The Sesame Plant as a Source of Protein and Other Nutrients

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ABSTRACT

Tropical varieties of sesame grown in California exhibit lush vegetative growth and could serve as sources of leaf protein concentrates. Green sesame plants were harvested in late August and, following 3 months of vegetative growth, produced 18.5 tons of fresh material per hectare, 543 kg/ha of protein. It is expected that these yields could be increased with breeding of better varieties and improvement of cultural practices. Amino acid composition of sesame leaves was comparable to alfalfa; 17 amino acids make up 21% of dry leaf weight.

INTRODUCTION

Previous research has shown sesame seed to be an excellent source of edible oil and protein. Similar investigations have not been conducted to determine the value of the green sesame plant in nutrition. Of particular significance in this respect is the strong response of the sesame plant to photoperiod, because of which tropical varieties of sesame grown in the temperate zone produce enormous quantities of leaf and stem material but very little seed. Because of their low seed production these tropical varieties have always been considered of no value for the U.S. agriculture except as sources of germplasm in sesame breeding.

Published reports on sesame photoperiodism are very few. Rhind (1), and Sen Gupta and Sen (2) presented data relating to changes in vegetative development and flowering of sesame grown under different photoperiods. Sen Gupta and Payne (3), and Gosh (4) studied changes in leaf morphology and time of flowering caused by different photoperiods. Kurnick (5), Alekseev (6), and Kluijver and Smilde (7) studied changes in the chemical composition of the seed and report that an extended photoperiod raises the oil content of the seed.

The potential value of tropical varieties of sesame as sources of nutrients was investigated in the University of California at Riverside in 1969 and 1970 and the results are presented in this report.

MATERIALS AND METHODS

The experiments and results of both 1969 and 1970 were essentially the same; therefore the information presented will be limited to the 1970 work. The following eight tropical varieties of sesame were included in the experiment: Aceitera, Glauca, Inamar, Morada, Venezuela-44, Venezuela-52, Blanquina, and Rana. Two temperate zone varieties were also grown: Oro and ER-7. (Blanquina was developed by A. Montealegre, I.N.A., Managua, Nicaragua; Rana is a local Nicaraguan variety. The other six tropical varieties were developed by B. Mazzani,

TABLE I

Plant Height of Eight Tropical and Two Temperate Zone Varieties of Sesame at Different Stages of Development

	Height, % total height at maturity				Height, cm				
	Days after emergence				Days after emergence				
Variety	40	53	68	80	40	53	68	80	90
Venezuela-44	7	17	40	74	14	37	84	156	212
Rana	6	17	31	63	13	35	66	132	210
Morada	6	16	30	60	12	32	60	122	202
Venezuela-52	7	18	34	63	14	35	67	126	200
Blanquina	9	22	42	73	17	42	81	143	195
Inamar	7	19	38	70	14	38	74	137	195
Aceitera	8	20	46	75	15	38	88	144	192
Glauca	9	21	40	75	16	36	70	131	175
Ave tropical var.	7	19	38	69	14	37	74	136	
Oro	10	25	55	96	14	35	76	133	
ER-7	24	53	76	96	26	57	81	103	

TABLE II

Leaf, Stem and Protein Production by 10 Sesame Varieties

	Green weight, kg/ha		Dry weight, kg/ha		Protein, % db		Protein produced, kg/ha	
Variety	Leaves	Stems	Leaves	Stems	Leaves	Stems	Leaves	Stems
Venez-52	6097	12378	1335	4505	24.9	4.7	332	211
Venez-44	5670	14156	908	3639	23.8	6.6	216	239
Aceitera	7308	10605	1001	3033	24.7	6.6	247	199
Rana	6020	8627	812	2821	23.1	7.8	187	220
Inamar	5380	12435	893	3867	25.9	4.4	232	169
Glauca	8477	9073	1136	2423	23.9	5.0	271	122
Blanquina	6371	10091	1013	2432	19.7	7.5	200	183
Oro	5752	10314	1087	2579	22.4	6.6	152	169
Morada	4006	5056	481	1056	24.9	6.9	119	73
ER-7	1237	3711	233	586	26.8	8.8	62	51

TABLE III

Per Cent Total Amino Acid Composition of Dried Sesame Leaves and Undecorticated Lipid Free Sesame Meal

