AMINO ACID COMPOSITION AND QUALITY IN SELECTED VARIETIES OF PECANS CARYA ILLINOENSIS[1]

FILMORE I. MEREDITH

USDA-ARS
Richard B. Russell Research Center
Athens, Georgia

Abstract. **Five varieties of pecans, Carya illinoensis, grown at three locations were analyzed for oil, moisture, total protein and amino acids. Varieties used for these analyses were 'Schley', 'Stuart' and 'Sioux', grown at Albany, Georgia; 'Schley', 'Stuart' and 'Moneymaker' grown at Byron, Georgia; and 'Sioux' and 'Choctaw' grown at Brownwood, Texas.**

The percent oil was lowest in 'Schley' of Byron (61%) and highest (75%) in 'Sioux' from Texas and 'Schley' from Albany. Moisture varied from 5 to 7%. Protein ranged from 6.6% for 'Sioux' from Albany, to 12.4% for 'Choctaw'. Percent shelled kernels were 39% for 'Stuart' of Albany, 46% for 'Moneymaker', 47% for 'Stuart' of Byron, 52% for 'Sioux' and 54% for 'Choctaw' of Texas, and 55% for 'Sioux' and 'Schley' of Albany. Eighteen amino acids were determined by ion exchange chromatography. In all varieties the concentration of glutamic acid was the highest and cystein was the lowest. Comparison of the essential amino acid data to whole egg showed that lysine was the limiting amino acid in all varieties tested.

The production of pecans, *Carya illinoensis*, in the United States has steadily increased since 1925 and was 2.2 million pounds in 1920 (11) and 247 million pounds in 1971 (4). The pecan industry in Georgia is valued at some 29.6 million dollars (4). The development of new varieties such as 'Choctaw' (6) and 'Sioux' (6) that are more prolific and disease resistant has increased interest in pecan production.

The utilization of pecans has increased with the extension of storage life, by control of temperature, relative humidities, air circulation, storage atmospheres, and better packaging (11). The capability of storing pecans up to 2 years, so that crop failures are not as large a risk, has allowed food manufacturers to steadily increase the number of food products containing pecans.

The growing concern over nutritional values of food in relation to protein content, increased utilization of pecans in food products and the limited information in the literature (3, 10) raised the question of the amino acid composition of pecans. Therefore, several varieties grown at different geographical locations were selected for determination of amino acid composition.

Materials and Methods

In the fall of 1973, pecans grown at three locations were selected for analysis. Varieties grown on USDA Horticultural Research Stations were 'Choctaw' and 'Sioux' at Brownwood, Texas, and 'Stuart', 'Schley' and 'Moneymaker' at Byron, Georgia. The remaining three varieties, 'Sioux', 'Schley' and 'Stuart', were locally grown and purchased from a pecan buyer in Albany, Georgia.

Pecan samples were mechanically shelled on a Champion Pecan Machine Company (model pecan seedling) sheller and chopped in a hand-powered food chapper to a particle size of 2 mm or less. AOAC (1) methods were used to determine oil, fiber, ash, moisture and total nitrogen on the chopped pecans.

Approximately 100g chopped pecans were Soxhlet extracted with hexane for 24 hours to remove the oil, as lipids can interfere with hydrolysis and ion exchange chromatography (2). The defatted samples were ground on a Wiley mill equipped with a 1-mm screen, ball milled for 24 hours and stored in a vacuum over phosphorus pentoxide.

Duplicate acid hydrolyzates of each sample were prepared by a previously described procedure (7). Tryptophane, which is destroyed by acid hydrolysis, was hydrolyzed by alkaline hydrolysis using the method of Hugli and Moore (5).

Amino acids were determined on a JEOL 6AH amino acid analyzer equipped with a JEOL DK two-channel integrator using the two column method of Moore *et al.* (8). Tryptophane was determined on the amino acid analyzer by the procedure of Hugli and Moore (5). A set of amino acid standards (Pierce Chemical Company) were analyzed with each set of five samples.

[1]The author acknowledges with appreciation Dr. George Madden, ARS, Brownwood, Texas, and Dr. Howard Malstrom, ARS, Byron, Georgia for furnishing selected varieties of pecans. Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U. S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

Table 1. Quality in five varieties of pecans grown at three locations.

