PEANUT SCIENCE

VOLUME 7 JULY - DECEMBER 1980 NUMBER 2

Effect of Location and Time of Harvest on Free Amino Acid and Free Sugar Contents of Florigiant Peanuts[1]

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ABSTRACT

Peanuts, *Arachis hypogaea* L., Florigiant cv., were grown in North Carolina counties, Northampton, Bertie, Chowan, Halifax, Hertford and Nash in order to determine the influence of locations and harvest dates on the individual free amino acids, free sugars, total sugars, arginine maturity index, and calcium. The peanuts were harvested at weekly intervals up to eight times, starting 125-130 days after planting. Location effects were significant for many precursors of typical roasted peanut flavor (aspartic acid, glutamic acid, peptide, and phenylalanine) and sugars (fructose, glucose, and sucrose). Locations did not significantly influence the atypicl roasted flavor precursors (tyrosine, lysine, and arginine). Changes in free amino acid and free sugar contents during the peanut harvesting period gave both linear and quadratic trends. Both free amino acid and sugar contents decreased after the early harvest times, followed by a flattening out near optimum harvesting period, and eventually increased during the late harvests. At optimum harvesting time, roasted flavor precursors were predominant among free amino acids comprising 64% of the total. Sucrose, a source of sugar reactants, constituted 86% of the total sugars.

Key Words: Peanuts, *Arachis hypogaea* L., Free Amino Acids, Sugars, Maturity, Locations, Peanut Flavor Precursors.

The free amino acids and free sugars are very important roasted peanut flavor precursors (9) and have been previously reviewed in more detail (10). The amounts of free amino acids (10, 16-18) and free sugars (10) in peanuts (*Arachis hypogaea* L.) vary significantly with planting location. Although numerous studies have been conducted on amino acids and sugars, further research on the quantitation of these peanut flavor precursors is needed before a relationship with roasted peanut flavor can be established. This is the second part of a survey and a portion of these data will be used in an ongoing study to relate these flavor precursors to roasted peanut flavor.

The primary objective of this investigation was to measure the changes in free amino acids, free sugars, AMI value and calcium contents of cured sound mature kernels of the Florigiant cultivar as affected by location and time of harvest.

Materials and Methods

Florigiant peanuts, which is a Virginia type cultivar with a runner growth habit (3), were planted at six locations (Northampton, Bertie, Chowan, Halifax, Hertford, and Nash Counties in North Carolina) in 1978 as part of a date of harvest study (12). The date of planting was April 15 for Bertie County and May 20 for the other counties. At 110 days after planting, the first harvesting was made on September 5 (digging 1) at Hertford, Nash, and Northampton counties, and on September 12 (digging 2) for all others. Diggings were made weekly for up to a maximum of eight harvests with the last harvest occurring on October 24 (digging 8). Dry weather during harvest permitted field and stack curing under near-ideal conditions. The stack cured peanuts were combined, shelled, and 2.27 kg peanut samples of sound mature kernels (SMK) from each harvest were received at our laboratory on December 20 and subsampled. For the arginine maturity index (AMI) and calcium (Ca) analysis, 50 g of peanuts were weighed into air-tight plastic bags until analyzed (4). For free amino acid and sugar analysis, 25 g of peanuts were ground and placed in a vial. All samples were stored at -18°C until analyzed. In previous laboratory studies, no measurable changes in these components during storage have been found.

The details of the procedure for extraction of the ground peanut samples and determination of free amino acids and free sugars by ion exchange chromatography and gas liquid chromatography, respectively, have been previously published (10). Duplicate analyses were made on each sample. In this study, the amino acids eluted in the following order: unknown 1 (U1); unknown 2 (U2); unknown 3 (U3); aspartic acid (ASP); threonine-serine-asparagine-glutamine (TSER) which usually eluted as a single peak; glutamic acid (GLU); alanine (ALA); peptide-cystine (PC) which eluted together, valine (VAL); isoleucine (ILE); unknown 4-tyrosine (U4T) which often eluted together; phenylalanine (PHE); histidine (HIS); lysine (LYS); ammonia (NH4); and arginine (ARG). As in the previous study (10), proline, glycine, methionine, and leucine were not measured. Sugars were eluted in the following order; unknown (UNK); fructose (FRU); glucose (GLC); inositol (INO); sucrose (SUC); raffinose (RAF); and stachyose (STA). Ribose was found only in trace quantities and was not reported.

