THE CHEMICAL COMPOSITION AND PROTEIN QUALITY OF AMARANTH GRAIN GERM PLASM IN GUATEMALA[1]

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SUMMARY

The present research was carried out for the purpose of collecting part of the germ plasm of grain amaranth in Guatemala, as well as to evaluate it in terms of yield, chemical composition and nutritive value. A total of 27 Guatemalan selections, one from Mexico and seven from Peru were planted in June 1982 in 7.5 m^2 experimental plots replicated four times. The harvest seed was utilized for analysis of protein, ether extract, crude fiber, tannin content and trypsin inhibitors, as well as for NPR assays. A group of five pooled samples was made based on protein content for amino acid analyses; 10 samples were selected for a second NPR and protein digestibility assay. A preliminary assay on amino acid supplementation of raw grain flour is also reported.

The selections were significantly different in grain yield. In general, selections which flowered at a short height and were harvested also at short height, tended to yield more seed. Findings revealed a negative relationship between plant height and grain yield, but a positive relationship between plant height and dry vegetable residue. Protein content of the grain averaged 15.0°/o with values ranging from 12.8 to 17.4°/o. Fat content varied from 5.6 to 10.6°/o with an average of 8.4°/o. Amaranth grain with a higher protein content contained greater amounts of amino acids on a

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weight basis, but when these were expressed on a nitrogen basis, differences disappeared. Based on the FAO/WHO amino acid reference pattern, grain amaranth protein was deficient in sulfur amino acids.

Although the biological trial corroborated this deficiency, more studies should be undertaken. The NPR values of the samples from Peru averaged 2.30, the one from Mexico 2.04 and those from Guatemala, 2.36. Protein digestibility was 80, 82 and 74%, respectively. The data suggest that there is sufficient variability to select materials of a higher chemical composition, nutritive value, and yield.

INTRODUCTION

Except for limited studies carried out by INCAP, there is little information in Central America on amaranth grain, although in the diets of the Maya, Inca and Aztec civilizations it was an important food (1, 2). Today its production and availability in the region are very low, and it is used in a limited extent in the preparation of special foods on festive days; however, it is extensively used in Peru (3, 4) and Mexico (3, 4). For the purpose of calling the attention of governments, agricultural sectors and food industries, it was considered necessary to develop a research program whose objectives were to obtain basic information on amaranth grain cultivars, its production potential, processing effects on nutritive value, and utilization in new food products. Although in this project emphasis was placed on amaranth grain, it has also been considered important to study the leafy types, since amaranth leaves are often consumed in the rural areas of the Central American countries as well as in other regions of the world (2-4). Data on chemical composition of amaranth grain is readily available, and an up-to-date review on the subject has been published recently (5). In this first report, chemical data on a limited Guatemalan germ plasm collection as well as some biological information on the nutritional value of a group of selected samples are presented.

MATERIAL AND METHODS

A total of 27 samples was collected in the highlands of Guatemala from December 1981 to February 1982; the actual locations are listed in Table 1.

From the total seeds collected, three groups were formed: the First one for chemical analysis (6), the second for storage and future retrieval, and the third for agronomic trials to evaluate the vegetative growth of the plants, their seed yield, and to produce enough seeds for nutrition evaluation purposes. Other samples used included one from Mexico *(A. cruentus)* and seven from Cusco, Peru *(A. caudatus)*, while the others were not classified.

A total of 35 samples were planted on June 16, 1982 in 132 plots (7.5 m^2/plot), assigning four replicates per selection collected. Data were obtained on the vegetable development of the plant, number of days it took to flower, problems presented in the past plants' height, yield, and other agronomic data which could be of interest. The seeds harvested from September to November 1982, and the plant residue were analyzed

TABLE 1

SITES OF AMARANTH GRAIN COLLECTIONS

Identification and origin		Identification and origin	
1.	F-INCAP 23	15.	F-INCAP
2.	Carrizal 13	16.	Río Concuá
3.	F-INCAP 5-X-81	17.	Caserío Chaley 24
4.	San Antonio Las Flores 14	18.	San Juan Sac. 10
5.	San Rafael Las Flores 20	19.	F-INCAP 21
6.	B1 San Martín Jilotepeque	20.	El Ciprés San Raymundo
7.	Dr. San Martín Jilotepeque	21.	Dr. G. El Edén S. Raymundo
8.	Jolón Cot. 18	22.	Est. Grande 12
9.	Dr. Sacsuy	23.	Las Joyas 19
10.	El. Sacsuy	24.	Sacsuy 8-X-81
11.	Est. La Virgen 17	25.	Dr. San Raymundo 2-12-81
12.	San Juan Sacatepéquez	26.	San Jerónimo Miramar 22
13.	Antigua 9	27.	Estancia Grande 15
14.	Estancia Grande		

for moisture, protein, crude fiber and ether extract content by the AOAC methods (6). They were also analyzed for tannic acid content (7) and trypsin inhibitor activity (8).