	Variety										
	Venezuela-52		Oro		Rana		Means of 3 varieties				Alfalfa leaf protein concentrates[a,b]
Amino acid	Leaf	Meal	Leaf	Meal	Leaf	Meal	Leaf	Meal	Leaf[a]	Meal[a]	
Lysine	1.03	1.52	1.14	1.41	1.08	1.27	1.08	1.40	5.20	2.94	6.2
Histidine	0.43	1.22	.47	1.04	.41	1.13	.44	1.13	2.12	2.37	2.5
Ammonia	.65	.40	.73	.33	.22	.36	.53	.36	2.55	.76	---
Arginine	1.29	6.91	1.37	5.96	1.21	6.60	1.29	6.49	6.21	13.64	6.5
Aspartic acid	2.79	4.39	3.44	3.94	2.09	4.13	2.77	4.15	13.33	8.72	10.2
Threonine	.97	1.83	1.09	1.76	.88	1.74	.98	1.78	4.72	3.74	5.3
Serine	.87	2.43	.85	2.16	.76	2.51	.83	2.37	3.99	4.98	5.3
Glutamic acid	3.02	10.55	2.79	9.36	3.50	10.44	3.10	10.12	14.92	21.27	11.2
Proline	.99	1.56	1.41	1.38	.77	1.48	1.06	1.47	5.10	3.10	5.3
Glycine	1.13	2.62	1.26	2.42	.99	2.50	1.13	2.51	5.44	5.28	5.6
Alanine	1.19	2.39	1.32	2.15	1.14	2.29	1.22	2.28	5.87	4.79	6.5
Half cystine	.35	.84	.40	.57	.05	.80	.27	.74	1.30	1.56	.9
Valine	1.19	2.48	1.31	2.24	1.12	2.40	1.21	2.37	5.82	4.98	5.9
Methionine	.28	1.37	.27	1.56	.21	1.40	.25	1.44	1.20	3.03	.9
Isoleucine	.94	1.95	1.05	1.85	.88	1.82	.96	1.87	4.62	3.93	5.3
Leucine	1.68	3.39	1.83	3.15	1.54	3.27	1.68	3.27	8.08	6.87	9.9
Tyrosine	.78	1.64	.93	1.56	.62	1.59	.78	1.60	3.75	3.36	4.0
Phenylalanine	1.21	2.34	1.32	2.05	1.06	2.26	1.20	2.22	5.77	4.67	6.8
	20.79	49.83	22.98	44.89	18.53	47.99	20.78	47.57			

[a]Amino acids expressed as percentage of total amino acids recovered.
[b]Amino acid composition of leaf protein concentrates, Gerloff et al. (12).

Center for Agricultural Research, Maracay, Venezuela. Oro was developed jointly by the Texas Agricultural Experiment Station and the U.S. Department of Agricultural and ER-7 is an introduction from Russia.) These 10 varieties were planted on May 13 on raised beds 75 cm apart and 13 m long, in a randomized block design with four replications. Irrigations were given at approximately 15 day intervals and all tropical varieties were cut during the last week of August. Leaf and stem production was recorded at cutting time and after drying the material in a forage drier at 44 C for one week.

TABLE IV

Mg Individual Amino Acids
Per Gram of Total Essential Amino Acids

Amino acid	Recommended pattern[a]	Sesame leaf	Sesame meal
Lysine	134	147	98
Threonine	89	133	124
Valine	134	164	165
Methionine	71	34	100
Isoleucine	134	130	130
Leucine	152	228	228
Phenylalanine	89	164	155

[a]By Food and Agriculture Organization—World Health Organization, 1957.

Nitrogen content of the dried leaves and stems was determined by the Kjeldahl method. The quantitative amounts of total amino acids were determined on duplicate 10 g ground leaf samples as described by Labanauskas and Handy (8) with a Beckman/Spinco Amino Acid Analyzer Model 120 C. The lipid component of the leaves and stems was determined by the Sohxlet method.

RESULTS

All tropical varieties exhibited greater vegetative growth in leafiness and height than the temperate zone varieties but they produced few capsules or none at all. Up to about 40 days after emergence, all varieties grew in height at about the same rate (Table I). On the 40th day, ER-7 was 26 cm tall while the other varieties ranged from 13-17 cm; on the 53rd day, ER-7 still surpassed the other varieties in height (57 cm vs. a range of 32-42 cm for the others). After the 68th day, the tropical varieties accelerated their elongation very sharply. On the 80th day, while ER-7 and Oro had attained 96% of their total height (measured on guard rows grown to maturity), the tropical varieties had reached only 63-75% of their total height.