Treatment	Brownwood, Texas		Byron, Georgia			Albany, Georgia		
	Choctaw	Sioux	Stuart	Moneymaker	Schley	Stuart	Sioux	Schley
Moisture (%)	5.0	7.3	5.9	6.8	5.6	5.4	6.6	6.1
Oil (%)	67.8	75.5	74.2	69.0	61.6	70.2	73.3	75.1
Fiber (%)	1.1	1.6	1.6	1.9	1.9	2.0	1.6	1.9
Ash (%)	1.8	1.6	1.6	1.8	1.7	1.7	1.5	1.5
Shelled pecan kernels (%)	54.0	52.0	47.0	46.0	56.0	39.0	55.0	55.0

Results and Discussion

Results of the analysis for pecent moisture, oil, fiber, ash and shelled pecans are given in Table 1. Moisture levels were from 5.0% in 'Choctaw' to 7.3% in 'Sioux' of Texas. Percent oil ranged from 61.6% for 'Schley' of Byron to 75.1% for 'Schley' of Albany and 75.5% for 'Sioux' of Texas. Fiber ranged from 1.1% in 'Choctaw' to 1.9% in 'Moneymaker', 'Schley' of Byron and 'Schley' of Albany. Ash content varied from 1.5% in 'Sioux' and 'Schley' of Albany to 1.8% in 'Moneymaker' and 'Choctaw'. The percentage of shelled pecan kernels ranged from 39% for 'Stuart' of Abany, 46% for 'Moneymaker', 47% for 'Stuart' of Byron, 52% for 'Sioux' of Texas, 54% for 'Choctaw' and 55% for 'Sioux' and 'Schley' of Albany.

The percents of nitrogen recovered from the amino acid determinations (Table 2) were all above 90% except for two, 'Sioux' of Albany and 'Stuart' of Byron, which were 89%.

Table 3 gives the patterns of the essential amino acids and the eight non-essential amino acids. The varieties with the highest to the lowest total concentration of essential amino acids were 'Choctaw', 'Moneymaker', 'Schley' of Byron, 'Stuart' of Albany, 'Sioux' of Texas, 'Stuart' of Byron, 'Schley' of Albany and 'Sioux of Albany. Of essential amino acids, in all varieties, concentration of cystein was lowest and of leucine was highest. The ratio of the concentration of the essential amino acids to the concentration of leucine for that variety appears in parenthesis. These values show that the distributions of the essential amino acids are very similar for all varieties. No differences in the amino acid concentration can be attributed to the different geographical locations.

Table 2. Total grams of nitrogen recovered from amino acid analysis, total nitrogen and percent protein and percent nitrogen recovered in pecans.

	Amino acid analysis recovered nitrogen	Kjeldahl nitrogen	Percent	
			Protein	nitrogen recovered
Brownwood, Texas				
Choctaw	1.89[a]	1.98[a]	12.4[c]	95.4
Sioux	1.44	1.54	9.6	93.5
Byron, Georgia				
Stuart	1.34	1.50	9.4	89.3
Moneymaker	1.54	1.60	10.0	96.2
Schley	1.65	1.76	11.0	93.7
Albany, Georgia				
Stuart	1.52	1.60	10.0	95.1
Sioux	.94	1.05	6.6	89.5
Schley	1.21	1.22	7.6	99.2

[a] Grams per 100g dry weight

[c] Kjeldahl nitrogen x 6.25

In lieu of bioassay or feeding trials, the quality of a food protein can be evaluated by comparison with egg protein. The quantity of an essential amino acid in the food protein divided by the quantity of the respective amino acid in the same amount of whole egg protein equals the egg ratio (9). Table 4 gives the egg ratios for essential amino acids in pecans. Egg ratios are also given for methionine + cystine and phenylalanine + tyrosine because, in man, methionine can be metabolically converted to cystine and tyrosine can be metabolically converted to phenylalanine (9). Therefore, between methionine and cystine the limiting amino acid is methionine or methionine + cystine, whichever has the lowest egg ratio; the relationship is the same between phenylalanine and tyrosine. In the variety 'Choctaw' the chemical score (egg ratio of the limiting amino acid) was lowest for cystine but since the score of methionine + cystine was higher than the score for lysine, lysine is the actual limiting amino acid. In all other varieties, lysine was found to have the lowest chemical score. The Food and Agricultural Organization (3) reported that in pecans the limiting amino acids were the sulfur amino acids and valine. These data were obtained by microbiological methods and not by ion exchange chromatography. The variety 'Moneymaker' had an overall higher distribution (egg ratio) of the essential amino acids than any of the other varieties but was not greatly