Since not all locations are represented at all digging dates it was necessary to use a general purpose least squares program to obtain the analysis of variance of the data (1, 7, 14). In all cases the sum of squares due to effect of digging was partitioned into components for linear and quadratic trends. Digging date by location interaction sum of squares was partitioned similarly. The absence of true replication in the study forced the use of the mean square (due to lack of fit in the interaction) as an

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estimate of experimental error. This may be an over-estimate of the true error, but as such would lead to conservative tests. The alternative of using the differences between duplicates would underestimate the true error and lead to invalid tests.

Results and Discussion

Location effects were: (a) highly significant for U1, U3, GLU, PC, VAL, PHE, NH4, UNK, FRU, GLC, INO, STA, total sugars and AMI; (b) significant for U2, ASP, ALA, SUC, and Ca; and (c) non-significant for TSER, ILE, U4T, HIS, LYS, ARG, and RAF (Tables 1 and 2). For the components that had highly significant location effects, the difference in the concentrations were noticeable (Tables 3 and 4). By grouping component variables that have similar statistical patterns for the digging effects (linear, quadratic, and deviation) and LOC x DIG interactions (linear and quadratic), an easier

Table 1. Mean square and levels of significance to test the deviation from linear and quadratic regression of free amino acids in Florigiant peanut at different locations and diggings.

Source	df	U1	U2	U3	ASP	TSER	GLU	ALA	PC
Location (Loc) (ignoring digging)	5	0.0026**	0.0013**	0.0371**	0.6459*	5.0403NS	7.8957**	1.0936*	0.6564**
Digging (Dig) (after Loc)									
Linear (Lin)	1	0.0045***	0.0001NS	0.0153NS	3.3369***	22.4405***	4.1163*	5.9747***	0.1194NS
Quadratic (Quad)	1	0.00005NS	0.0047***	0.0013NS	0.0211NS	20.2501***	6.1998**	2.4838**	0.4885***
Deviation (Dev)	5	0.00014NS	0.00024NS	0.0072NS	0.2469NS	2.7608NS	1.4568NS	0.2121NS	0.0710NS
Loc x Dig (after Loc and Dig)									
Loc x Dig (Lin)	5	0.0005NS	0.00025NS	0.0015NS	0.5440NS	6.3464**	2.6194NS	0.5988NS	0.3165**
Loc x Dig (Quad)	5	0.0004NS	0.00026NS	0.0037NS	0.0879NS	0.9810NS	0.3138NS	0.0526NS	0.1162NS
Dev (Error)	17	0.00024	0.00042	0.0071	0.2134	1.2655	1.2145	0.2721	0.0481
Grand mean		0.0859	0.0748	0.1784	1.4815	2.0119	7.0135	1.2909	1.1816

Source	df	VAL	ILE	U4T	PHE	HIS	LYS	NH_4	ARG
Loc (ignoring digging)	5	0.1468**	0.0028NS	0.0075NS	2.5724**	0.1038NS	0.0158NS	1.1872**	3.0797NS
Dig (after Loc)									
Lin	1	1.1432***	0.00018NS	0.0468***	2.0843**	0.2858***	0.2355***	2.8512***	39.8274***
Quad	1	0.1917*	0.00098NS	0.0619***	0.7850NS	1.2957***	0.0677***	2.5852***	9.4369*
Dev	5	0.0137NS	0.00096NS	0.00028NS	0.7016*	0.0070NS	0.0047NS	0.1147NS	1.1860NS
Loc x Dig (after Loc and Dig)									
Loc x Dig (Lin)	5	0.0321NS	0.0029NS	0.0079NS	0.9768**	0.1482***	0.0113NS	1.1563***	2.4261NS
Loc x Dig (Quad)	5	0.0089NS	0.0012NS	0.0033NS	0.3162NS	0.0653*	0.0057NS	0.1315NS	1.1021NS
Dev (Error)	17	0.0412	0.0017	0.0035	0.2092	0.0211	0.0054	0.1071	1.5140
Grand mean		0.5751	0.1324	0.3139	0.8064	0.5456	0.1487	1.8949	1.7444

NS, *, **, *** Mean square is non-significant and significant at 5%, 1% and 0.1% level of probability, respectively.

