In the U.S. food uses of oils, soy oil continued to dominate formulations for shortening, margarine, and salad and cooking oils. Coconut oil is strongest in the "other uses" category such as filler creams or coffee whiteners. Palm oil participates significantly in shortening formulations.

Since coconut oil utilization breakdowns have not been available to CRB Jersey City partially in 1978-79 and almost completely in 1980-83 and totally in 1984 we must depend on private research institutions like the one our industry commissioned. The data derived therefrom for 1979 is tabulated herein and graphed.

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The Biotechnology of Oilseed Crops

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ABSTRACT

A general summary of possibilities and limitations application of biotechnology processes to processing and/or production of fats and oils is presented. Enzymatic processes, cloning of premium perennial oil crops and genetic manipulation of oilseed compositions are discussed.

INTRODUCTION

The last five years have seen many imaginative ideas on, and the beginning of commercial exploitation of, biological methods for control of the composition of natural oils and fats, with the aim of providing tailor-made fats for defined end uses.

The processes involved are different. In order of complexity, they are: use of isolated enzymes as catalysts; use of fermentation systems using microorganisms, plant cells and animal cells (using recombinant DNA techniques for transfer of biosynthetic sequences); and use of plant propagation by plant tissue culture, somaclonal variation, and genetic engineering of oil seed crops to generate improved plants. Each of these is considered separately as they have different advantages and disadvantages. Each will have a different effect on the various types of commercial oil seeds and their products. Table I shows the world production of plant oils and fats in 1981. The next fifteen years may see major changes in the exploitation of these materials.

TABLE I

World Production of Vegetable Oils (in terms of oil or fat)

	1980/1981 (Provisional) (thousand tons)
Edible oils	
Cottonseed	3,100
Groundnut	2,810
Soybean	14.530
Sunflower	4,600
Olive	1,905
Rapeseed	3,685
Palm oil	4,590
Coconut	3,020
Other	3,120
Total edible	41,360
Industrial oils	
Linseed	740
Castor bean	350
Other	135
Total industrial	1,225
World totals	42,585

ISOLATED ENZYMES AND PRODUCTION CATALYSTS FOR SYNTHESIS OF SPECIALIZED OILS AND FATS

The ability to use a triglyceride 1:3 specific lipase as a catalyst to exchange acyl groups between triglycerides and free fatty acids and between triglyceride classes (1) has opened up a new area for production of specialized oils and fats.

The first major commercial exploitation lies in the conversion of palm oil fractions rich in POP triglycerides to a mixture of POP, POS and SOS triglycerides. The product mix is then fractionated and recycled (Fig. 1).

Clearly, such acyl exchange can be exploited in a variety of ways for a variety of products. The process is extremely flexible and can be accurately controlled to give a range of specialized triglycerides. The larger part of plant costs are found in the downstream processing end, not in the primary reactor. This will frequently be the case when an enzyme is used to get rapidly to a new chemical equilibrium state. The overall process is not cheap and is therefore applicable only to high added-value products such as specialized fats and is dependent on both a cheap flexible feed stock and a cheap source of free fatty acid of reasonable purity. Palm oil is a major contender as such a feed stock.

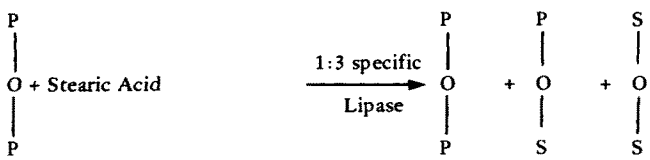

FIG. 1. Exchange of triglycerides and fatty acid.

Extensions of such acyl exchanges to other processes/products are obvious, but this requires lipase enzymes of higher thermal stability and lower cost. Full exploitation of such triglyceride lipases and even phospholipases is in sight, and we will need to look elsewhere for new approaches.

Oxyderivatives of fatty acids are unlikely to be produced by isolated enzyme processes since the enzymes are complex, usually unstable and often possess complex electron transport systems. Production of these where economically feasible is more likely to be by intact cell systems (see next section).