Due to the large number of samples, only five were analyzed for their amino acid content. These were selected on the basis of their protein content, which ranged from 10.2 to 17.4% protein. Amino acid analysis was carried out on 6 N HCl hydrolyzates by ion exchange chromatography with a Technicon amino acid analyzer. Tryptophan was determined according to Villegas, Ortega and Bauer (9).

Enough seeds from all four replicates were produced from all selections except for No. 11 and No. 24. The raw seed was ground in a laboratory mill and included in a basal diet to provide 10% protein. The diet contained raw amaranth flour, 4% mineral mixture (10), 5% cottonseed oil, 1% cod liver oil, and corn starch to adjust to 100 g. All diets were supplemented with a complete B-vitamin solution (11). The assay conducted was a net protein ratio (NPR) in which eight rats per group were distributed to each diet according to their weight. The animals were placed in individual all-wire cages with raised screen bottoms. Feed and water were supplied *ad libitum* for a period of 14 days. In a second study, the seven selections from Peru, one from Mexico and one from Guatemala (No. 17) were assayed as indicated for the 14 days trial. During the last seven days feces were collected for protein digestibility. Besides the experimental diet groups, two additional groups were included, a nitrogen-free diet group and a 10% protein-casein as control. A preliminary biological assay using the PER method was carried out to confirm amino acid deficiencies in a pool of raw amaranth grain. To a basic diet of raw amaranth flour, individual amino acids were added based on amino acid scores. The test was conducted for 28 days with six animals per group.

RESULTS AND DISCUSSION

Although the sowing technique and planting dates were the same for all 33 selections (two were lost), the data presented in Table 2 indicate the different time periods needed among selections to reach flowering stage at different heights. Flowering varied from 50 to 110 days after planting, at heights ranging from 70 to 225 cm. Seed harvest ranged from 94 to 151 days at heights from 105 to 300 cm. The seed yield varied from 418 to 4,800 kg/ha, and the differences were highly significant. In general, as Table 3 illustrates, the selections which reached the flowering stage earlier at lower height were those which gave higher grain yields, a fact which merits further study. The samples from Guatemala varied in yield; but within a high yield, they produced the same or more than the limited number of lines from Peru or Mexico. The best samples for seed production were those collected at INCAP's Experimental Farm in San Raymundo Sacatepéquez, Guatemala, possibly because they were well-adapted to the region. Unfortunately, most of the national selections yielded seeds of a deep brown color, and only one white selection was collected. Figure 1 shows a negative significant relationship between grain yield and plant height at harvest, when selections with a high height produced less seed than those of a lower height.

The yield of the dehydrated leafy residue in the four plots harvested after the grain collection is also presented in Table 2. The yields of all four replicates varied from 9.09 to 19.09 kg per 30 m^2. As was to be expected, a positive relation was found between plant height at harvest and dry matter yield (Figure 2). The chemical analysis of this residue is shown in Table 4. Although its fiber content is as high as in most crop residues (12), it contains 7.25% protein, which is relatively good for ruminant feeding.

As indicated in Table 5, chemical analysis of the grain for all samples collected in the field included protein, which ranged from 12.8 to 17.4% with an average of 15.0%. The average ether extract content was 8.4% with values ranging from 5.6 to 10.6%, while those for crude fiber varied from 2.9 to 9.9%, with an average of 6.5%. Protein, ether extract, and crude fiber of the samples harvested at the Experimental Farm are shown in Table 6. As the data reveal, protein was 14.8%, ranging from 14.0 to 17.5%, and crude fat, from 5.2 to 7.1%, with and average of 6.1%. These values fall within figures reported by various authors (4, 5, 13). The crude fiber values for some samples of the seed harvested at the Experimental Farm were relatively high, maybe because grains still contained the cuticle which holds the grain. The variability found in nutrient content offers the possibility of obtaining cultivars with higher fat and protein values. Compared with cereals, amaranth is higher in protein content, and its high fat content suggests it to be a relatively high-energy food. A salient fact is that the samples from Guatemala had higher protein, fat and fiber content than those from Peru and Mexico. Crude fiber content exhibited higher differences: thus, in the samples from Guatemala, crude fiber content was 7.1% on the average, as compared with 3.9 and 3.0% for the samples from Peru and Mexico. It is important to state that these aspects need further studies due to the nutritional implications they may have, as well as for genetic and agronomic purposes.

