the glycolipid fraction was richer in linolenate (37.5%) compared to 4-9.5% in TL, NL and PL. Our data differ from the Stoianova-Ianova et al. report (17) that palmitic acid is the predominant fatty acid in garlic flesh, but agrees with their observation that oleic, linoleic and linolenic are the major unsaturated fatty acids. The relevance, if any, of the richness of unsaturates in garlic lipids to the reported pharmacological properties of garlic remains to be seen. Further studies regarding the characteristics of neutral, glyco- and phospholipids are in progress.

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Jojoba—Variability in Oil Content and Composition in a Collection of 1156 Native Plants

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ABSTRACT

Data are presented on the oil content and composition in the seeds of 1156 native jojoba plants harvested individually from inland and coastal areas of California and Arizona in the U.S. and from Sonora and Baja California in Mexico. The mean oil content of these samples was 53.2%; 34.2% of the samples exceeded 53%. The mean single seed weight was 0.56 g. A significant correlation between single seed weight and oil content was found but there was no correlation between oil content of the seed and seed yield per plant. Analysis of the oil for fatty acids and fatty alcohols showed very little variability among samples. This compositional uniformity is a major asset in terms of industrial application of this oil. Half the seeds studied in 144 samples had a mean oil content of 49.5% and mean single seed weight of 0.39 g. Simple correlations between fatty acids and oil content were similar to those reported earlier.

INTRODUCTION

The successful development of jojoba (*Simmondsia chinensis* [Link] Schneider) as a cultivated crop depends greatly on the breeding of cultivars which have a high production of oil per acre. Two quantitative characteristics are important in this connection: yield of seed per acre and oil content of the seed.

Large numbers of single plant selections from several populations of jojoba were made by us in 1978 with these breeding objectives in mind. The purpose of this study was to identify individual plants producing large amounts of seed with a high oil content in the collection of 1156 single plants harvested in the area of the Sonoran Desert. In addition, correlations were studied between seed weight and oil content, and seed yield per plant and oil content.

MATERIALS AND METHODS

A total of 1156 native jojoba plants were harvested individually from inland and coastal areas of California and Arizona in the U.S., and from Sonora and Baja California in Mexico. Seeds were taken at random from each parental plant. About 25 g from each such sample were used to estimate the oil content of the seed. The same seed sample was later crushed in a Carver Press at 10,000 psi to extract oil for fatty acid and fatty alcohol analyses. Jojoba fruits may have 1-3 seeds each. When there is one seed per fruit, the seed is large and spherical in shape. When there are 2 or 3 seeds they are considerably smaller and are shaped like half-spheres. The spherical seeds will be referred to in this text as "whole" and the half-sphere seeds as "half" seeds. These 2 kinds of seeds were analyzed separately.

The oil content of the seed was determined using wide line nuclear magnetic resonance (NMR) with a Newport Mark III instrument. Chemical analyses were performed by the ethanolysis procedure described by Duncan et al. (1). Separation of fatty acid ethyl esters and fatty alcohols was achieved by gas liquid chromatography (GLC) on a 100 cm x 0.3 cm (OD) stainless steel column packed with 20% Apiezon L on 100/120 mesh Chromosorb W (AW DMCS) and run isothermally at 265 C with a helium carrier gas flow of 80 ml/min. The instrument was a Varian 2700 fitted with FID detectors. Peaks were integrated by a Spectra Physics Autolab System 1 integrator.

RESULTS AND DISCUSSION

The mean oil content of the 1156 samples studied was

53.2% with a range 39.7-59.7% (Table I). Their mean single seed weight was 0.65 g and ranged from 0.20 to 1.41 g (Table II). A large proportion of the population–34.3% of the samples–exceeded 53% in oil content and 4.2% exceeded 56.1%. Thus, an opportunity is available to raise substantially the mean oil content of the seed of jojoba cultivars by artificial selection. It is notable that the mean seed oil content of this population of plants not subjected to artificial selection was so high. Similar levels of oil content were reached in other oil crops after long-term, persistent selection.

