipoprotein cholesterol (HDL-c) in response to a diet rich in PUFA and Mensink and Katan (1989), who reported a decrease in HDL-c in response to diets enriched in either MUFA or PUFA, neither canola oil nor sunflower oil had any effect on plasma HDL-c levels. Similar results were observed (Chan et al, 1991) when a mixed fat diet was replaced by canola oil, soybean oil or a mixture of sunflower-olive oil or of sunflower-olive-flax oil; all of the test fats resulted in a similar decrease in plasma total and LDL cholesterol but had no effect on HDL-c levels. This study also showed that dietary α-linolenic acid, unlike the long chain omega-3 fatty acids in fish oils (Kestin et al, 1990), is equally as effective as dietary oleic acid and linoleic acid in lowering blood total and LDL cholesterol.

Thrombogenesis Effects

Cardiovascular disease is characterized by two events: 1) the formation of atherosclerotic plaque, which decreases the size of the lumen of the blood vessel; and 2) thrombosis or the formation of a clot, the event that leads directly to a coronary attack if it occurs in a major vessel in the heart. Interest in the effect of dietary fat on thrombus formation stemmed from the observation (Dyerberg, 1986) that Greenland Eskimos have a low incidence of coronary heart disease (CHD) and that the long-chain omega-3 fatty acids, such as eicosapentaenoic acid (EPA) in fish oils, decrease platelet aggregation and clot formation. The physiological effect of EPA is thought to be the result of its effect on eicosanoid metabolism, namely the formation of thromboxane and prostacyclin, "hormone-like" substances that are intimately involved in platelet aggregation and clot formation.

Renaud et al (1986) reported a marked decrease in platelet aggregation when saturated fat was replaced by canola oil in the diets of French farmers for a period of one year. McDonald et al (1989) found that bleeding times were longer and the in vivo production of prostacyclin (an inhibitor of platelet aggregation) was greater when subjects were fed a diet rich in canola oil than when they were fed a mixed fat diet. The antithrombotic effect of sunflower oil, however, was equal to that of canola oil even though the canola oil diet resulted in appreciably higher levels of the long chain omega-3 fatty acids in the platelet phospholipids than either the mixed fat or sunflower oil diets.

The effect of dietary linolenic acid on phospholipid fatty acid composition, however, is much less pronounced than that of the long chain omega-3 fatty acids from fish oils (Sanders and Roshanai, 1983). The relatively poor conversion of α-linolenic acid to EPA reported with humans may relate to the failure to control the ratio of linoleate to linolenate in the diet; it has been suggested that the desirable ratio of n-6/n-3 fatty acids in the diet is approximately 5 (Budowski and Crawford, 1985).

Studies at the University of Manitoba found that the levels of EPA in plasma phospholipid fractions were appreciably higher when subjects were fed diets rich in canola oil or a mixture of sunflower-olive-flax oil (same 18:2/18:3 ratio as the canola oil diet but twice the levels of each) than when they were fed diets rich in soybean oil (same level of 18:3 as the canola oil diet but much higher 18:2/18:3 ratio) or a mixture of sunflower-olive oil (Figure 6) (Chan, 1990). These results show that the human is capable of converting α-linolenic acid to the longer chain omega-3 fatty acids and that the ratio of 18:2/18:3 is important in this conversion.

Research Opportunities

The fatty acid composition of canola oil, namely, the low saturated fatty acid content, the relatively high oleic acid and linolenic acid content, and the favorable ratio of 18:2/18:3, appears to provide certain health benefits. However, there is need to further define the most favorable fatty acid pattern for canola oil. The fact that low-linolenic acid canola oil is more stable than traditional canola oil (Eskin et al, 1989) point out the need to investigate the nutritional properties of the low-linolenic acid oil.

Stable oils with favorable nutrition properties also are important in view of the recent report (Mensink and Katan, 1990) suggesting that the trans fatty acids in hydrogenated oils may be "at least as unfavorable as the cholesterol-raising saturated fatty acids, because they not only raise LDL cholesterol level but also lower HDL cholesterol levels". More testing is required to confirm this report.