TABLE 2

AGRONOMIC TRIALS CARRIED OUT WITH AMARANTH SELECTIONS COLLECTED IN GUATEMALA AND OTHER SAMPLES FROM MEXICO AND PERU

Entry	Flowering			Harvest			Average yield kg/ha	Color seed	Yield vegetable residue kg/30 m^2
	Date*	Days	Height m	Date	Days	Height m			
1	24/09	98	1.90	25/10	129	2.40	811	DB	15.91
2	01/10	105	2.00	20/11	145	2.30	725	DB	13.64
3	25/08	69	2.25	29/09	103	1.85	738	DB	15.91
4	03/08	50	1.60	20/09	94	1.68	4119	DB	18.64
5	17/08	61	1.30	30/09	104	2.10	2219	DB	18.64
6	12/09	86	1.65	25/10	129	2.10	679	DB	13.64
7	17/08	61	1.48	18/10	22	2.09	704	DB	17.27
8	07/08	51	0.85	29/09	103	1.05	4800	DB	13.18
9	07/08	51	1.45	29/09	103	1.68	3812	DB	17.33
10	17/08	61	1.08	11/10	115	2.30	689	DB	19.09
11	12/09	86	1.70	18/10	122	2.10	438	DB	15.91
12	23/09	97	2.15	16/11	150	2.80	1402	DB	17.33
13	22/09	96	1.95	16/11	150	2.70	1601	DB	18.18
14	19/08	63	2.20	16/11	150	2.70	2121	DB	14.55
15	17/08	61	1.00	29/09	103	1.70	3509	DB	15.45
16	16/03	60	0.75	28/09	103	1.20	3097	W	12.73
17	24/09	98	1.00	30/09	104	1.80	2376	DB	17.73
18	22/09	96	1.95	17/11	151	2.80	1777	DB	17.23
19	01/10	105	2.00	17/11	151	2.80	1234	DB	17.27
20	24/09	98	2.00	17/11	151	2.70	1796	DB	17.27
21	17/08	61	1.90	18/10	122	2.40	877	DB	14.55
22	19/08	63	1.00	06/10	110	2.30	1536	DB	15.45
23	18/08	62	1.00	01/10	105	1.90	3006	DB	9.09
24	06/10	110	2.10	26/10	130	3.00	418	DB	19.09
25	19/08	63	2.10	17/11	151	2.80	1135	DB	15.91
26**	19/08	63	1.30	12/10	116	2.10	916	W	14.55
27**	18/08	62	1.00	12/10	116	2.35	1526	DB	14.04
28**	18/08	62	1.20	11/10	115	2.30	1045	DB	16.36
29**	07/08	51	0.90	12/10	116	1.80	2100	W	16.82
30**	07/08	51	0.70	11/10	115	2.35	1044	DB	16.82
31***	19/08	63	1.20	29/09	103	1.80	3723	W	14.55
32**	19/08	63	1.35	11/10	115	2.30	1040	DB	13.64
33	19/08	63	1.20	18/10	122	2.40	959	W	15.45

* Date planted June 16, 1982.

** Peru.

*** México.

DB: Dark brown seeds.

W: White seeds.

TABLE 3

DAYS TO HARVEST, HEIGHT OF PLANT AND YIELD OF AMARANTH GRAIN SELECTIONS

Days to harvest	Height, m			Production, g/7.5 m^2		Days to flowering
	No.	Range	$\bar{x}$	Range	$\bar{x}$	
100-105	6	1.05 - 1.80	1.41	2,323 - 3,000	2,882	58
106-110	3	1.80 - 2.10	1.93	1,664 - 2,255	1,900	63
111-115	1	—	2.30	—	1,152	62
116-120	7	1.80 - 2.35	2.21	517 - 1,575	896	60
121-125	4	2.10 - 2.40	2.32	329 - 719	558	78
131-135	4	2.10 - 3.00	2.59	313 - 641	504	80
146-150	1	—	2.30	—	707	107
151-155	7	2.70 - 2.80	2.76	851 - 1,591	1,186	100