FERMENTATION

Microbiological

Although there is a wide range of production systems—batch, continuous, and cells immobilized in various semi-solid media, the overall cost per ton of microbiological fermentation, starting from simple carbon substrates, is still high in comparison with oil seeds. This limits production to the more expensive oils that are not easily obtainable from plant sources. Inspection of world tonnages of the lower cost oils and consideration of the high capital and revenue costs of fermenters make it very unlikely that the process will ever succeed for bulk oils. However, there are a few oils where there may be some advantages in microbial fermentation of γ-linolenic containing oils where the existing oil seed (oenothera) is not highly bred and so has relatively low yields. Other specialist oils, e.g., those containing other fatty acids normally limited to animal systems (arachidonic acid for example), could be produced provided the necessary gene transfers are made for the Δ5 desaturase and its associated electron transport system. Whether or not much of a market exists for such oils has yet to be determined.

Plant Cells

Oil synthesis by plant cells in liquid media is relatively easily achieved using embryogenetic cultures, but only at a low level. Even if attained at a high level the costs will be enormous, even with the most optimistic assumptions, as compared with normal agricultural production.

Animal Cells

The only likely use of such systems would be for production of the animal-type polyunsaturated acids, and this could be done more cheaply with microbial systems suitably genetically modified.

GENETIC IMPROVEMENT OF OIL SEEDS

This area divides fairly neatly between those tropical and subtropical perennial species that have not been subjected to intensive breeding and the more temperate annual oil seeds that have already been bred to high yield and uniformity. The first group at this stage is best dealt with below.

Propagation of Elite Variants of Perennial Oil Crops by Plant Tissue Culture

This technique has already been developed for the oil palm and is now in the commercial exploitation phase. The advantage lies in being able to select individual trees (on the basis of performance followed over a number of years) and to multiply them as a single clone on any desired scale. It is applicable to such crops by the existence within the normally seed-derived plants of a considerable range of genetic variation.

Clones have been produced that have yields higher than the average, clones that possess markedly different oils, and clones that possess a wide range of levels of mesocarp carotenoids (2-4). Clonal selection is also based on other criteria such as disease resistance, response to fertilizer, etc. Plantation operators can therefore now choose whether to produce conventional bulk palm oil at higher yields, more liquid oils such as the higher linoleic acid clones, or less colored oils. Indeed, the wide genetic variation that exists in the crop makes genetic modification by recombinant DNA techniques of little advantage for many years, at least until the full range of natural genetic variation has been explored and exploited.

The next oil seed perennial to be cloned will be the coconut palm. Indeed this crop even more urgently requires upgrading as many of the palms in the hands of small farmers are of very poor quality. Production could be greatly enhanced by the widespread introduction of clones of the best existing breeding material. Although plantlets have been generated in a few laboratories, we have yet to see them successfully transferred to soil, but this stage is now very close.

The next phase will be the use of the technique on wild oil-bearing crops. This is dependent on study of such crops in situ in forest (e.g., the babassu palm) and the selection of useful variants. Exploitation in plantations will have to wait for these developments and the necessary testing in a variety of climates and soil types.

Somaclonal Variation

While some plants are genetically stable in tissue culture, others undergo (or express existing) genetic change so that some of the regenerated plants are clearly distinct from the parent. This offers the plant breeder a new route to improvement by incorporating any useful variants in a conventional breeding program and is an alternative to chemical or UV-induced mutagenesis. This technique already is being exploited for potatoes, cereals, etc. (5). It is of most use in crops already bred to uniformity where there is a shortage of genetic variation. Normal mutation procedures are of course used in the oil seed rape improvement program and have recently been used to try to improve the fatty acid composition (decreasing α-linolenic acid levels) of soybean (6). The work is slower than somaclonal variation and only occasionally leads to complete loss of single component. Gametoclonal variation uses cell cultures derived from gametic tissue (e.g., pollen). The plants regenerated possess half the normal chromosomal complement and need to be doubled up, but have the advantage that genetic differences are rapidly revealed.

All these processes are random and entail screening of many regenerated plants. A more useful direct technique would be to utilize existing recombinant DNA methodology to delete a nominated gene. For example, take the sequence shown below:

$$\text{Stearic} \xrightarrow{\Delta 9\text{ desaturase}} \text{oleic} \xrightarrow{\Delta 12\text{ desaturase}} \text{linoleic} \xrightarrow{\Delta 15\text{ desaturase}} \alpha\text{-linolenic}$$

Inactivation of the terminal Δ15 desaturase would cause synthesis to be directed solely to the other fatty acids in the sequence. No work along these lines has yet been reported.

