Seed Oils from *Citrus Sinensis*[1]

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Abstract

Comparative analyses of seed oils from the four most important orange varieties at different stages of maturity have shown remarkably similar fatty acid content by GLC. Percentage distribution of fatty acids, refractive index, and iodine number could probably be used to differentiate or help confirm *Citrus* species since there is enough variation between species to make a valid comparison. Seed content was noted as being related to fruit maturity, as was moisture content of seeds. The oil content of pineapple-orange seeds was found to be variable, correlated to moisture content of seeds, and it reached a maximum when seed moisture had decreased to approximately 49%.

Introduction

CITRUS SEED OIL has been classified as a linolenic acid oil (2) or as a seed fat that is rich in both oleic and linoleic acids (7). It is produced commercially in Florida, primarily from a mixture of predominantly grapefruit and smaller quantities of orange seeds accumulated in making sections and citrus salads at the various processing plants. With the likelihood in the foreseeable future of a standardized dried citrus pulp having a uniform quantity of seeds, there would be available even larger quantities of grapefruit and orange seeds to more firmly establish a seed oil industry that has been more promised than established. A void in published literature on seed oil from Florida oranges has been partially compensated by only a few isolated analyses of orange seed oil from other parts of the world; California Valencia orange (12), West Indian sweet orange (4), Ceylon sweet orange (13), Nagpur orange (8), Spanish bitter orange (9), and bitter orange of India (3). The most complete discussion to be found on seed oils of the genus *Citrus*, is probably that of Eckey's (5), but again no mention of seed oils from oranges of Florida. Information was sought, therefore, on the composition and influence of maturity upon seed oils manufactured from Florida's four important orange varieties.

Methods

The coldpressed seed oil samples were prepared at approximately monthly intervals from seeds of known *Citrus* varieties growing at the University of Florida Citrus Experiment Station. After being counted, weighed, and dried, the separated seeds were hulled and the kernels hydraulic-pressed to expel a clear unrefined seed oil for analysis.

A Bausch and Lomb Precision Refractometer with sodium lamp was used for refractive index measurements, while iodine values were determined by the Hanus method (10). The GLC analyses were carried out with an A-90-C Aerograph equipped with a four filament thermal detector, 1 mv Brown recorder and Disc integrator. Operating parameters were: a 10-ft column packed with 15% DEGS on 60–80 mesh firebrick, oven temperature 195C and helium flow rate of 70 ml/min. Prior to injection of a 1 or 2 μl sample, the seed oils were transesterified on semi-micro scale with a 1% sulfuric-methanol mixture (1).

Results and Discussion

The seed measurements and seed oil characteristics for the oranges investigated are given in Table I. The more complete seasonal results shown for Parson Brown oranges indicate the approximate extent of sample variation in each variety surveyed, while the change in average number of seeds per fruit also implies that a portion of the developed seeds in seedy varieties atrophy during maturation. The decreasing percentage of seeds in the Parson Brown variety at later picking dates was typical of all *Citrus* varieties and suggests, as other unpublished data have shown that the seeds reach full size sooner than its fruit. Table I further shows the extent of seed moisture decrease that can be expected with greater fruit maturity. Again Parson Brown results were typical for all orange varieties. The variations in iodine and index of refraction values were not clearly correlated with processing date for the orange varieties studied and these data were contrary therefore to the very discernible increase in iodine number with maturity noted for grapefruit seed oils (6).

There was, however, a very noticeable relationship, which has been discussed by others such as Eckey (5), between refractive index and iodine number over a wider range of values. This relationship within the genus *Citrus* is shown in Figure 1, wherein a scatter diagram has been plotted for seed oils made from oranges, grapefruit, tangerines, and lemons. The respective order of these species shows the sequence of degree of unsaturation, while the points and curve show further that these *Citrus* species could be discriminated from one another by the combination of refractive index and iodine number.

Investigation of the percentage of seed oil in dried orange seeds by solvent extraction demonstrated that it was variable and correlated to fruit maturity as was seed moisture content. In the 1961–62 season, between November 15 and April 18, the percentage oil content of dried pineapple-orange seeds was determined at irregular intervals and recorded as changing in the following pattern: 30.2,35.5,45.2,42.1,36.5, and 36.9. Moisture percentage of the same seed samples had the following respective sequence: 53.0,52.2,51.1,47.5,46.4, and 47.2. The maximum percentage oil content oc-

TABLE I

Seed and seed oil characteristics of four varieties of oranges.