There also is need for additional study on the health benefits of oleic acid. It has been reported (Parthasarathy et al., 1990) for example, that diets enriched in oleic acid may inhibit the progression of atherosclerosis by producing low-density lipoproteins which are resistant to oxidation. Balasubramanian et al (1988) also support an in vivo antioxidant role for oleic acid. They found oleic acid was the active inhibitory substance of enzymatic and non-enzymatic peroxidation that had been reported in homogenates of intestional muscosal.

THE FUTURE

Recent events and possibilities related to utilization, processing, nutrition and health, point towards a potentially bright future for the overall LEAR/canola rapeseed industry. Some opportunities have been identified in the Processing and Nutrition sections above. Future utilization levels depend upon many variables, including availability of supply.

Obviously, it is impossible to accurately predict the future; however, analysis of recent trend lines combined with judicious extrapolations into the near future, may be of interest. After reviewing past and present oilseeds data, the first step was to revise and recalculate the historical data, then develop trend charts for projecting supply and utilization into the near future.

Global trends indicate that growth rates in oilseed production and utilization may be somewhat lower than in the past, due to nutrition/health concerns in the developed countries, farmland utilization factors, etc. However, significant growth rates will probably continue for both population and per capita consumption on a world basis. Major growth sectors for utilization will probably be in the developing countries, such as those in the Far East and in Latin America.

Population

Mr. J. Stanton of Experience Inc., projected world oilseed crushing capacity end demand, into the year 2001. World population is projected to be 5961 million (M) people vs. the 4698 M people in 1988, assuming population growth in each country will continue at current rates. This is an increase of 1263 M people over the period, or +27%.

Countries with the largest population growth rates should be Pakistan (63%), Middle-East (54%), Africa (48%), Philippines and South Korea (42%). Areas with the lowest growth rates should be Eastern Europe (1%), Japan (6%), USSR (11%), United States (13%), and Canada (15%). China's rate of growth could well be +18% to 1280 M people and India +32% to 1083 M people. Obviously, there are many unpredictable factors such as government programs, wars, etc., which can alter population trends over the next 10 years.

Consumption

Countries with the highest per capita consumption are USA (28.5 kg/yr), Malaysia (28.0), EC-12 (24.8), and Canada (24.7). Countries with the lowest per capita usage are Thailand (4.2 kg/yr), India (5.9), China (6.0), Philippines (6.7), Africa (9.6), and Indonesia (9.7).

Analysis of Oil World statistics indicates that there has been a strong upward trend in per capita consumption since 1909-1913. By 1985/86, average per capital consumption had increased to 14.8 vs. 7.7 over the period 1909-1913. Until recently, the average increase per year was 1.0% or less. During the period 1973-1977 to 1985/86, this average percent increase rose to 2.5% per year. Using a conservatively projected average percent increase of 1.2 kg per year to the year 2000, the estimated per capita consumption for year 2000 would be 17.6 kg per person. Combination of these estimated population (5961 M people) and per capita consumption (17.6 kg) figures results in a possible utilization of ca. 104.9 Mt (or 105) by the year 2000/2001.

Supply

Information from S. Milke was also reorganized and calculated to develop trend charts to the year 2000. In 1990, the world supply/utilization of major oils and fats was 79.1 Mt, of which 41.3 Mt (52.3%) was from traditional oilseeds, 16.1 Mt (20.3%) from tree fats, 20.6 Mt (26.1%) from animal fats, and 1.1 Mt (1.3%) from "others" such as linseed and castor. Within the oilseed group, soybean contributed 37.3%, sunflower 18.7%, and rapeseed/canola 17.4%, as the major oils in this group. Of the tree fats sector, the major contributor was palm oil with 69.7% of that sector.

Supply trend lines were developed from historical data and modified slightly for compatibility with utilization projections. As a result, projected trend lines from 1960 to date and on to 2000, forecasts that the total availability of fats and oils might be ca. 105 Mt by the year 2000. The trend lines also indicate that oil from the oilseeds group may increase to 53 Mt by 2000. Tree oils, spurred on by the growth in palm oil, may continue their acceleration in growth, to a level of 29 Mt by the same date. Animal fats should continue their history of slow growth. They will probably continue to increase slightly in tonnage, but at a much lower rate than the previous two groups. This deceleration in market share will probably result in a production of 21.9 Mt of animal fats by the year 2000. The "other" group will probably continue its zero growth history, with a 1.1 Mt supply level at the end of the century.