Table 3. Amino acid patterns for pecans

Amino Acids	Brownwood, Texas		Byron, Georgia			Albany, Georgia		
	Choctaw[a]	Sioux	Stuart	Moneymaker	Schley	Stuart	Sioux	Schley
Iso*	429.8 (6)[b]	336.4 (6)	299.0 (6)	380.2 (6)	389.0 (6)	352.7 (6)	211.5 (6)	285.1 (6)
Leu*	735.1 (10)	545.7 (10)	482.1 (10)	616.5 (10)	611.7 (10)	553.1 (10)	337.9 (10)	445.1 (10)
Lys*	424.0 (6)	278.3 (5)	275.6 (6)	350.8 (6)	317.4 (5)	331.7 (6)	201.5 (6)	264.5 (3)
Met*	208.2 (3)	187.8 (3)	167.5 (3)	193.1 (3)	219.6 (3)	190.8 (3)	136.2 (4)	144.5 (3)
Cys*	106.1 (1)	122.8 (2)	92.8 (2)	135.0 (2)	110.0 (2)	99.2 (2)	56.6 (2)	79.1 (2)
Phe*	581.2 (8)	411.1 (7)	387.0 (8)	510.6 (8)	478.7 (8)	441.3 (8)	282.4 (8)	331.8 (7)
Tyr*	388.0 (5)	302.9 (5)	267.9 (5)	353.8 (6)	382.2 (6)	315.3 (6)	207.9 (6)	227.3 (5)
Thr*	359.5 (5)	260.0 (5)	240.9 (5)	299.2 (5)	298.2 (5)	270.7 (5)	176.4 (5)	227.5 (5)
Typ*	245.2 (3)	180.6 (3)	161.4 (3)	219.1 (3)	248.1 (4)	186.4 (3)	159.1 (5)	237.9 (5)
Val*	545.0 (7)	391.7 (7)	358.8 (7)	449.0 (7)	441.0 (7)	408.2 (7)	249.0 (7)	333.6 (7)
Total Essential A.A.	4336.7	3017.3	2733.0	3507.4	3496.1	3149.4	2211.4	2589.6
Arg	1634.0	1206.5	1074.8	1348.9	1334.0	1226.1	690.8	941.6
His	326.6	221.7	217.6	260.5	269.4	250.3	150.9	193.8
Ala	490.6	337.3	316.8	383.7	379.3	356.2	222.5	296.0
Asp	1051.6	762.4	697.0	829.6	870.5	770.6	400.4	619.9
Glu	2249.2	1599.8	1483.9	1760.4	1733.1	1677.2	962.7	1579.7
Gly	523.5	356.1	349.1	425.0	416.9	397.0	240.3	313.6
Pro	461.1	355.2	338.6	406.0	431.3	408.2	277.8	319.1
Ser	528.3	372.3	357.5	413.1	430.2	390.7	246.4	315.3
Total Non-Essential A.A.	7264.9	5211.2	4835.3	5827.2	5864.7	5476.3	3281.8	4579.0
Total A.A.	11601.6 [c]	8228.5	7568.3	9334.6	9360.6	8625.7	5493.2	7168.6

[a] Mg amino acid per 100 g dry weight
* Essential amino acids
[b] Ratio of the essential amino acid divided by the essential amino acid leucine x 10.
[c] Total amino acids equal to total essential A.A. + total non-essential A.A.

superior to any of the others. From a nutritional standpoint the varieties of pecans tested were comparable to cereal grains in amino acid content and total nitrogen (3). They are not as good a source of protein as a leaf protein such as turnip greens, which have a much higher amino acid content and total nitrogen content (7). The plant breeder should be aware of this and make every effort to develop varieties with higher levels of essential amino acids. Although pecans do not have a high amino acid content their popularity as a food item is steadily increasing. This can be demonstrated by

Table 4. Egg ratio of essential amino acids in pecans

	Egg Ratio x 100							
	Brownwood, Texas		Byron, Georgia			Albany, Georgia		
Amino Acid	Choctaw	Sioux	Stuart	Moneymaker	Schley	Stuart	Sioux	Schley
Lys[a]	46	37	37	45	37	42	39	45
Met	56	59	56	59	62	59	65	59
Cys	43	62	47	62	48	47	41	48
Met + Cys	51	60	53	60	57	55	57	55
Phe	89	78	74	93	78	80	78	78
Tyr	86	81	74	92	92	81	84	79
Phe + Tyr	88	79	74	92	84	81	81	78
Leu	70	64	58	70	64	62	58	68
Iso	61	59	54	64	59	59	54	63
Thr	61	55	53	61	55	55	55	61
Val	65	58	53	63	56	58	53	62
Trp	100	100	100	100	100	100	100	100

[a] Underscored numbers are chemical score based on limiting amino acid.

a 100 fold increase in production in the last 50 years.