Table 2. Mean squares and levels of significance to test the deviation from linear and quadratic regression of free sugars, AMI and calcium in Florigiant peanut at different locations and diggings.

Source	df	UNK	FRU	GLC	INO	SUC	RAF	STA	Total sugars	AMI	Calcium
Location (Loc) (ignoring digging)	5	0.036**	0.058**	0.064**	0.032**	172.534*	0.017NS	8.735**	158.446**	732.537**	0.020*
Digging (Dig) (after Loc)											
Linear (Lin)	1	0.175***	0.012NS	0.001NS	0.013*	1387.127***	1.150***	1.660NS	1404.441***	2661.693***	0.035*
Quadratic (Quad)	1	0.074***	0.007NS	0.007*	0.000NS	413.816**	0.161*	0.004NS	451.117***	38.448NS	0.007NS
Deviation (Dev)	5	0.007*	0.006NS	0.001NS	0.003NS	17.528NS	0.026NS	0.788NS	22.037NS	15.103NS	0.003NS
Loc x Dig (after Loc and Dig)											
Loc x Dig (Lin)	5	0.019***	0.004NS	0.001NS	0.003NS	97.661*	0.062NS	1.200NS	87.169*	252.282**	0.006NS
Loc x Dig (Quad)	5	0.007*	0.007NS	0.001NS	0.005NS	26.555NS	0.036NS	0.447NS	24.682NS	78.416*	0.002NS
Dev (Error)	17	0.002	0.007	0.001	0.002	30.096	0.029	0.507	30.894	23.715	0.006
Grand mean		0.108	0.226	0.097	0.132	35.639	0.581	3.591	40.374	45.262	0.321

NS, *, **, *** Mean square is non-significant and significant at 5%, 1% and 0.1% level of probability, respectively.

Table 3. Average values of free amino acids (μmoles/g) of Florigiant peanuts. At 6 locations for up to 8 diggings.

