A CHEMICAL AND NUTRITIVE STUDY OF PECAN OIL

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In the last twenty-five years there has been a phenomenal increase in the number of pecan trees and consequently in the quantity of nuts produced. In 1900 there were reported 693,000 trees in the United States. and in 1925 there were 8,959,000, or an increase of 1300 per cent in twenty-five years (1).

There are two distinct types of pecans, the improved pecan, such as the Schley, Stuart, Moneymaker, Halburt, etc., and the seedling or native pecan. The latter type has many disadvantages, as nuts of all shapes, sizes, and colors are grown. In addition, some have thin, soft shells while the other extreme is the hard, thick shell, all of which makes grading impractical or impossible. In the period 1925 to 1928, 78 per cent of the pecans produced were seedlings and only 22 per cent of the improved varieties. In this same period, over 90 per cent of the improved varieties were harvested in the southern states east of the Mississippi river. In the last four years Oklahoma and Texas have produced two-thirds of the 39,000,000 pounds (average per year) harvested. Oklahoma averaged only 58,000 pounds of improved pecans per year for the period 1924 to 1928, in contrast to an average of 6,182,000 pounds of seedlings per year.

At the present time the seedling crop is sold to the confectioner, the baker, the salter, and to the grocers for mixed nuts with improved varieties, taking the lead in the demand for a delicacy. However, even the baker prefers pecan halves and the small broken pieces are not favored.

Due to the production of rancidity it is impractical to carry over nuts from one season to another.

For these reasons, it seems that a study of the pecan and its utility other than as a nut to be used in confections, pastries, etc., would be of possible value to pecan growers of Oklahoma and Texas where such a large percentage of seedlings is produced.

The literature concerning the pecan meat and its extracted oil is limited. Frops and Deiller (2) published a work on the constants of pecan oil obtained by ether extraction, and an article (3) giving some of the chemical properties of pecan meats. Friedeman (4) published an article of similar chemical properties. It was noted that no work has been done on expressed oil.

Cajori (5) reported that the pecan fed as the sole source of protein gave satisfactory growth only when the bitter thin integument was removed by blanching. He concludes that the tannin in the integument is probably detrimental to growth of animals.

Holmes (6) determined the coefficient of digestibility of pecan oil and found it to be 96.8 per cent. He states that the oil is very well assimilated by the human body and that whenever available should be used freely for food purposes.

Cajori, reporting on vitamin B, found that satisfactory growth occurred in young rats in which the pecan furnished the sole source of vitamin B (7). Later, in 1925. Salmon and Livingston (8) found that vitamin A of pecan meats caused rapid growth for four or five weeks; then a flattening of the curve appeared which was not affected by addi-

tion of 5 per cent of cod liver oil, indicating that there was no deficiency of vitamin A which was causing the curve to flatten. They also report the pecan as containing adequate quantities of vitamin B.

Since there had been no report of the vitamin content of the oil itself, it was decided to test for A and D. Inasmuch as rancidity has been known to affect the vitamin content of oils it was deemed of value to study the vitamin content of both new and old pecan oils. Likewise, it was considered profitable to determine physical and chemical properties of these oils and to compare them with those of oils of improved varieties.

EXPERIMENTAL

The native seedling pecans used in this experiment were obtained from groves in the immediate vicinity of Stillwater, Oklahoma. The same applies to the rancid pecans. The improved varieties were produced on the College farm, hence the nuts were all grown on similar types of soil.

The pecans were weighed, cracked by machine, and the meats picked out by hand. The edible portion was removed as cleanly as possible, and the percentage of meats obtained from each variety of nut determined. They were then placed in a hand oil press and left there under 20,000 pounds of pressure for approximately twelve hours. The oil was then filtered by suction. The product was a clear, deep straw-colored oil of pleasant odor and taste. The press was located in a dark room, and at all times the oil kept in brown bottles and stored in ice. It is believed that ample precautions were taken to protect the oil from the deteriorating effect of light.

As would be expected, the large improved varieties yield a much greater percentage of edible substance than the native nuts.

Some physical constants were determined for the varieties studied: the refractive index was made at a constant temperature of 20° C. by the use of the Abbe refractometer; for specific gravities a calibrated specific bottle was used, and a temperature of 15° C. maintained. Saponification numbers were determined as described on page 159 of Woodman's *Food Analysis* (9). For the iodine numbers the Hanus method was deemed most convenient (9), page 164. The data obtained, as well as those which had been previously determined by Fraps, Deiller, and Boone, are listed in Table I.

TABLE I

Physical Constants of Pecan Oils

Variety	Refractive Index	Specific Gravity	Saponification No.	Iodine No.	Reichert Meissl No.	Insol Fatty Acids	Remarks
Native Seedlings	1.4728	.9203	192.5	107.7	.73		Constants determined by the author.
Rancid Native Seedlings	1.4720	.9196	194.8	101.1	1.32		
Halburt	1.4730	.9199	196.0	108.0	.57		
Moneymaker	1.4720	.9196	196.0	99.8	1.10		
Stuart	1.4725	.9190	196.0	104.0	.78		
The type of nuts used was not stated		.9184	198.0	106.0	2.2	93.4	Constants determined by Fraps and Deiller
Schley	1.4730	.9118	191.5	97.1			Constants determined by Boone.