The tropical varieties were cut 90 days after emergence. At that time they were still growing in height but their lower leaves had started turning yellow and abscising; thus a delay in harvesting would be to no advantage in terms of

TABLE V

Grams of Protein in Sesame Leaves, Sesame Seed Meal
and Alfalfa Leaf Protein Concentrates Providing Recommended
Level of Each Essential Amino Acid to Maintain Nitrogen Balance in Adult Man

	Sesame			
Amino acid	Leaf	Meal	Alfalfa leaf protein concentrates[a]	Recommended g/day[b]
Lysine	31	54	25	1.6
Phenylalanine	38	47	32	2.2
Methionine	183	72	244	2.2
Threonine	21	27	19	1.0
Leucine	27	32	22	2.2
Isoleucine	30	36	26	1.4
Valine	27	32	27	1.6

[a]Amino acid composition of leaf protein concentrates, Gerloff et al. (12).
[b]Rose (15).

leaf production. Oro and ER-7 were cut 8 and 15 days earlier, respectively, for the same reasons and because they had started to bear several capsules setting seed. Anthesis started much later in the tropical varieties than in the temperate varieties. At harvest time Venezuela-52 and Blanquina had just started blooming and had no capsules; Glauca, Morada and Inamar averaged 5-10 young capsules per plant; Rana and Venezuela-44 had 20-32. Aceitera responded to photoperiod by growing 18% taller than in Venezuela; in spite of that, blooming was not greatly delayed and thus the mean number of capsules set per plant was as high as 96. Glauca was the most succulent, leafy and fine stemmed variety.

The leaves, including petioles, made up 29-48% of the weight of the green sesame plant and 19-32% after drying (Table II). The ranking of the tropical varieties in terms of per cent leaves was essentially the same before and after drying. Moisture content ranged from 78-88% in the leaves and from 64-84% in the stems. The highest yield of dried leaves and stems, 1335 and 4505 kg/ha, respectively, was given by Venezuela-52; however the highest protein content, i.e., N x 6.25, was found in ER-7, 26.8% and 8.8%, respectively. Total protein content ranged from a high of 543 kg/ha by Venezuela-52 to a low of 113 kg/ha by ER-7. Protein content of leaves and stems ranged from 19.7-26.8% and from 4.4-8.8%, respectively.

The amino acid composition of the leaves of three of the varieties used in this study is shown in Table III. In spite of the very diverse genetic background and the major morphological and physiological differences of these varieties, the amino acid composition of their leaves is very similar. Compared with the amino acid composition (expressed as per cent of total amino acids recovered) of the undecorticated lipid free meal of the seed of the same varieties, the leaves were higher in lysine, aspartic acid, proline and leucine, but lower in arginine, glutamic acid and methionine. Sesame meal is highly prized for its high methionine content which distinguishes it from all other oil seed meals; thus, it is interesting to note the low relative methionine content of the leaves. A comparison between sesame leaves and alfalfa indicates that they are both very similar except for higher glutamic acid, aspartic acid and methionine in sesame leaves. Four amino acids, arginine, aspartic acid, glutamic acid and leucine, make up 43% of all amino acids in sesame leaves, 50% in sesame meal and 38% in alfalfa. Finally the 17 amino acids determined make up 21% of the weight of dried leaves and 48% of the undecorticated lipid free sesame meal.

Table IV shows the ratio of each essential amino acid to the total essential amino acids, excluding tryptophane, in leaves and in meal. The ratios in the leaves compare favorably with those recommended by Food and Agriculture Organization - World Health Organization in 1957 and with the meal ratios, except for methionine. Table V indicates the amount of protein concentrates that would be needed to provide the recommended level of each essential amino acid to maintain nitrogen balance in an adult man.

TABLE VI

Lipid Content of Dried Total Sesame Leaves and Stems and Lipid Production Per Hectare

Variety	Lipid content, %		Lipid production, kg/ha
	Leaves	Stem	
Venezuela-52	2.3	.9	72.3
Venezuela-44	2.6	.9	56.4
Aceitera	2.8	1.0	58.4
Rana	2.4	.8	42.1
Inamar	2.4	.8	52.4
Glauca	2.2	.9	46.8
Blanquina	2.1	.7	38.3
Oro	2.8	.8	51.0
Morada	2.0	.9	19.2
ER-7	2.7	.8	11.0

Sesame leaf protein is not very different from alfalfa leaf protein concentrates, but because of its higher methionine content 183 mg of sesame leaf protein provides the same amount of methionine as 244 mg of alfalfa leaf protein. The lipid content (Table VI) varied from 2.0-2.8% in the dried leaves and from 0.8-1.0% in the dried stems. The highest quantity of lipids was produced by Venezuela-52 (72.3 kg/ha) and the lowest by ER-7 (11.0 kg/ha).