Digging	1	2	3	4	5	6	7	8
Unknown 1								
Northampton	0.13	0.10	0.09	0.09	0.10	0.09	0.08	0.06
Bertie		0.12	0.13	0.12	0.09			
Chowan		0.09	0.08	0.06	0.09	0.10		
Halifax		0.09	0.07	0.06	0.07	0.06	0.07	0.07
Hertford	0.08	0.09	0.09	0.07	0.07	0.08	0.05	0.07
Nash	0.11	0.08	0.08	0.10	0.10	0.08	0.10	0.07
Unknown 2								
Northampton	0.05	0.08	0.06	0.05	0.06	0.05	0.06	0.07
Bertie		0.07	0.08	0.07	0.08			
Chowan		0.08	0.08	0.07	0.08	0.09		
Halifax		0.08	0.08	0.09	0.07	0.04	0.08	0.11
Hertford	0.11	0.07	0.08	0.08	0.07	0.09	0.08	0.11
Nash	0.09	0.09	0.09	0.06	0.04	0.05	0.08	0.08
Unknown 3								
Northampton	0.15	0.18	0.13	0.16	0.17	0.12	0.18	0.20
Bertie		0.13	0.23	0.16	0.22			
Chowan		0.10	0.05	0.09	0.09	0.10		
Halifax		0.11	0.11	0.16	0.09	0.23	0.17	0.15
Hertford	0.10	0.24	0.29	0.16	0.15	0.35	0.32	0.19
Nash	0.26	0.25	0.19	0.16	0.27	0.28	0.25	0.21
Aspartic Acid								
Northampton	2.03	1.67	1.13	1.22	1.16	1.48	0.69	0.96
Bertie		1.80	1.73	1.87	2.03			
Chowan		1.60	1.48	1.08	1.13	1.26		
Halifax		2.19	2.93	1.39	1.86	1.58	1.41	0.65
Hertford	1.59	1.11	1.70	1.53	0.69	1.50	1.11	1.36
Nash	1.62	1.69	1.63	1.39	1.60	1.85	1.13	1.46
Threonine-Serine-Asparagine-Glutamine								
Northampton	4.71	2.87	1.67	1.53	0.68	2.96	1.20	1.12
Bertie		0.70	0.48	0.69	0.61			
Chowan		3.47	2.19	0.93	0.89	1.70		
Halifax		2.62	1.70	1.81	1.30	1.88	2.93	2.41
Hertford	8.09	2.11	3.56	2.17	1.58	2.32	1.36	0.94
Nash	1.67	2.50	1.23	1.31	1.83	2.08	2.14	2.54
Glutamic Acid								
Northampton	8.58	6.96	6.36	5.82	6.60	7.32	6.41	4.97
Bertie		4.94	4.80	6.30	5.86			
Chowan		6.93	7.84	6.35	6.65	6.77		
Halifax		8.05	6.98	7.50	7.60	6.67	9.38	7.59
Hertford	9.69	7.92	9.25	7.25	6.41	7.53	6.85	7.90
Nash	7.41	6.77	6.00	6.47	6.70	6.29	7.50	7.37
Alanine								
Northampton	2.24	1.93	1.18	0.81	0.77	0.98	0.77	0.79
Bertie		1.08	0.72	0.72	0.73			
Chowan		1.17	1.22	0.64	0.70	0.81		
Halifax		2.12	2.06	1.66	0.90	1.00	1.95	1.25
Hertford	2.47	1.84	1.84	1.46	1.39	0.79	0.99	0.88
Nash	1.25	2.53	1.12	0.93	1.08	1.21	1.86	1.79
Peptide-Cysteine								
Northampton	1.30	1.25	0.95	0.88	1.08	0.81	0.72	0.95
Bertie		1.42	1.56	1.52	1.78			
Chowan		1.54	1.41	1.32	1.51	1.32		
Halifax		1.23	0.75	0.92	0.98	0.88	1.01	1.05
Hertford	2.06	1.40	1.27	1.36	0.89	0.83	1.26	1.36
Nash	0.99	0.76	0.77	1.09	1.17	1.52	1.19	1.24
Valine								
Northampton	0.93	0.62	0.54	0.46	0.46	0.48	0.41	0.31
Bertie		0.52	0.33	0.36	0.36			
Chowan		0.54	0.49	0.45	0.43	0.47		
Halifax		0.82	0.74	0.93	0.67	0.54	0.68	0.61
Hertford	1.11	0.65	0.74	0.38	0.65	0.48	0.35	0.36
Nash	0.73	1.11	0.60	0.49	0.47	0.48	0.62	0.61
Isoleucine								
Northampton	0.16	0.11	0.18	0.14	0.17	0.10	0.14	0.16
Bertie		0.09	0.09	0.09	0.14			
Chowan		0.16	0.14	0.14	0.14	0.15		
Halifax		0.12	0.09	0.19	0.12	0.12	0.18	0.15
Hertford	0.14	0.15	0.16	0.13	0.15	0.09	0.09	0.09
Nash	0.12	0.17	0.10	0.11	0.09	0.12	0.15	0.16
Unknown 4 - Tyrosine								
Northampton	0.42	0.35	0.26	0.22	0.22	0.27	0.23	0.23
Bertie		0.32	0.31	0.26	0.36			
Chowan		0.36	0.36	0.28	0.27	0.31		
Halifax		0.38	0.29	0.37	0.29	0.26	0.34	0.41
Hertford	0.43	0.34	0.42	0.31	0.30	0.30	0.28	0.27
Nash	0.36	0.40	0.26	0.28	0.28	0.28	0.32	0.38
Phenylalanine								
Northampton	0.92	0.34	0.15	0.17	0.62	0.18	0.16	0.70
Bertie		0.34	0.93	0.15	0.30			
Chowan		0.94	1.07	1.18	1.93	0.79		
Halifax		0.43	0.37	1.38	2.16	1.70	1.43	2.89
Hertford	1.41	0.47	0.40	0.48	0.98	1.27	0.87	1.00
Nash	0.28	0.24	0.41	0.34	0.58	1.11	0.50	0.54
Histidine								
Northampton	0.85	0.57	0.41	0.27	0.28	0.41	0.30	0.41
Bertie		0.58	0.46	0.27	0.43			
Chowan		0.82	0.63	0.42	0.39	0.45		
Halifax		0.66	0.53	0.48	0.43	0.36	0.69	1.24
Hertford	1.13	0.67	0.85	0.58	0.54	0.52	0.49	0.35
Nash	0.66	0.67	0.40	0.38	0.44	0.52	0.51	0.79
Lysine								
Northampton	0.42	0.29	0.15	0.09	0.06	0.13	0.06	0.04
Bertie		0.10	0.06	0.05	0.06			
Chowan		0.24	0.22	0.10	0.09	0.09		
Halifax		0.27	0.22	0.13	0.12	0.14	0.30	0.13
Hertford	0.25	0.18	0.31	0.15	0.14	0.10	0.08	0.09
Nash	0.24	0.23	0.11	0.10	0.10	0.09	0.13	0.13
Ammonia								
Northampton	2.19	1.92	1.41	1.36	1.32	1.35	1.36	1.45
Bertie		1.88	1.81	2.09	3.17			
Chowan		3.25	3.09	1.63	1.80	1.73		
Halifax		2.10	2.25	1.44	1.42	1.38	1.62	1.48
Hertford	2.82	1.84	2.17	2.07	1.59	2.01	1.96	2.28
Nash	2.67	1.92	1.68	1.69	1.68	1.49	1.56	1.89
Arginine								
Northampton	5.55	3.91	2.01	1.02	0.61	2.18	0.76	0.54
Bertie		1.24	0.40	0.32	0.51			
Chowan		2.70	2.13	0.86	0.82	0.64		
Halifax		3.60	2.95	1.22	1.29	1.14	3.77	0.87
Hertford	2.95	2.08	4.45	1.78	1.23	1.15	0.81	0.90
Nash	2.72	2.13	1.05	1.20	1.45	1.43	1.65	1.74