The major fats and oils have been, and should continue to be into the near future, soybean, palm, rapeseed/canola and sunflower. Projections for these individual oils are much more difficult than the above groupings because of frequent changes in world political and economic factors. Sunflower had the largest growth rate during the period

1960-1965. Soybean was the leader in the periods 1965-1970 and 1975-1980. Palm oil led in 1970-1975 and 1985-1990, while rapeseed/canola was the leader in 1980-1985. It is interesting to note that rapeseed/canola exhibited the most consistent growth rate, by always exceeding the average of this group over all the five year periods since 1960.

Trend lines from this data, combined with the known development of additional plantations in South East Asia, produced a projection of 22 Mt of palm oil supply by the year 2000 (Figure 7). If this projection comes true, palm oil will take over from soybean as the largest source of vegetable oils and fats in the world. Stronger meal demand, especially in EC-12, should stimulate an upturn in the growth rate for soybeans, resulting in a projected 19.1 Mt supply by the end of the century. Sunflower and rapeseed/canola should continue their steady growth rate. Since 1990, rapeseed/canola has shown a stronger growth rate and could be at the level of 10.5 Mt production by 2000. Continuation of sunflower's present growth rate may put it at 10.0 Mt by the end of the century.

With regard to market share, palm oil, because of its lower price, will probably continue to increase its share to a projected 26.8% by 2000 vs. 19.5% in 1990. Soybean should continue to increase its tonnage, but will probably drop in its share of market to 23.3% vs. its 1990 level 26.8%. Rapeseed/canola's share may increase to 12.8% from 12.5%, while sunflower will probably drop to ca. 12.2% from 13.4% in 1990. Of the minor oils, palm kernel oil is showing the greatest growth rate, due to its crop relationship with the production of palm oil.

There are many factors, some of which are unpredictable at this time, which could impact on market shares over the next 10 years, for both oil types and geographic production areas. Some of these are availability of farm land, competition with other crops, nutritional and health developments, economics, free trade vs. trade wars, political decisions, etc. Over the next 10 years, various events will take place within these factors which may have a profound affect on the quantity of oil and meal available for utilization.

The combination of actual availability figures for the period 1986/87 and 1990/91, plus trend charts projects that the total amount of rapeseed/canola seed could well be 35 Mt by the year 2000-2001. Although supply quantities will increase in all rapeseed/canola growing areas, it has been observed that there is a rapidly increasing supply shift from the developed countries, such as Europe and North America to developing countries, such as China and India. It is projected that the average growth rate over this new decade will be approximately 3.5% per year. Probable growth rates for EC-12 (+3%), Eastern Europe (+1.5%) and Canada (+1.5%) will be below the average and areas such as China (+4%), India (+9%), and other countries (+10%) will be above average. Thus, by the year 2000-2001 China should be the leading producer with 9.2 Mt (26%), followed by India with 7.8 Mt (22%), EC-12, 7.6 Mt (22%), Canada 3.8 Mt (11%), and Eastern Europe 2.6 Mt (7%).

EV Gunar, scientific secretary of the food industry for the Academy of Agriculture Sciences in the Soviet Union (INFORM, Vol. 2, no. 1-Jan'91) reported that the USSR will increase crushing capacity by 3000 Mt per day by 1995. Because oil cake is considered a byproduct of oil production, high oil content seeds, such as LEAR/canola and sunflower would have an advantage. Climatic conditions may mean that the Soviets may have to turn to LEAR/canola varieties to produce sufficient oilseeds to satisfy domestic demand. Such a result would add more strength to the projected strong growth for rapeseed/canola to the year 2000.

In conclusion, we do have opportunities to increase the market share for rapeseed/canola over the foreseeable future. Processing challenges have been described which, if overcome, will result in increased demand for both oil and meal through improved quality and reduced cost. Increased efforts in health/nutritional studies and breeding programs are essential for maintaining LEAR/Canola in the forefront of the edible oils desired for their quality, performance and fatty acid composition. A combination of breeding and processing improvements may further improve the quality of canola meal to a level which would be more competitive with soybean meal and widen its advantage over sunflower meal.