RECOMBINANT DNA

The annual oil seeds already bred to uniformity but producing oils of lower utility that require much processing are the

major targets for genetic engineering. A number of groups have reported successful gene insertion and expression in plants but until recently no one has succeeded in getting expression only in the seed tissues—the target tissues for oil seeds that need improvement in their storage products. However, a general report has just been published in *Biotechnology* by Netzer (7) describing successful insertion of the phaseolin gene (phaseolin is the major storage protein of bean seed) into a tobacco plant with this major expression in its seed. The report identifies the workers as J. D. Kemp and T. C. Hall of Agrigenetics in Madison, Wisconsin.

So far as the major components of oil seed tissue are concerned, proteins, fats and polysaccharides, the difficulty of genetic controlled changes in composition markedly increases from left to right. Proteins in seed tissues, however, are notoriously complex mixtures of many components. Expression of a gene for a new protein must therefore be at a very high level to become a major component. Major fatty-acid modifications could be attained by insertion of a gene coding for a new enzyme.

THE FUTURE

The next ten years will see the gradual introduction of oil seed varieties improved in yield and other properties dictated by complex groups of genes by exploitation of clonal selection and somaclonal variation. In addition, recombinant DNA techniques will provide plants improved in composition of the oil seed so that the products are better adapted to major end users of the protein, triglyceride and polysaccharide components. This will be supplemented by isolated enzyme-based systems that transform low cost bulk oils and polysaccharides to higher value specialized products. All these developments will tend to decrease processing costs of bulk raw materials and open up new opportunities in the oil and fat-based industries.

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Contribution of Biological Research to the Development of the Coconut Industry

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ABSTRACT

Current developments in coconut breeding, embryo and tissue culture, and the studies on the etiology of cadang-cadang disease are discussed. The present state of the art for each of these with specific reference to the Philippine situation is presented.

INTRODUCTION

This paper focuses on three areas of concern with regard to coconut as a commercial crop: breeding and conservation of germplasm, plant tissue culture studies, and the characterization of cadang-cadang disease. Selection of these topics was based mainly on their critical importance to coconut as well as the availability of literature for this review.

This is by no means a complete review, but it will attempt to present the state of the art, as well as highlight current efforts, especially in the Philippines.

COCONUT BREEDING

One of the best means to improve the coconut industry is by breeding improved varieties towards the following objectives (1,2,3):

- Increased production of nuts and copra at different levels of soil fertility,
- Improved quality of yield in terms of oil and protein content, and
- Stability of annual production through resistance to environmental stresses such as drought, strong wind and outbreak of pests and diseases.

In the Philippines, coconut breeding work has been done at various levels of activity in the Bureau of Plant Industry (BPI), University of the Philippines at Los Baños (UPLB), the Visayas State College of Agriculture (VISCA) and the Philippine Coconut Authority (PCA). In addition to these, there are a few private farms involved in the breeding effort.

As a guideline, it has been felt that any cultivar developed by national institutions must be directed toward the needs and capabilities of the average farmer and farm (2). These cultivars must be precocious and must give high yields under a wide range of environment and management levels.

The coconut breeding program being implemented in the Philippines includes three basic activities (2,3):

- Identification and collection of cultivars,
- Evaluation and selection of cultivars – hybridization and evaluation and selection of hybrids, and
- Seed production.

The identification and collection of cultivars is directed toward the establishment of a gene pool and the conservation of genetic resources. This effort was started as early as 1668 by Alzina. There are about 28 local cultivars in the collection of UPLB, VISCA and PCA (Table I), and 40 collections from foreign sources at BPI (Table II) and PCA (Table III). These collections can serve as the breeders' working collection and the conservationists' base collection. According to Santos (3), due to the high variability of the coconut, the seednuts collected to be used for the breeding program must come from as many palms to be planted. This is to ensure that large-scale seed production can be undertaken if promising hybrids are obtained.

There is now a continuing evaluation for these collections with regard to their vegetative and reproductive characters. Characteristics of these collections with particular reference to their copra is presented in Tables IV, V and VI. Further work is being undertaken to evaluate these local and foreign collections for the content and quality of their oil and protein.