Table 4. Average values of free sugars (mg/g), AMI value and calcium content (mg/g) of Florigiant peanuts at 6 locations for up to 8 diggings.

Digging	1	2	3	4	5	6	7	8
Unknown								
Northampton	0.23	0.19	0.10	0.05	0.11	0.08	0.11	0.08
Bertie		0.22	0.21	0.21	0.29			
Chowan		0.22	0.11	0.02	0.07	0.09		
Halifax		0.23	0.12	0.04	0.02	0.02	0.08	0.06
Hertford	0.43	0.13	0.18	0.05	0.06	0.05	0.02	0.03
Nash	0.13	0.07	0.05	0.03	0.06	0.04	0.04	0.03
Fructose								
Northampton	0.30	0.18	0.15	0.16	0.17	0.15	0.12	0.13
Bertie		0.28	0.43	0.24	0.34			
Chowan		0.37	0.37	0.30	0.48	0.20		
Halifax		0.24	0.21	0.15	0.19	0.17	0.23	0.22
Hertford	0.22	0.17	0.26	0.21	0.13	0.16	0.20	0.26
Nash	0.23	0.20	0.17	0.25	0.22	0.25	0.24	0.15
Glucose								
Northampton	0.10	0.07	0.08	0.07	0.07	0.08	0.06	0.09
Bertie		0.13	0.20	0.12	0.16			
Chowan		0.15	0.10	0.06	0.10	0.08		
Halifax		0.09	0.09	0.05	0.06	0.07	0.09	0.14
Hertford	0.10	0.10	0.16	0.12	0.06	0.10	0.09	0.11
Nash	0.11	0.12	0.08	0.10	0.08	0.10	0.10	0.10
Inositol								
Northampton	0.17	0.11	0.09	0.11	0.08	0.12	0.11	0.13
Bertie		0.07	0.09	0.04	0.05			
Chowan		0.05	0.11	0.09	0.11	0.08		
Halifax		0.14	0.22	0.18	0.15	0.17	0.21	0.28
Hertford	0.09	0.15	0.29	0.19	0.14	0.24	0.18	0.17
Nash	0.06	0.09	0.08	0.11	0.12	0.13	0.14	0.14
Sucrose								
Northampton	49.64	43.72	32.87	26.43	26.56	25.48	24.48	24.99
Bertie		37.50	37.53	37.56	40.37			
Chowan		50.06	51.03	34.60	38.56	38.97		
Halifax		44.72	36.81	26.96	31.72	30.70	32.97	32.55
Hertford	46.17	39.33	45.20	40.35	25.11	32.31	29.90	33.76
Nash	40.12	35.12	35.55	32.97	32.30	34.74	33.25	32.66
Raffinose								
Northampton	0.78	0.74	0.62	0.54	0.44	0.35	0.48	0.44
Bertie		0.86	0.55	0.50	0.47			
Chowan		0.61	0.51	0.45	0.63	0.40		
Halifax		0.95	0.96	0.44	0.38	0.42	0.33	0.58
Hertford	0.64	0.84	0.44	0.67	0.33	0.70	0.60	0.51
Nash	0.92	0.83	0.87	0.54	0.55	0.48	0.47	0.41
Stachyose								
Northampton	3.41	3.57	2.76	3.97	3.58	4.02	4.22	3.23
Bertie		2.76	1.61	1.46	0.96			
Chowan		3.28	3.74	3.17	3.68	3.07		
Halifax		3.75	4.45	3.86	4.67	5.38	4.69	4.46
Hertford	2.87	4.19	3.79	3.58	4.73	4.20	4.40	4.42
Nash	3.35	3.71	3.94	2.87	3.01	2.48	4.61	3.53
AMI								
Northampton	68	63	56	41	41	30	30	32
Bertie		35	25	25	24			
Chowan		39	47	45	42	37		
Halifax		58	54	49	49	43	49	38
Hertford	50	56	54	49	49	42	44	38
Nash	59	54	49	49	52	54	46	53
Calcium								
Northampton	0.38	0.35	0.38	0.33	0.30	0.36	0.35	0.42
Bertie		0.31	0.26	0.24	0.26			
Chowan		0.32	0.34	0.28	0.30	0.32		
Halifax		0.33	0.32	0.36	0.32	0.43	0.44	0.39
Hertford	0.25	0.20	0.18	0.20	0.46	0.32	0.35	0.32
Nash	0.29	0.31	0.32	0.25	0.32	0.35	0.31	0.36
Total Sugars								
Northampton	54.62	48.59	36.67	31.37	31.01	30.28	29.57	29.09
Bertie		41.82	40.62	40.10	42.63			
Chowan		54.72	55.96	38.69	43.61	42.90		
Halifax		50.10	42.79	31.72	37.20	36.93	38.60	38.27
Hertford	50.56	44.92	50.32	45.16	30.55	38.02	35.38	39.25
Nash	44.91	40.13	40.74	36.88	36.35	38.14	38.84	37.00