The mineral composition of leaves, stems and meal of two tropical varieties of different geographic origin, Glauca and Blanquina, was determined. The differences between the two varieties were not major; stems were higher in K_2O and Cl content than leaves, but the reverse was true in regard to CaO.

Leaves and stems were strikingly higher than undecorticated meal in SO_4 content; the reverse was true for P_2O_5 (Table VII). Crude fiber of the leaves ranged from 5.1-8.5%, and of the stems from 39.4-48.2%.

DISCUSSION

Leaf proteins have attracted considerable attention as a potential source of protein that could be tapped in an effort to relieve the world protein shortage (9). The Protein Advisory Group of the United Nations, considered the advantages and disadvantages of leaf protein concentrates and found them suitable, at this time, as animal feed rather than as supplements to human nutrition (10). However encouraging preliminary results have been obtained with a new, wet process for the separation of proteins, carotenes and xanthophyll from fresh chopped alfalfa which in addition to animal feed provides protein concentrates suitable for human nutrition (11). The identification of superior sources of leaf protein and other nutrients is as important as the advances in the processing field if this new source of nutrients is to be exploited successfully.

The yields of leaves and stems reported in this study are considered as average rather than as maximum. Cool nights in Riverside tend to slow down vegetative development of sesame. Earlier tests with the same varieties in Shafter,

TABLE VII

Mineral Composition of Leaf, Stem and Undecorticated Meal of the Varieties Glauca and Blanquina, %

Mineral	Leaf		Stem		Meal	
	Glauca	Blanquina	Glauca	Blanquina	Glauca	Blanquina
K_2O	1.85	1.35	3.05	2.30	2.16	0.92
Na_2O	0.12	0.10	0.15	0.10	0.26	0.70
CaO	3.35	3.65	1.95	1.96	1.54	2.24
MgO	0.47	0.40	0.37	0.38	0.50	0.64
P_2O_5	0.78	0.83	0.67	0.90	2.80	2.16
SO_4	0.88	0.72	0.76	0.45	0.06	0.04
Cl	0.30	0.21	0.53	0.57	0.22	0.36

California, and in the Imperial Valley, California, showed that in these locations tropical sesame varieties exhibited strikingly greater vegetative growth. For example the variety Aceitera attained a height of 250 cm and 129 capsules per plant. Further increases in yield should be expected from better cultural practices maximizing vegetative growth rather than seed production. The plant populations used in this study were those recommended for highest seed yields. Closer spacing and higher populations would probably increase leaf and stem yields and palatability by reducing the crude fiber content. Other aspects that deserve further investigation are the possibility of having two cuttings, and the selection or breeding of superior varieties in terms of forage and protein production and quality.

Considering the great differences among the varieties studied in maturity, photoperiod response, morphology and growth habit, it is noteworthy that the amino acid composition of their leaves was very similar. Gerloff et al. (12) also found that leaves of nine plant species sampled at different growth stages and managed differently had similar amino acid composition. Plant species appear to differ mainly in their total yield of leaf protein and not in its digestibility or amino acid composition (13).

In a survey of several sources of protein, Akeson and Stahman (13) found that alfalfa produced the largest quantity of the essential amino acids per hectare, with soybean seed second. They also point out that land used for leaf protein production would yield much more edible protein per hectare than when used to produce meat. Future research in this area should include the evaluation of tropical plant species which respond to photoperiod and produce greater amounts of foliage when grown in temperate latitudes. The information reported here on tropical varieties of sesame is not sufficient for reaching final conclusions as to their rating in comparison with alfalfa. Chemical composition data must be supplemented by feeding trials or laboratory evaluations of the nutritive value of proteins by determining the amino acid release by digestive enzymes (14). However the data are encouraging enough to make further research with tropical sesame advisable. As already mentioned the present attitude is to consider leaf proteins suitable for poultry and pig feeding. This may be a necessary starting point for leaf proteins until processing techniques may be developed for their conversion into attractive food for humans, as has happened with soybean meal.

No effort is made in this report to specify how tropical sesame could fit into different crop rotation schemes. Alfalfa dehydration plants experience yearly shortages of raw materials around August when the supply of alfalfa is low. Grown as a second crop after cereals, tropical sesame which reaches its maximum development in August could conceivably be used initially to alleviate this situation.

ACKNOWLEDGMENTS

The project was supported in part by a grant from the Oil Seed Crop Research Trust, Fresno, California. B. Mazzani and A. Montealegre provided seed of tropical sesame varieties.

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[Received March 11, 1971]