Novel Palm Oils from Cloned Palms

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ABSTRACT

The ability to propagate oil palms vegetatively, using tissue culture techniques, allows us to select unique individuals for clonal propagation. Although yield improvement is the major criterion, there is considerable variation in oil composition among individual palms.

Fatty acid composition is under genetic control although it also is influenced by environmental factors. Nevertheless, it is now possible to select palms for oil quality. Clones also can be propagated from interspecific hybrids, yielding more liquid oils.

Development of commercial clones of oil palm with novel palm oil composition will depend greatly on the availability of long term markets for premium priced oils.

INTRODUCTION

Recent years have seen rapid increases in the planting of oil palm, particularly in Southeast Asia. The annual production is approaching 10 million tons and ranks second to soy in importance in world vegetable oil production. Palm breeding and agronomic developments have resulted in a steady improvement in yield, so that today's palm plantings in the favorable environment of, for example, Papua, New Guinea, can regularly yield 6 tons of oil per hectare per annum. A major further improvement in yield can be achieved by clonal propagation of outstanding individual palms from today's best progenies.

Tissue Culture

Our tissue culture research started in the late 1960's has resulted in development of the ability to use tissue culture techniques to propagate clones of selected palms.(1) This enables us not only to choose palms of exceptional yield potential, but also to include selection for oil quality and to establish clones of widely different composition.

Variation of Oil Composition

Several studies have been made of the range of variation available within the existing crop.

Corley(2) summarized the reported range of fatty acid composition from analyses by various authors. Simplifying this data into a single list of the reported range of composition includes both differences in genetic origin and effects of growth in different environments (Table I). Nevertheless, it demonstrates that the existing oil palm crop is capable of producing a range of different oils.

Noiret and Wuidart(3) found large differences in oil composition between different breeding populations, and their results showed quite a high heritability for oil composition.

TABLE I

Reported Range of Fatty Acid Composition of Palm Oils (Simplified from Corley (2))

Fatty acid		Range (per cent of total fatty acids)
Myristic	C14:0	2-6
Palmitic	C16:0	32-64
Stearic	C18:0	0.6-11
Oleic	C18:1	29-52
Linoleic	C18:2	2-14
Iodine Value		51-59

RESULTS

We now have results of analyses of oils from a range of different clones grown on one site in Malaysia(1,4) (Table II). These clones were derived from early tissue culture experiments at Colworth House and were not from selected palms. The source material for the cultures was young, aseptically germinated seedlings. We found a surprisingly wide range of differences in oil composition among clones, but high within-clone uniformity. This observation confirms the strong genetic control of oil composition and demonstrates that even from a small random sample of seedlings there are considerable differences. Clearly, one would expect the range available in the crop gene pool to be quite large.

Although clearly under genetic control, the fatty acid composition also is modified by environmental factors. Bienaime(5) showed that seasonal variation in oil composition occurred in West Africa. In common with observations in other oil seeds, more unsaturated oils are formed in periods of lower temperature. In general, results of analyses of African oils give higher levels of saturated fatty acids than Malaysian oils. However, it is not clear whether such differences are genetic or environmental in origin since different genetic stocks of planting material are used in different countries.

TABLE II

Composition of Oil from 11 Clones (From Corley (4)) (2-4 palms/clone, mean of 8 samples/palm)

Clone	Fatty acids (per cent)				Iodine	Triglycerides (per cent)			Carotene
	C16:0	C18:0	C18:1	C18:2	value	C50	C52	C54	ppm
905	39.9	5.8	42.8	9.8	57.2	34.6	43.1	13.3	1344
907	42.2	4.6	35.0	16.6	62.3	41.2	40.8	9.6	357
924	40.3	6.2	38.3	13.0	59.0	35.6	42.0	12.2	1056
926	42.9	5.3	36.6	13.1	57.4	40.5	39.6	9.2	640
931	38.9	6.6	43.0	10.0	57.5	34.4	44.1	13.9	1158
932	42.6	5.3	40.3	9.5	54.5	39.1	40.2	9.5	1289
960	42.6	5.6	40.3	9.3	54.1	39.4	41.4	13.7	1268
970	38.9	5.8	41.9	12.2	60.7	34.5	44.8	13.7	634
975	41.5	5.8	41.2	9.5	55.2	37.3	42.7	11.3	1093
976	42.9	5.1	37.4	12.7	57.6	41.3	40.2	8.8	583
997	45.8	5.5	35.5	11.5	52.8	43.3	38.6	7.6	1204
S.E.	1.4	0.6	1.2	0.8	3.4	1.9	1.9	1.4	188

TABLE III

Comparison of Fatty Acid Composition of 3 Oil Palm Clones in Malaysia and Cameroon.