interpretation of these data is possible. Five groupings (with two or more) contain 21 of 26 of the total variables. Four of these five groups contained all of the variables which had non-significant differences for the LOC x DIG interaction terms.

The largest group (GLU, ALA, VAL, U4T, LYS, ARG, and RAF) showed highly significant linear and quadratic trends across digging dates. The changes in the quantities of the components present were appreciable and presented similar patterns at the six locations. U1, ASP, INO, and Ca were similar to the above group except that the quadratic effect was not significant. U1 and ASP showed a strong linear trend (decrease) with time, whereas, INO and Ca showed a poorer linear trend. U2 and GLC showed a significant quadratic effect. The next group (U3, ILE, FRU, and STA) did not show any statistically significant trends.

Statistical analyses of PC, TSER, NH4, SUC, and total sugars revealed that trends (quadratic) differed significantly among locations with changes in harvest date. PHE showed highly significant linear trends with time and some evidence of a lack of fit for the linear plus quadratic model. The trends differed from location to location. UNK and HIS showed a quadratic trend with time that varied among locations. The anlaysis of the AMI values indicated highly significant linear trends which also differed from location to location. When significant interactions of trend by location occurs, this implies that the trends differ among locations (15). In this study, this may be due to the variation in peanut maturity at different harvest dates.

When amino acids were ranked in descending order according to amounts (see grand mean values, Table 1), GLU and TSER had the highest concentrations followed by NH4, ARG, ASP, ALA, PC, PHE, VAL, HIS, U4T, LYS, ILE, U3, U1, and U2. Higher concentrations of GLU and TSER have

been previously reported (18). ARG was shown to be highest in immature peanuts (18).

ASP, TSER, PHE, HIS are mostly associated with typical roasted peanut flavor precursors (9): in this study, they totaled 11.86 μmoles/g and comprised 64% of the total amino acids. These components totaled 19.81 μmoles/g (78%) in a previous study (8). TYR, (which in this study contained small amounts of unknown 4), LYS, and ARG which are classified as atypical roasted peanut flavor precursors were present at a level of 2.21 μmoles/g.