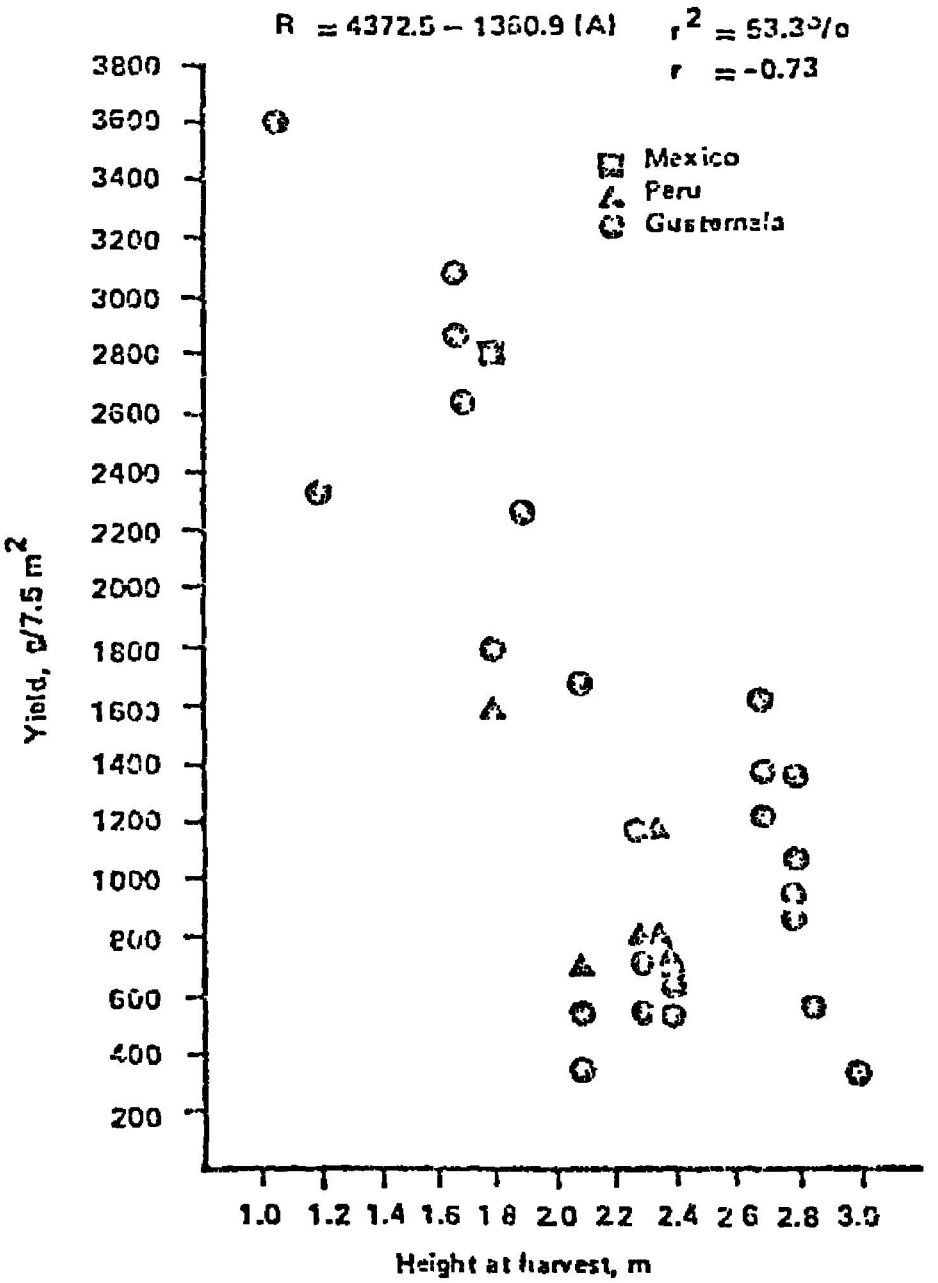

FIGURE 1

Relationship between plant height at harvest and seed yield

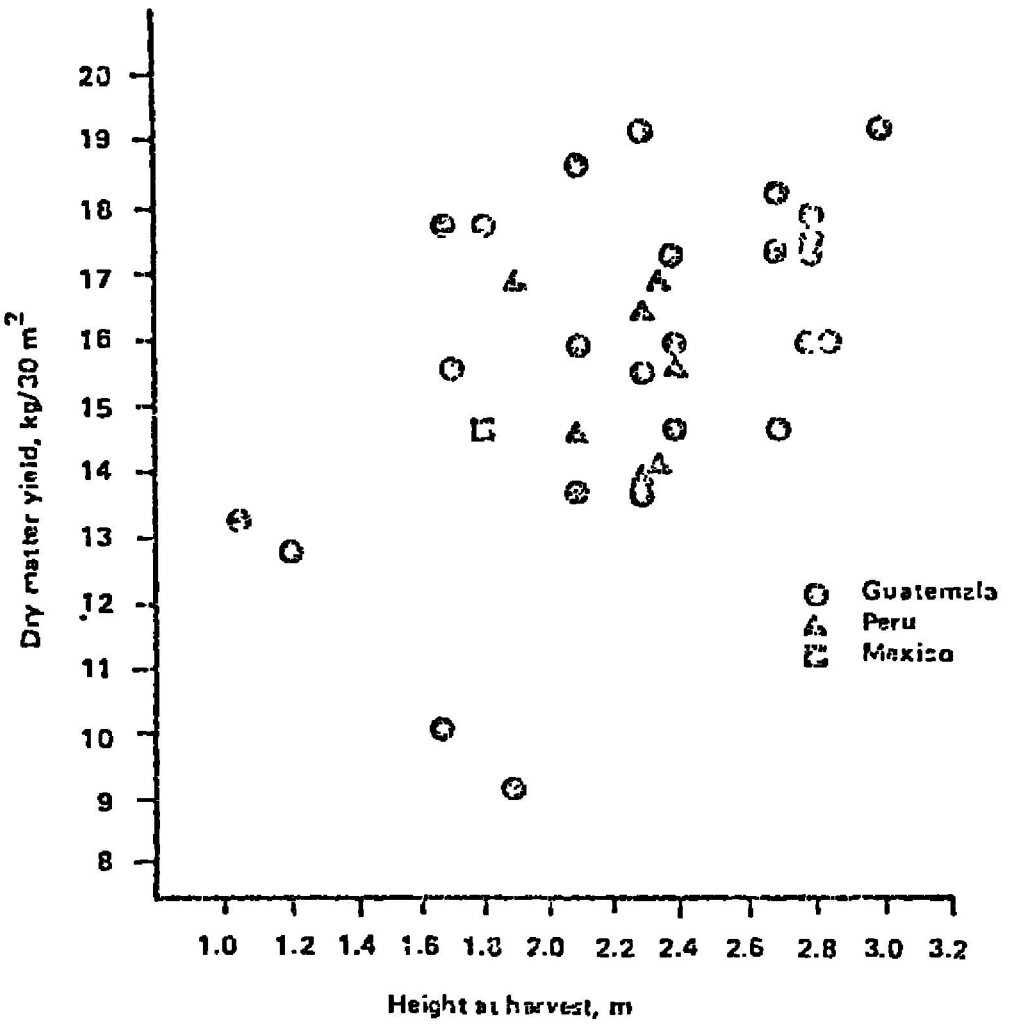

FIGURE 2

Relationship between plant height at harvest and dry matter yield

TABLE 4

CHEMICAL COMPOSITION OF AMARANTH PLANT RESIDUE (g %)

Moisture	11.26 ± 0.56
Ether extract	1.94 ± 0.63
Crude fiber	35.82 ± 5.08
Protein	7.25 ± 1.72
Ash	11.08 ± 1.57

Table 6 also presents tannic acid content and trypsin inhibitor activity. The values for both are low and fall within values reported by other authors (5, 13). Some samples, however, may have relatively high anti-trypsin activity such as selections 16W and 17W.

Essential amino acid content of the five samples analyzed, expressed on weight basis is detailed in Table 7, while Table 8 presents the same

TABLE 5