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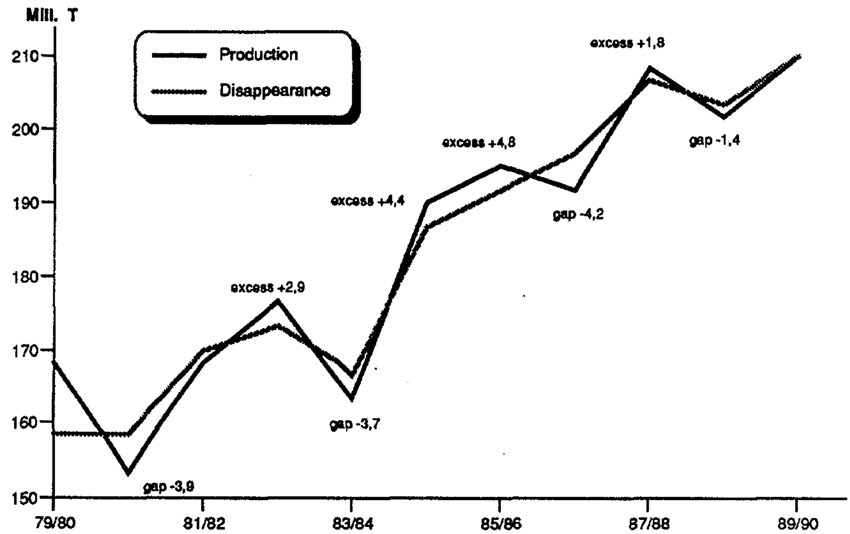
FIGURES

Ten Major Oilseeds
World Production and Disappearance



OIL WORLD ,Sep. 1989

FIGURE 1

Average World Utilization of Fats & Oils

	Ⓐ 1909/1913	1935/1939	1958/1962	1973/1977	Ⓑ 1985/1986	△% Ⓑ vs Ⓐ
Total World Production (Mt)	13.09	20.23	29.76	45.96	70.86	441
World Population (10^9)	1.7	2.1	2.9	3.9	4.9	188
Per Capita Consumption (Kgs)	7.7	9.6	10.3	11.8	14.8	92