Sugars ranked based on greatest concentrations (mg/g) in descending order are: SUC, STA, RAF, FRU, INO, UNK, and GLC. In this study, sucrose accounts for 86% of total sugars and an average of 36 mg/g of peanut. In other studies where total sugars were expressed as mg/seed, it was concluded that sugar content increased throughout seed growth period (11, 13). Total sugars were reported to be about 30 mg/seed. Sugar contents of Spanish type peanuts were also reported for FRU, GLC, INO, and SUC as 1.7, 1.9, 1.3, and 149 mg/g of oil free meal respectively (8). Cultivar effects, and to a lesser degree, the method of extraction, probably account for most of the differences observed between this study and published values.

Presently the information on the quantities needed or even which components give the best prediction of optimum roasted peanut flavor has not been established. But, published information has focused primarily on eight precursor components that are considered to be the major contributors to roasted peanut flavor, both typical and atypical. A mathematical treatment (1) of the data (taken from Table 1) on these selected components produced prediction equations. These equations (not shown) were used to produce the computer drawn curves shown in Figure. 1. GLU, one of the more important flavor precursors, had the highest concentration among free amino acids and is thought to contribute strongly to the roasted peanut flavor (9). Peanuts grown at Hertford County contained the highest GLU content (9.6 μmoles/g) and sharply declined from the earliest harvest date (Figure 1A). In the other counties, the GLU content showed small and non-significant changes throughout the harvesting period. Peanuts grown at Chowan County gave a linear trend for GLU from 6.8 to 72 μmoles/g.

In the PC component, cysteine was not resolved and was reported to be present in trace amounts (18). Therefore, the majority of PC component was considered to be a peptide, which was referred to as peptide-2 by Newell et al. (9). In Figure 1B, not all PC curves demonstrated a linear increase as established by Mason et al. (8). Only peanuts grown at Nash and Bertie counties had increasing PC as the date of planting increased. Peanuts grown at Hertford had the highest PC at the early harvesting stage (2 μmoles/g). Peanuts grown at Chowan, Halifax, and Northampton counties showed small changes in PC content throughout the harvesting period. This peptide is mostly comprised of the amino acids in the typical roasted peanut flavor precursor group (8) of which GLU is the major constituent (8, 16). During roasting, this peptide is hydrolyzed to give the amino acid reactants and appears to be a major contributor to a good roasted flavor; a large amount of this component would be desirable (8).

HIS, though present in small amounts was predicted to be a typical roasted peanut flavor precursor (9). Figure 1C shows HIS curves of different locations which appeared to have similar patterns and concentrations except for peanuts grown at Hertford and Halifax counties. At the late harvest date (digging 8) HIS in peanuts grown at Hertford County continued to decrease, while HIS in peanuts grown at Halifax County increased sharply.

The TSER peak contains threonine (atypical), serine (neutral), glutamine (typical), and asparagine (typical) as roasted peanut flavor precursors, with glutamine and asparagine predominating (10, 18). For peanuts grown at Hertford, Northampton, and Chowan conties (Figure ID), TSER at the early harvesting date was twice as high (4-6 μmoles/g) than at the later optimum harvest period; a sharp decrease occurred within two weeks. The peanuts at Bertie, Halifax, and Nash counties showed only small differences in TSER levels across diggings.

ARG (atypical roasted peanut flavor precursor) was reported to decrease as date of harvest increased (8, 9). Peanuts grown at Northampton County had the highest ARG at the early digging dates (5 μmoles/g and declined very rapidly within four weeks (Figure 1E). Peanuts grown at Chowan, Halifax, Hertford, and Nash counties contained about the same amount of ARG (3 μmoles/g) at the early digging, and gradually declined to less than 2 μmoles/g in five weeks. Peanuts grown at Bertie County contained the lowest ARG content throughout this study indicating that they were older and more mature.

Decreasing AMI values during peanut maturation have already been established (5, 6, 16). Generally, AMI curves show the same trends as ARG curves, which is to be expected since AMI is an estimate of free arginine content in peanuts. However, peanuts grown at Hertford and Chowan counties gave inverse results (Figure 1F). Adverse harvest and curing conditions might have caused these results but no adequate explanation is known.