PARTIAL CHEMICAL COMPOSITION OF SELECTIONS OF AMARANTH GRAIN FROM GUATEMALA, AND SAMPLES FROM PERU AND MEXICO

INCAP No.	Moisture %	Ether extract %	Crude fiber %	Protein %
1	11.6	7.7	8.0	15.2
2	11.1	7.0	6.5	15.3
3	11.2	5.6	5.3	14.3
4	10.8	7.6	5.1	17.4
5	11.4	8.0	5.6	14.3
6	10.8	7.6	7.4	15.6
7	7.1	7.5	7.0	15.6
8	12.5	7.5	7.2	15.0
9	12.1	8.1	7.9	15.9
10	13.7	9.4	7.0	14.1
11	11.1	9.6	6.6	15.7
12	9.8	10.1	7.7	14.3
13	10.9	10.5	7.7	14.8
14	11.9	9.6	6.9	15.0
15	12.9	8.9	5.9	16.8
16	11.8	10.5	4.4	16.3
17	13.0	8.6	4.6	15.7
18	13.0	9.4	7.0	15.6
19	13.1	9.9	7.1	14.3
20	13.5	8.2	7.4	15.1
21	13.9	7.9	9.3	14.3
22	11.5	7.7	9.4	17.4
23	13.9	7.9	8.7	14.5
24	17.3	6.7	7.2	13.6
25	10.9	9.4	9.9	12.8
26	11.8	8.2	2.9	13.2
27	11.7	7.6	6.0	15.2
28*	11.1	8.4	3.0	14.7
29*	11.2	8.1	3.0	14.1
30*	11.8	8.6	5.0	15.0
31**	11.9	5.8	3.0	14.7
32*	11.3	8.5	3.4	14.7
33*	11.4	9.3	3.8	15.0
Average	12.0 ± 1.6	8.4 ± 1.2	6.4 ± 2.0	15.0 ± 1.0