It is found that generally the refractive index and specific gravity bear a direct relationship to the percentage of unsaturated acids present. Hence, as the iodine number increases, the refractive index increases, and vice versa. The saponification number indicates the presence of the lower fatty acids. The iodine number represents unsaturated acids of the oleic of linoleic series, as well as their glyceryl esters. The Reichert Meissl number represents the volatile fatty acids.

It is interesting to note that in the rancid oil, oxidation of the unsaturated compounds must have taken place as the iodine number of the old oil was less than that of the new. It is apparent that there is no very great difference in the values determined for ether-extracted oil and those of expressed oil.

Table II records the analyses of the meats of the varieties of nuts used by the author together with data as reported by others.

TABLE II

Proximate Analyses of Whole Pecan Meats (Percentages)

Variety	Ether Extracted Oil	Ash	Moisture	Crude Fiber	Proteins	Nitrogen Free Extract	Remarks
Native Seedlings	68.96	1.35	3.79	1.68			
Rancid Native Seedlings	70.39	1.89	2.99	2.48			Determined by the author
Halburt	63.83	1.63	5.44	2.49			
Moneymaker	71.46	1.43	4.35	1.63			
Stuart	66.49	1.53	4.26	2.27			
Variety was not listed	70.40	1.57	3.20	2.31	10.66	9.82	G. S. Fraps
Schley	69.76	1.70	3.75	1.71	12.27	10.81	Friedeman

BIOLOGICAL TESTS

Vitamin D Content

The rats used were selected from healthy litters at an age of four weeks and weighing approximately 45 to 50 grams each, and were distributed in cages. The usual care observed in vitamin studies was taken. A vitamin D-free diet consisting of

Yellow Corn	73 parts
Gelatin	3 parts
Wheat Gluten	20 parts
$CaCO_3$	3 parts
NaCl	1 part

was kept before the animals at all times. Fresh water was supplied liberally.

At the end of four weeks X-ray pictures were made of the knee joint of the left hind leg, and a rachitic condition was demonstrated. One lot of animals was given 1/3 cc. of new native pecan oil per day; likewise. those in another cage received 2/3 cc. each; while those in a third cage were given 1 1/3 cc. each. The fourth group which received no supplement, was used as a control. The oil was administered orally from a 1 cc. pipette.

In ten days X-rays were again made. In all cases the rachitic condition was increased showing the oil contained little, if any, vitamin D.

Vitamin A Content

The same technique was observed as for studies on vitamin D. The vitamin A-free diet was prepared by the following formula:

Alcohol extracted and heated casein	18 parts
Dried Fleischman's Yeast	8 parts
Ground Dextrin	71 parts
McCollum's Salt Mixture (No. 185)	3 parts

As soon as the growth curves flattened, supplements of new native pecan oil were given to one series of three cages, and old native pecan oil to another group of three cages. Animals of cage 1 of each series received 0.5 cc. of supplement per rat per day, those of cage 2 were given 1 cc., and those of cage 3 were given 2 cc.

During the period in which supplements were administered, it was noted that except in a few instances no xerophthalmia was apparent, and these cases occurred in the fifth week of feeding. However, it was observed from the curves plotted that the animals did not show normal growth although they maintained their weight somewhat better than the control animals which developed xerophthalmia and died before the feeding was discontinued. Little difference is noted between the results of the three levels of oil given, although the animals receiving 1 cc. per day apparently were in better health. It is believed that 2 cc. of oil daily is too much fat, resulting in a lowering of protein intake. The vitamin A content of the rancid oil seemed not to have been destroyed. At the end of the forty day period in which supplement was given, 0.5 cc. of cod liver oil was given each rat per day for twelve days. Growth began in each case, indicating that there was possibly a deficiency in vitamin A.

It was deemed advisable to test the whole meats for vitamin A and to compare results. The animals were given the vitamin A-free diet described above, and under the same conditions. When the growth curves showed that the residual vitamin A had been exhausted, the following amounts of meats were fed daily: Animals of cage 1 received 0.5 gram per rat, those in cage 2 received 1 gram each, and those in cage 3 received 1.5 grams each. The animals all gained rapidly for a week, then merely maintained their weight and in some instances lost a few grams throughout the remainder of the forty day period. Those animals showing signs of xerophthalmia at the beginning were cured and no more signs of deficiency returned.

The fact that animals are cured of xerophthalmia yet do not gain in weight may be another case of toxicity produced by something in the meats, which Cajori reported. He was investigating the completeness of the protein in pecans and accredits the slow growth to a toxic effect of the bitter thin integument of the pecan meat, since after its removal normal growth was obtained.

It becomes apparent, therefore, that the pecan contains vitamin A, but that it also contains another factor that interferes with growth.

CONCLUSIONS AND SUMMARY

1. The percentage of meats in improved pecans was found to be very much higher than in native nuts.

2. No marked variation in physical constants of improved pecan oil and the same constants of native pecan oil was noted.

3. Rancid pecan oil has a lower iodine number than fresh pecan oil, as would be expected. This is probably due to oxidation of unsaturated compounds.

4. The only marked difference between constants of expressed oil and those of ether-extracted oil was in the Richert Meissl numbers—those of the expressed pecan oil were lower than those of the ether-extracted oil.

5. No appreciable amount of vitamin D was found in pecan oil.

6. New pecan oil apparently contains vitamin A, although as much as 2 cc. per day is insufficient to permit normal growth. There is no appreciable difference in the vitamin A content of new pecan oil and that of rancid pecan oil.

7. Animals fed new native pecan meats apparently suffered no vitamin A deficiency, but failed to continue growth after two weeks from the time the meats were added to the diet.

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