Variety	Processing Date	Undried Seeds			Seed Oil	
		Avg No.	% in Fruit	% Moisture	Iodine Value	n_D^{25}
Parson Brown	9/21/61	18	3.4	63	95.2	1.4691
Parson Brown	10/16/61	12	1.9	56	92.5	1.4686
Parson Brown	11/13/61	18	2.6	54	91.8	1.4687
Parson Brown	12/18/61	15	2.0	53	94.2	1.4689
Parson Brown	1/15/62	12	1.6	52	93.6	1.4688
Parson Brown	2/15/62	14	1.8	49	95.6	1.4688
Parson Brown	3/19/62	12	1.4	52	97.0	1.4688
Parson Brown	4/18/62	11	1.2	51	95.4	1.4689
Parson Brown	5/15/62	11	1.3	48	96.4	1.4689
Hamlin	12/18/61	3	0.4	55	95.1	1.4688
Pineapple	1/15/62	16	2.5	50	93.0	1.4687
Valencia	3/19/62	5	0.6	48	92.9	1.4686

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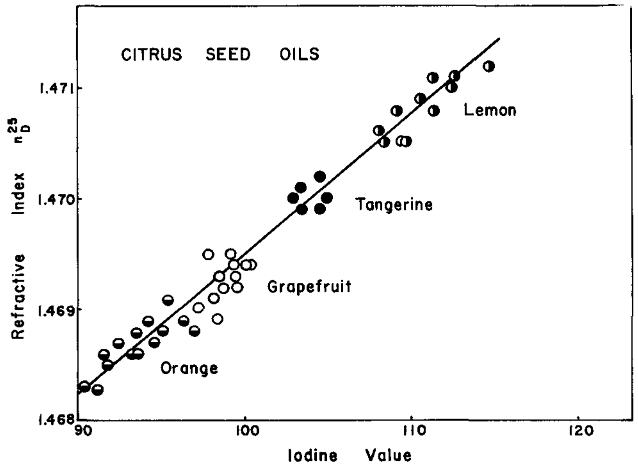

FIG. 1. Relation between iodine value and refractive index for seed oils from various *Citrus* species.

curred on January 16, and it is suggested that physiological maturity of this *Citrus* variety has probably been indicated. Maturity is understandably an intangible value, and is legally more conveniently defined and determined for regulatory purposes in the citrus industry by measurement of total soluble solids/acid ratio of extracted citrus juices.

The GLC analyses of this study are presented in Table II. Average values have been shown that represent in each case a minimum of seven samples. The fatty acid composition of orange varieties were quite similar and were not discernibly changed by maturity. This similarity within a species shows, as has been suggested (11), the tendency of certain plant species to characterize their oil by virtue of the quantity of specific unsaturated acids being present. Data for seed oils made from King orange, Dancy tangerine, and the Ponderosa and Avon lemon are included in

TABLE II

Average fatty acid composition of seed oils from four important Florida orange varieties and some other *Citrus* species.

Variety	Fatty Acid Composition %				
	Palmitic	Stearic	Oleic	Linoleic	Linolenic
Hamlin	31.7	4.1	24.4	36.6	3.1
Parson Brown	30.9	4.1	24.9	36.6	3.4
Pineapple	30.0	4.6	25.0	36.8	3.7
Valencia	31.8	3.2	26.4	35.9	2.6
King Orange	31.7	3.0	18.2	43.9	3.0
Dancy Tangerine	31.6	3.3	20.5	40.0	4.6
Ponderosa Lemon	23.8	3.7	50.1	18.7	3.7
Avon Lemon	24.9	3.0	29.8	30.3	12.0

Table II for comparison. Fatty acid composition of King orange was noted as being more similar to Dancy tangerine than to the four orange varieties shown; the relationship is suggested by taste also. Likewise, the seed oil of Ponderosa lemon was quite different from other lemon seed oils which are represented by the Avon lemon.

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Growth Stimulating Effects of High Levels of Vegetable Oils

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Abstract

Diets containing up to 30% of vegetable oils resulted in increased growth and feed efficiency in the chick. At 40 and 46% levels, the liquid nature of the mixture, and not a deleterious effect of the fat as such, reduced the availability of the solid constituents and resulted in high levels of mortality.

No beneficial effects on growth or feed efficiency resulted after increases in the levels of vitamin and/or mineral mixtures with increase in energy. The growth response to added vegetable oils does not appear to be caused by an unidentified factor, such as may be found in distillers dried solubles, antibiotic fermentation residue, whey product, fish meal, or condensed fish solubles.

Introduction

HIGH ENERGY rations for the production of broilers, introduced by Scott et al. (1) has resulted in the general use of fat as an energy source in animal feed. Other reported benefits from adding fat include improvement in appearance of the feed, increased feed efficiency, and sometimes improved growth. Yacowitz and Chamberlin (2) observed a slight improvement in growth and improved feed efficiency from feeding 1.5–3.0% soybean oil and animal tallow. Other workers (3,4) have also observed increases in the growth of chicks associated with the presence of fat in the diet.

The ability of the chick to utilize high levels of dietary fat has not been investigated extensively. Henderson and Irwin (5) reported that feeding soybean oil in excess of 10% of the diet resulted in a negative growth response. More recently Donaldson et al. (6,7) found that feeding corn oil or animal fat at levels up to 30% of practical or purified diets resulted in slight improvements in growth and feed efficiency.

The objectives of the present study were to investigate the response of chicks to high dietary levels of unsaturated fats, to test for the need of increased vitamins and minerals with very high levels of dietary fat, and to test the possibility that the growth re-

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