* Peru
** Mexico

data, but expressed on a nitrogen basis. As would be expected, amino acid content on weight basis is higher for samples with higher protein content. On nitrogen basis, however, amino acid content is relatively

TABLE 6

SELECTED CHEMICAL COMPONENTS, OF 33 VARIETIES OF AMARANTH GRAIN HARVESTED IN GUATEMALA IN 1982

Sample No.	Protein (%)	Ether extract (%)	Crude fiber (%)	Tannic acid (%)	Trypsin inhibitors (UTI/ml)	NPR
1 W	14.0	5.2	14.1	0.640	3.30	2.43
2 D	14.4	5.6	14.6	0.636	1.76	2.60
3 D	14.4	6.5	11.6	0.599	1.89	2.68
4 D	15.0	6.0	9.2	0.501	3.92	2.53
5 D	16.0	5.6	13.7	0.545	1.39	1.84
6 D	14.4	6.1	16.3	0.554	1.80	2.35
7 W	14.4	6.2	13.1	0.683	1.10	2.42
8 W	16.2	6.4	10.2	0.501	1.23	2.11
9 D	16.0	6.0	13.0	0.536	1.12	1.77
10 D	14.1	5.2	14.2	0.579	1.10	2.43
11* W	15.0	5.5	17.1	0.490	1.62	—
12 W	14.0	6.1	17.8	0.322	2.16	1.97
13 D	14.4	6.0	11.5	0.431	1.37	2.15
14 D	14.9	5.8	11.3	0.288	2.66	2.22
15 D	15.7	5.6	10.2	0.454	1.30	2.18
16 W	17.5	6.2	5.6	0.281	5.98	2.96
17 W	17.2	6.1	5.7	0.245	10.88	3.17
18 D	14.6	6.1	12.0	0.415	3.04	2.00
19 D	14.8	5.4	12.1	0.520	3.94	1.93
20 D	14.2	5.9	12.2	0.408	3.03	2.34
21 D	15.3	5.5	11.9	0.372	0.00	2.20
22 W	14.3	6.8	11.6	0.536	0.00	1.75
23	15.3	6.4	10.0	0.438	3.03	1.96
24* D	14.3	5.6	12.3	0.322	3.00	—
25 D	14.7	6.4	10.7	0.438	0.00	1.92
26	15.7	6.5	4.8	0.211	1.73	2.37
27	16.0	6.7	5.9	0.256	1.46	2.23
28	15.6	6.8	5.2	0.218	0.95	1.82
29	15.6	6.2	4.3	0.254	2.25	2.06
30	15.7	6.4	7.2	0.256	0.09	1.74
31	14.6	6.2	4.1	0.256	0.67	2.08
32	15.8	6.4	6.0	0.218	0.00	2.25
33	15.7	7.1	5.6	0.365	0.00	1.98
Casein	—	—	—	—	—	3.82
Ave. ISD	14.8 ±	6.1 ±	10.4 ±	0.417 ±	2.05 ±	2.53

* These two selections did not produce enough seed for biological assay.

constant among selections with different protein content. This must be confirmed by additional studies. The average amino acid content of the five samples, expressed as g/16 gN is presented in Table 9 which includes

TABLE 7

ESSENTIAL AMINO ACID CONTENT OF FIVE SELECTIONS OF AMARANTH SEED OF DIFFERENT PROTEIN CONTENT (g°/o)

	Seed amaranth samples				
	1	2	3	4	5
Protein (g °/o)	17.4	16.3	15.3	14.3	13.2
Arginine	1.48	1.28	1.21	1.13	0.74
Histidine	0.54	0.49	0.44	0.46	0.31
Isoleucine	1.41	1.37	1.10	0.98	1.14
Leucine	1.08	1.07	0.93	0.84	0.93
Lysine	1.00	0.88	0.90	0.88	0.71
Methionine	0.14	0.14	0.10	0.16	0.09
Phenylalanine	0.67	0.69	0.51	0.51	0.56
Tyrosine	0.39	0.31	0.34	0.23	0.27
Threonine	0.75	0.74	0.60	0.66	0.59
Valine	0.63	0.64	0.58	0.54	0.56
Tryptophan	0.124	0.136	0.114	0.128	0.096