Literature Cited

1. Assoc. of Off. Anal. Chem. 1970. Official Methods of Analysis. 11th ed., Washington, D.C.
2. Blackburn, S. 1968. Amino acid determination, methods and techniques. Marcel Dekker, Inc., New York. 15.
3. Food Policy and Food Science Service. Amino acid content of foods and biological data on proteins. 1970. *Food Agr. Organ. U.N. FAO Nutr. Studies.* 24:74.
4. Galloway, F. T. and C. L. Crenshaw. 1972. Pecans. Georgia Farm Rep., *Georgia Crop Rep. Service.* Athens, Georgia.
5. Hugli, T. E., and S. Moore. 1972. Determination of the tryptophan content of proteins by ion exchange chromatography of alkaline hydrolyzates. *J. Biol. Chem.* 247(9):2828-2834.
6. Madden, G. D. and L. D. Romberg. 1968. Pecans for everybody; USDA breeding program turns out improved varieties. *Texas Agric. Progress.* 14(3):12-14.
7. Meredith, F. I., M. H. Gaskins and G. G. Dull. 1974. Amino acid losses in turnip greens (*Brassica rapa* L.) *J. Food Sci.* 39:689-691.
8. Moore, S., D. H. Spockman, and W. H. Stein. 1958. Chromatography of amino acids on sulfonated polystyrene resins. An improved system. *Anal. Chem.* 30:1185-1190.
9. Sheffner, A. L. 1967. In vitro protein evaluation. Newer methods of nutritional biochemistry. Ed. Albonese, A.A., Academic Press, New York. 125-131.
10. Taira, H. and H. Taira. 1964. Amino acid composition of seeds and nuts. *To Shokuryo.* 17(4):244-247.
11. Woodroof, J. G. and E. K. Heaton. 1961. Pecans for processing. *Georgia Agri. Expt. Sta.* Bulletin N.S. 80.

SALES, MARKETING AND PROFITABILITY OF A SMALL PICK-YOUR-OWN VINEYARD

E. A. GROSZ

Florida's Vineyard
Gainesville
and

T. E. CROCKER

IFAS Fruit Crops Dept.
Gainesville

Abstract. **Costs per acre of establishing a 16 acre Pick-Your-Own (PYO) vineyard near Chattanooga, Tennessee in 1966-1968 were $556. Production costs per acre for the first 3 years were $240. Net profit per acre in 1973 was $723.17. Fruit sales history and the cost and type of advertisement are given. Production and harvesting tips are given for PYO operations.**

Pick-Your-Own (PYO) operations have been advocated by many people as a means of increasing profits from small plantings. Physical layouts and management of operations in different geographical areas of the U. S. have been discussed (1, 2, 3, 4, 5). This paper deals with the sales, marketing and profitability of a 16 acre vineyard located 50 miles N. E. of Chattanooga, Tennessee. Planting dates and cultivars for the vineyard are given in Table 1. Intensive study of other vineyards as well as professional help from various University personnel were utilized in planning and selection of cultivars for the vineyard. Original plan for this vineyard was to sell the fruit to a winery located in Georgia. Predicted gross sales were approx $480 (4 tons @ $120/ton delivered) with net profit approx $200 per acre if the fruit were sold to a winery.

Table 1. PYO vineyard planting calendar for 1966-68.

Year		Varieties
1966	112 Vines (½ A)	Hunt, Higgins, Magoon
1967	1800 Vines (10 A)	Hunt, Scuppernong Magnolia
1968	1000 Vines (5½ A)	Mixed varieties

Costs of establishing the orchard; ground preparation, vines, post, wire and labor, exclusive of land cost, was $371 per acre. (Table 2). Production costs for the first 3 years including labor, tractor, fertilizer and miscellaneous, were $240 per acre (Table 3). Total per-acre cost through 3 years including land was $1,285.

Fruit sales increased with each year of production (Table 4). It was found that a large amount of fruit was being eaten by the PYO cus-

Table 2. Costs of establishment PYO vineyard near Chattanooga, Tennessee in 1966-68.

Land - 16 acres		$3,000.
Ground Preparation - 20 tractor hrs @ $4.50/hr		90.
Vines - 2912 @ 50¢ each		1,456.
Planting labor ($1.25/hr)		300.
Posts - 2600 @ 75¢ (3" x 6½')		1,800.
240 @ $2.50 (6" x 10')		576.
Setting posts (800 hrs)		1,000.
Wire - 56,000' 9 gauge ($11.50/CWT)		430.
Labor to string (240 hrs)		300.
	TOTAL	$8,952.
(Per acre w/o land)		($371.)