Main effect means of component fatty acids (FAME WT. per cent)			
	Site effect		
Fatty acid	Cameroon	Malaysia	Significance level
Myristic C14:0	1.85	1.40	***
Palmitic C16:0	46.24	43.29	***
Stearic C18:0	4.99	5.78	***
Oleic C18:1	36.01	37.95	*
Linoleic C18:2	9.60	10.81	N.S.
Iodine value (calculated)	51.14	54.76	***
Carotene (ppm)	1159	909	N.S.

	Clone effect			
	Clone 924	926	975	Significance level
Myristic C14:0	1.90	1.47	1.49	**
Palmitic C16:0	44.19	45.95	44.15	*
Stearic C18:0	5.64	4.81	5.71	**
Oleic C18:1	36.43	35.33	39.19	***
Linoleic C18:2	10.79	11.60	8.23	***
Iodine value (calculated)	53.52	53.81	51.52	*
Carotene (ppm)	1046	923	1133	N.S.

Significance level: *** $p<.001$; ** $p<.01$; * $p<.05$

Effects of Environment

The availability of clonal palms is enabling us to examine the effects of different environments independently of genotype by planting genetically identical plants in different environments. By also planting a range of clones in each environment we soon shall be able to analyze the interactions between genotype and environment and select the clones best adapted for use in a given region.

As yet few results are available, but some plants of 3 clones were planted in 1979 in Cameroon, and have now come into bearing. Since we also have analyses from the same clones in Malaysia, it is possible to compare results from the 2 different environments.

Table III shows the major fatty acid composition, iodine value and carotene content of bunches analyzed from 4 replicate palms of 3 clones in Cameroon.

The analyses of the same clones in Malaysia are derived from a much larger experimental sample harvested between 1980 and 1983.

There were no significant site-genotype interactions for the major fatty acid components, and main-effect means are given in the table. Oil composition was affected significantly by both site and genotype.

Although clone 975 has lower linoleic acid and higher oleic acid content than the other 2 clones in both environments, there was a consistently lower level of unsaturated fatty acids in the Cameroon material. This is reflected in the consistently lower iodine value in those samples. The Lobé (Cameroon) palms were harvested in June 1983 following a period of drought, and it may be that this was responsible for higher levels of saturated fatty acids in African oils.

It is clearly impossible to draw any firm conclusions from these early results except to confirm that oil composition is modified by environment, and in the 3 clones examined there were no significant interactions. In other words the different genotypes all responded in the same way to the environmental change.

We now have properly replicated trials planted in a number of sites in different countries, all using the same clones, so in the future we shall be in a position to analyze the separate and interactive effects of genotype and environment in some detail.

Although the compositional shifts are generally seen in terms of saturation and unsaturation, it should be noted that the major change is towards longer chain fatty acids in Malaysia. Since stearate is only a minor component of palm oil (about 10%), any increase in C18 levels will be accompanied by higher iodine values.

The relative differences in composition between the Malaysian and Cameroon results are shown in Table IV. It can be seen that there was a general increase in C18 fatty acids in the Malaysian environment with a concomitant decrease in C14 and C16. Superimposed on this there was a higher than proportional increase in linoleic acid, and some evidence that this was most marked in clone 975. More data will be required to establish the significance of these trends.

PALM BREEDING AND SELECTION

E. guineensis

Since we now have evidence of strong heritable effects on oil composition, it is possible to select parents and make

TABLE IV

Relative Differences in Major Fatty Acid Composition. Ratio of Levels in Malaysia/Cameroon.