TABLE 8

ESSENTIAL AMINO ACID CONTENT OF FIVE SELECTIONS OF AMARANTH GRAIN OF DIFFERENT PROTEIN CONTENT (g AA/gN)

	Amaranth grain samples				
	1	2	3	4	5
Protein, g °/o	17.4	16.3	15.3	14.3	13.2
Arginine	0.49	0.49	0.50	0.49	0.35
Histidine	0.19	0.19	0.18	0.20	0.15
Isoleucine	0.51	0.52	0.45	0.43	0.54
Leucine	0.39	0.41	0.38	0.37	0.44
Lysine	0.36	0.34	0.37	0.38	0.34
Methionine	0.049	0.054	0.040	0.071	0.014
Phenylalanine	0.24	0.26	0.21	0.22	0.27
Tyrosine	0.14	0.12	0.14	0.12	0.13
Threonine	0.27	0.28	0.24	0.29	0.28
Valine	0.23	0.24	0.23	0.24	0.27
Tryptophan	0.044	0.052	0.046	0.056	0.045

chemical score (C.S.) based on the FAO/WHO reference pattern (14). The data indicate that amaranth protein is deficient in sulfur amino acids (C.S. 23.4°/o), which are the most limiting essential amino acids, followed

TABLE 9

AVERAGE ESSENTIAL AMINO ACID CONTENT IN AMARANTH GRAIN

Amino acid	g AA/16 gN	FAO/WHO pattern	Reference chemical score
Arginine	7.52	—	—
Histidine	2.93	—	—
Isoleucine	7.87	4.0	—
Leucine	6.34	7.0	90.6***
Lysine	5.71	5.5	—
Methionine	0.82	3.5	23.4*
Phenylalanine	3.84	6.0	—
Tyrosine	2.11	—	—
Threonine	4.37	4.0	—
Valine	3.84	5.0	76.8**
Tryptophan	0.78	1.0	78.0**

Order of deficiency:
* (1)
** (2)
*** (3)

by valine (C.S. 77.4%) and tryptophan (C.S. 78.0%). These results are contradictory with information rendered in the literature, derived from chemical data that indicate that leucine is the first limiting amino acid in amaranth protein (2, 5). The low chemical score for methionine may be due to the lack of cystine values as well as of losses which occur during the acid hydrolisis of the samples. Therefore, it is important to confirm such results with biological data. Another aspect worthy of mention is its high lysine content (0.357 g/gN). These characteristics indicate that amaranth could be a good supplement for maize and other cereal grains, for it is known they have a protein which is low in lysine.

Amaranth, hence, could be a good supplement for maize since this grain is deficient in lysine and has excess of leucine (15), as shown by several authors (5).

Protein quality of the experimentally produced seed is shown in Table 6. Net protein ratio (NPR) varied from 1.74 to 3.17 with an average rate of 2.33; the variability is quite large, but is not associated with tannin content of trypsin inhibitor activity. Nevertheless, protein quality was negatively associated with protein content where the two high-protein content samples were excluded from the regression analyses. No explanation is possible at this time, unless it were due to the presence of anti-physiological substances which are not present in large quantities of the high-protein selections. This is possible in view of the essential amino acid pattern shown in Table 7, which suggests higher NPR values than those obtained.

Protein quality expressed as NPR in the second assay and apparent

protein digestibility of 10 amaranth grain samples, are presented in Table 10. NPR values showed an average of 2.80 for the seven samples from Peru, 2.04 for the sample from Mexico and 2.36 for those from Guatemala. which are similar to those previously obtained. Average apparent digestibility was 80, 82, and 74°/o for the samples from Peru, Mexico and Guatemala, respectively. NPR of casein was 3.35, which demonstrates that protein quality of amaranth varies from 60.9 to 75.5°/o to that of casein, suggesting that it may be due to the sulfur amino acid deficiency, as mentioned in the results referring to amino acid content. In preliminary amino acid supplementation studies (Table 11), it was possible to obtain an increase in protein quality caused by methionine addition, increment which was not observed with the addition of any other single amino acid. These experiments must be repeated to confirm this finding as well as to determine the maximum quantity of amino acids that should be added. Other possible deficiencies should also be established, since the improvement obtained with methionine addition was not large.