A significant correlation between single seed weight and oil content was found in the total population of samples, r = 0.49. To investigate a possible correlation between seed yield per plant and oil content of the seed, the 86 highest (over 2,000 g of seed per plant) and the 50 lowest (less than 200 g of seed per plant) yielding plants were studied separately. The first group with an average oil content of 53.9% did not differ significantly from the second group with an average oil content of 52.7%. The mean single seed weight of the first group was 0.89 g and that of the second was 0.77 g; in this case, too, the difference was not statistically significant at the 5% level of probability. Thus, high seed yield apparently was not correlated with high oil content or high seed weight. In both high- and low-yielding plants, the variability in oil content was considerably smaller than that in seed weight (coefficients of variation 2.9 vs. 10.4, in the high-yield samples, and 4.9 vs 28.4 in the low-yield samples, respectively). The same was true in the entire population of samples.

Half seeds were studied in 144 samples in which half seeds made up 30% or more of the total single plant yield by weight. The mean oil content of these seeds was 49.5% with a range 35.9-53.9%. Their mean single seed weight was 0.39 g and ranged from 0.17 to 0.72 g. The mean oil content of the corresponding whole seeds was 51.0% with a range 42.3-59.7%. Their mean single seed weight was 0.56 g with a range 0.25-1.02 g. These data lead to 2 notable observations: (a) the seed weight of half seeds was significantly lower than that of the corresponding whole seeds of a given sample and that of the entire population of samples; (b) the oil content of the half seeds, though significantly lower than that of the entire population at the 5% level of probability, was not significantly different from the oil content of the corresponding whole seeds of a given seed sample in spite of the sizeable difference in weight between these 2 types of seed. The similarity in oil content of half and whole seeds in a given sample, though the half seed are lighter than the whole seeds, suggests the following interpretation: while seed weight is positively correlated with oil content in comparisons among plants, these 2 traits are not correlated in the seed of a single plant. In the whole seed's case, the ability of the maternal plant to produce high oil content, rather than the weight of the individual seed, appears to be the predominant factor determining oil deposition. Thus, artificial selection should favor strains of jojoba with as low a percentage of half seeds as possible both because these seeds are harder to harvest mechanically due to smaller size and because they tend to have a lower oil content.

The average fatty acid and fatty alcohol composition of the whole population is shown in Table III. The composition of 86 samples from high-yielding plants and 50 samples from low-yielding plants did not deviate significantly from that of the entire population of samples. In all cases, the variation was highest for the 24:1 fatty acid and alcohol. This large variation in part reflects inaccuracies of integration of this late-appearing peak. The frequency distribution for individual fatty acids and fatty alcohols was essentially the same as that reported by Yermanos et al. (2). In these samples too, fatty alcohols 20:1 and 22:1 had a much wider range than fatty acids 18:1, 20:1 and 22:1.

The correlations between fatty acids and alcohols for the entire population of samples are shown in Table IV. The correlations for the high- and low-yielding plants were essentially identical to those shown in Table IV except for fatty acid 20:1 which was significantly correlated with fatty acids 22:1, 24:1 and fatty alcohol 24:1 in the seed from high-yielding plants. The observation that fatty acid

TABLE I

Oil Content of Jojoba Seed Frequency Distribution of 1156 Samples (Mean = 53.2%)

Oil (%)	39-44	44-47	47-50	50-53	53-56	56-60
Plants (%)	3.0	7.6	17.1	38.0	30.1	4.2

TABLE II

Single Seed Weight of Jojoba Seed (g) Frequency Distribution of 1156 Samples (Mean = 0.65 g)

Weight (g)	.21-.40	.41-.60	.61-.80	.81-1.00	1.01-1.20	1.21-1.40
Plants (%)	14.9	34.9	36.2	13.0	0.7	0.3

TABLE III

Means and Standard Deviations of Fatty Acid and Fatty Alcohol Composition of the Oil of 1156 Native Jojoba Plants