Fatty acid		Clone No. 924	926	975	Mean
Myristic	C14:0	0.58	0.85	0.85	0.76
Palmitic	C16:0	0.87	0.89	0.91	0.89
Stearic	C18:0	1.24	1.18	1.04	1.15
Oleic	C18:1	1.11	1.05	1.06	1.07
Linoleic	C18:2	1.22	1.17	1.36	1.25

TABLE V

Composition of Mesocarp Oils of Oil Palm Species and Their Hybrids (from Cornelius (6))

Component Fatty Acid (per cent)		*E. guineensis*	Eg x Eo hybrid Nigeria	Eg x Eo hybrid Colombia	*E. oleifera*
Lauric	C12:0	–	–	0.7	0.5
Myristic	C14:0	2.5	0.6	0.8	0.2
Palmitic	C16:0	40.8	33.3	27.3	22.5
Palmitoleic	C16:1	–	–	0.45	2.4
Stearic	C18:0	3.6	3.4	6.1	0.6
Oleic	C18:1	45.2	51.8	52.5	55.4
Linoleic	C18:2	7.9	10.9	11.35	18.0
Linolenic	C18:3	–	–	1.3	0.4
Iodine value		48-56	66.3	69.8	77.6
Melting range		38-45 C	24-34 C	–	13-14 C

crosses aimed at creating oils of specified quality. From the segregating progenies of such crosses we now can select the individuals with desirable properties and propagate them as clones.

Selection of interspecific hybrids

There is a further source of variation from which to draw. The South American oil palm *Elaeis oleifera* bears fruit with a more liquid oil containing a higher level of unsaturated fatty acid than the West African oil palm. Its composition is similar to olive oil in both fatty acid and triglyceride composition(2). *E. oleifera* also has useful properties of low stature and disease resistance. Unfortunately, it has a very low oil to bunch ratio, usually less than 5%.(6).

However, hybrids between the 2 species are possible, and in the first generation they bear oil intermediate in composition to the 2 parents.

The data of Cornelius(7) (Table V) is typical of the values found by a variety of authors (summarized by Corley(2)). In general, yields of the hybrids are also intermediate between the species. By back-crossing onto *E. guineensis* an F_2 population is produced that shows segregation of the whole range of parental characters (8).

From these highly variable F_2 populations it is possible to select individuals of good yield potential carrying oil composition close to *E. oleifera*(9). It now should be possible to propagate clones from such individuals and to create new varieties of palm with an extremely wide range of fatty acid composition. The clonal propagation of hybrid palms forms part of the IRHO program(10).

Timescales and incentives

At present it seems unlikely that the highest oil quality will be found in combination with high yield, but appropriate breeding and selection should enable the construction of gene combinations with properties of high yield, disease resistance and specific oil quality. This will, of course, take time, since a single generation of an oil palm breeding program takes about 8 years. Selection of new clones, from first tissue culture step through field testing to production, takes a similar time so novel palm oils will not appear overnight. Indeed they will appear at all only if there is a clear advantage in their production. This can come only from a price premium on special oils. The decision to plant a clone of special oil type must be coupled with the resources to harvest and process bunches on a separate factory line, and to store and transport the oil separately. The palm breeder must be able to see a long-term need for a particular oil, the clonal propagator must see a reasonable return on his tissue culture costs and the grower must be assured that there will be a continuing market for this particular oil. Thus, even if yield is comparable with other oil palm crops, there will have to be some price premium for specialist oils if they are to be attractive to both the producer and the grower.

Probably the first direction will be to move towards more liquid oils, since without fractionation palm oil is denied access to the large liquid oils market. Already we have clones with IV 60, and selective breeding, especially including hybridization with *E. oleifera* makes IVs of 70 or more a distinct possibility.

Oil palm clones will become a major feature of many plantations by the end of this decade. One consequence will be that it will be possible to specify composition within narrow limits (although allowance will have to be made for environmentally induced variations perhaps using a 'heat unit' correction). This will mean that it will be much more difficult to adulterate such oils undetected. Although we shall need a separate specification for each clone, the bulk composition of a given sample easily can be computed from the proportion contributed by each clone, and the expected composition of any given load can be specified within narrow limits.

The future development of clonal palm oils is very much in the hands of the industry. Selection for yield, followed by agronomic features, will be the primary goals. If novel types of palm oil are to be bred for quality there will have to be both a ready market and a premium price.

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