TABLE 10

AVERAGE PROTEIN VALUE OF AMARANTH SELECTIONS FROM MEXICO, GUATEMALA AND PERU

Country of origin	Code No.	Average weight gain, g	NPR	Apparent protein digestibility	Protein value °/o of casein
Mexico	H.B. Mexicana	12 ± 5.33	2.29 ± 0.46	83.1 ± 1.71	68.3
		15 ± 5.57	2.43 ± 0.33	80.4 ± 2.53	72.5
Guatemala	B.E.	10 ± 5.30	2.04 ± 0.34	74.2 ± 5.95	60.9
Peru	5F	14 ± 3.23	2.53 ± 0.22	78.5 ± 4.21	75.5
(Cusco)	36F	12 ± 4.71	2.55 ± 0.37	82.3 ± 1.35	76.1
	2A	10 ± 2.93	2.29 ± 0.20	81.8 ± 1.45	68.3
	4A	11 ± 4.30	2.11 ± 0.28	77.5 ± 2.06	63.0
	2005	12 ± 5.98	2.10 ± 0.36	77.0 ± 2.51	62.7
	2042	9 ± 5.01	2.09 ± 0.51	80.2 ± 1.51	62.4
	2083	14 ± 6.61	2.45 ± 0.46	79.9 ± 2.08	73.1
Casein	—	—	3.35 ± 0.14	—	100.0

The data presented suggest that, primarily, it should be established whether chemical composition and nutritive value vary among amaranth species. Moreover, other studies should be conducted to determine possible differences between light and dark seeds. Biological data obtained are below what would be expected for amino acid content, which suggests that this seed contains antiphysiological substances, even when only small amounts of trypsin inhibitors and hemagglutinins have been reported (5). It is also possible that bioavailability of nutrients may be low, particularly amino acids, an aspect which has still to be established.

TABLE 11

EFFECT OF THE ADDITION OF SOME AMINO ACIDS ON THE PROTEIN QUALITY OF AMARANTH

Amino acid added	Weight gain g	PER
None	41 ± 7.34	1.48 ± 0.29
+ L-Leucine	47 ± 10.33	1.46 ± 0.18
+ L-Valine	26 ± 6.02	1.04 ± 0.26
+ L-Threonine	26 ± 8.57	1.19 ± 0.39
+ L-Methionine	59 ± 6.81	1.73 ± 0.25
+ Leu + Val + Threo + Met	59 ± 14.23	1.82 ± 0.29
Casein	113 ± 23.15	2.74 ± 0.14

RESUMEN

COMPOSICION QUIMICA Y CALIDAD PROTEINICA DEL GERMOPLASMA DE GRANO DE AMARANTO EN GUATEMALA

El presente trabajo se llevó a cabo con el propósito de recolectar parte del germoplasma de grano de amaranto de Guatemala y evaluarlo en términos de rendimiento, composición química y valor nutritivo. Junto con una selección de México *(A. cruentus)* y siete de Cusco, Perú *(A. caudatus)*, se sembraron 27 selecciones de Guatemala en junio de 1982, en lotes experimentales de 7.5 m^2, en cuatro repeticiones. Las semillas cosechadas se utilizaron para análisis químico de proteína, grasa, fibra, cruda, taninos e inhibidores de tripsina, así como NPR. Con base en su contenido proteínico, se formaron cinco grupos para análisis de aminoácidos y 10 selecciones se evaluaron en un segundo ensayo, para determinar calidad proteínica, por medio del método de NPR y digestibilidad proteínica. Se informa, asimismo, sobre un ensayo de suplementación con aminoácidos en semilla cruda.

Las selecciones difirieron significativamente en cuanto a rendimiento de grano. Se encontró una relación negativa entre la altura de la planta y rendimiento de materia seca vegetativa. El contenido proteínico del grano varió entre 12.8 y 17.4°/o con un promedio de 15.0°/o. Se encontró que las semillas con mayor contenido de proteína acusaban mayor contenido de aminoácidos por peso, pero al expresarse por gramo de nitrógeno, los contenidos fueron muy parecidos. De acuerdo al patrón de FAO/OMS, la proteína es deficiente en aminoácidos azufrados, lo que se demostró por medio de un ensayo de PER. La calidad proteínica de un grupo seleccionado fue variable. Las muestras del Perú dieron una NPR de 2.30, la de México de 2.36, y una de Guatemala de 2.04. La digestibilidad proteínica aparente fue de 80, 82 y 74°/o para las muestras del Perú, México y Guatemala, respectivamente. Los datos indican diferencias en rendimiento, composición química y valor nutritivo, y un rendimiento favorable de grano.

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