	Fatty acid					Fatty alcohol			
	16:0	18:1	20:1	22:1	24:1	18:1	20:1	22:1	24:1
Mean	1.32	9.55	73.70	14.11	1.21	0.80	44.73	56.57	7.66
SD	0.27	1.80	1.65	1.45	0.68	0.23	4.81	3.63	2.27

TABLE IV

Simple Correlation Coefficients between Fatty Acids and Alcohols and Percent Oil in the Seed of 1156 Samples of Native Jojoba Plants

	Fatty acid					Fatty alcohol				Oil
	16:0	18:1	20:1	22:1	24:1	18:1	20:1	22:1	24:1	(wt %)
Fatty acid										
16:0		0.75[a]	-0.24	-0.31[a]	-0.53[a]	0.64[a]	0.55[a]	-0.54[a]	-0.56[a]	-0.13
18:1			-0.21	-0.49[a]	-0.64[a]	0.54[a]	0.75[a]	-0.77[a]	-0.70[a]	-0.11
20:1				-0.71[a]	-0.33[a]	-0.05	0.30	-0.30	-0.34[a]	0.16
22:1					0.61[a]	-0.33[a]	0.78[a]	0.79[a]	0.74[a]	-0.04
24:1						-0.47[a]	-0.70[a]	0.70[a]	0.75[a]	-0.03
Fatty alcohol										
18:1							0.49[a]	-0.55[a]	-0.50[a]	-0.04
20:1								-0.95[a]	-0.87[a]	-0.03
22:1									0.84[a]	0.05
24:1										0.01

[a]Significant at 5% level of probability.

20:1, which is the major oil constitutent, correlates significantly only with longer chain acids and alcohols suggests that synthesis of this fatty acid does not involve fatty acids 16:0 and 18:1 as in animal systems (3,4).

The results presented indicate that in a large population of jojoba seed samples from diverse habitats, there was extensive variability in oil content but low variability in chemical composition. Compositional uniformity is a major asset in terms of the industrial application of this oil. No correlation was found between oil content of the seed and seed yield per plant. A strong correlation was found between oil content of the seed and seed size.

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Extraction of Tallow from Meat Meals: I. Assays in Bench Scale

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ABSTRACT

A laboratory study on solvent extraction of tallow from meat meals is described for both a stirred batch system and a flooded percolation system. The stirred batch system data, interpreted by standard diffusion concepts, show that the extraction process proceeds through a somewhat complex mechanism, which involves at least two types of extractable fat. The results for the percolation system, which show the effect of different operating variables, indicate good yields are possible with a substantially low solvent requirement.

INTRODUCTION

Meat, or meat and bone meal are obtained by high temperature rendering of meat and bone scrap and other residues that normally contain a high fat level. Coagulation of proteins and almost total elimination of water occurs during the rendering step, yielding a semisolid product (a mixture of melted fat and solids) which, after being drained and pressed, is milled, constituting the product known commercially as "meat meal" (1).

This product is marketed on the basis of its protein level—typically ranging between 40 and 55%—to be used in animal and poultry feeds. Other important components of the product are mineral salts, water and fat (tallow); the tallow is present in quantities of 10-20% in most cases. This relatively high residual fat level in the meal impairs its conservation capability because of possible rancidity and degradation. The total or partial extraction of fat from the product, besides minimizing those problems, results in additional advantages: (a) the protein level is increased, which makes commercialization more flexible; (b) the tallow obtained from the product is sold for an economic value that is not apparent in the original product; and (c) if the reduction of the fat content is carried out before the milling step, the efficiency of this operation is notably increased, providing a potential augment in the production rate.

On this basis, it seemed relevant to do a bench-scale study on the solvent extraction of tallow from meat meal, for the purpose of developing a simple method that could fit the requirements of many rural packing installations (such as those typical of southern Brazil) of low and discontinuous productions, where the possibility of grouping or associating is scarce. In choosing the method, the possi-

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