re: Oil World

FIGURE 2

CANOLA SEED PREPARATION & PREPRESS SYSTEM

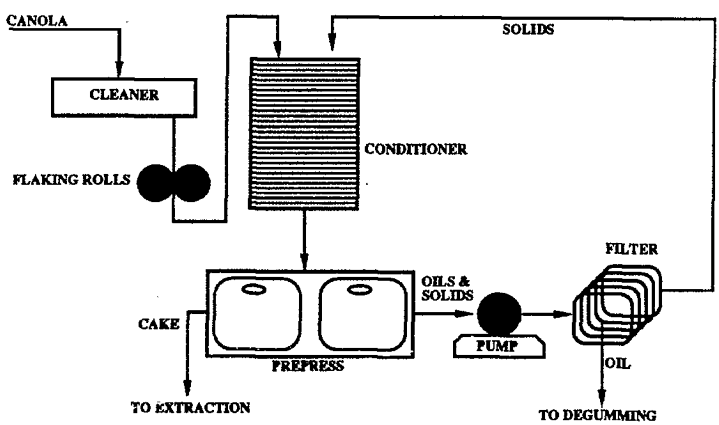


FIGURE 3

EXTRACTION OF CANOLA OIL

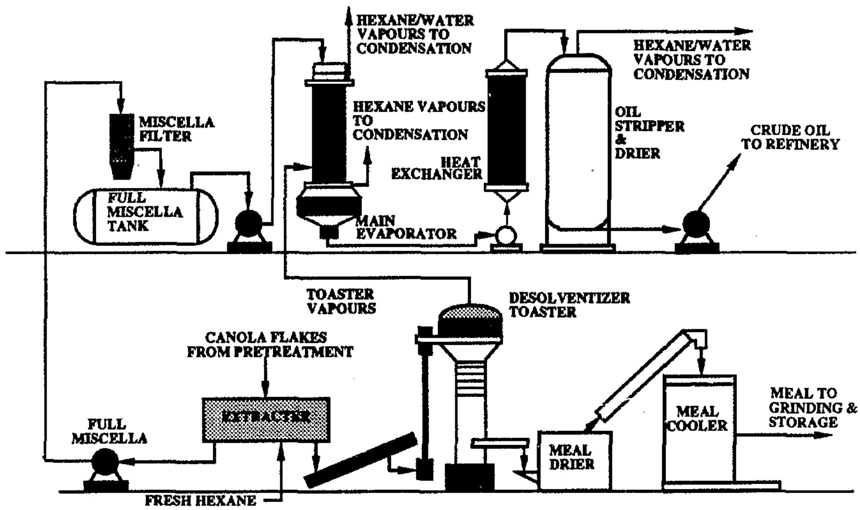


FIGURE 4

OIL PROCESSING

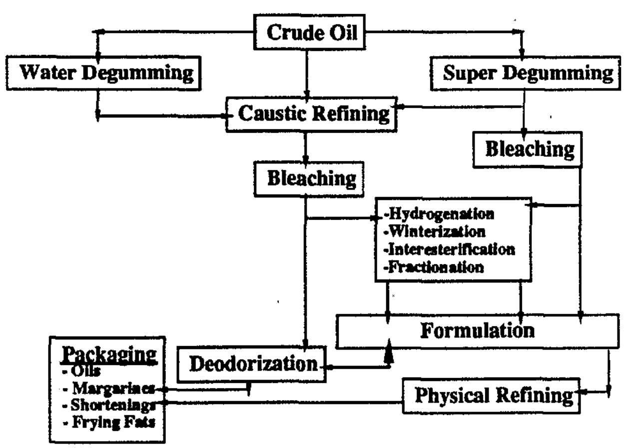
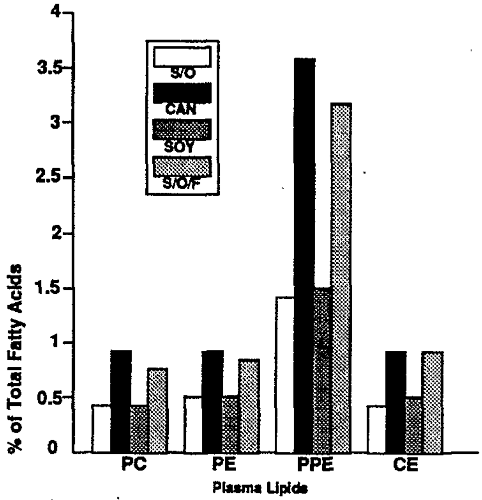


FIGURE 5

Eicosapentaenoic Acid Levels in Plasma Phospholipid Cholesterol Ester Fractions of Subjects Fed Diets Varying in Level and Ratio of Linoleic Acid and Linolenic Acid.



PC phosphatidylcholine
PE phosphatidylethanolamine
PPE alkenylacyl ethanolamine phosphoglyceride
CE cholesterol esters

FIGURE 6

Growth Trends Major Vegetable Oils

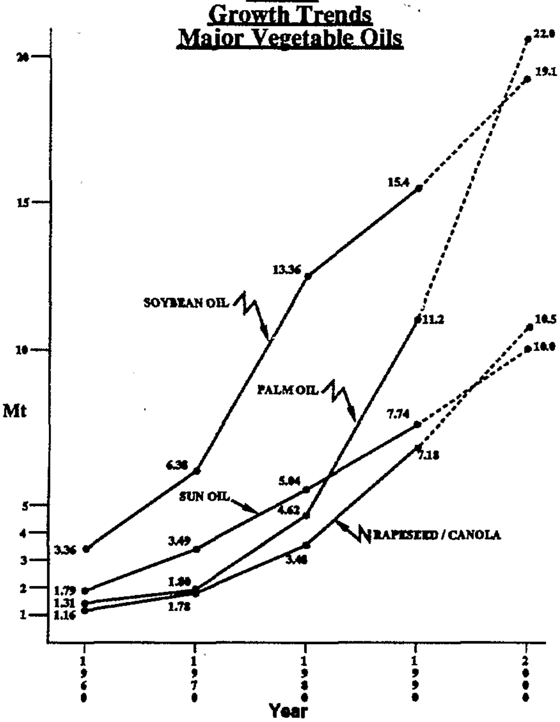


FIGURE 7