Sucrose and total sugars (Figure 1G and 1H) gave similar plots which might be expected since sucrose constituted 86% of the total sugars. Peanuts grown at Chowan County had the highest amount of sucrose, whereas, those grown at Northampton

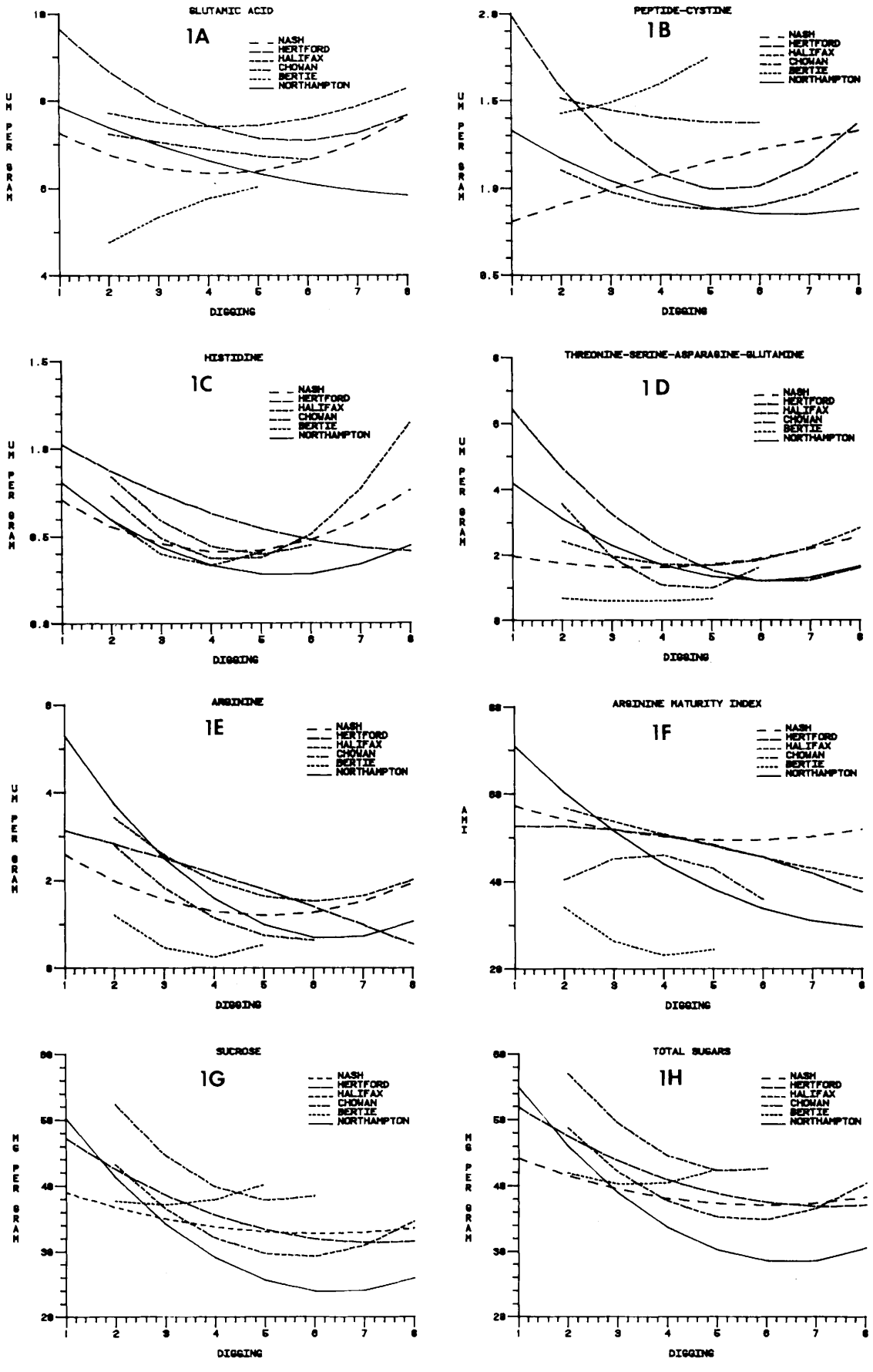

Fig. 1. Plots of the curves of free amino acids and sugars in peanuts from 8 diggings and 6 locations.

County were the lowest in sucrose. Peanuts grown at the other counties were similar with an average of 32 mg/g. The sucrose curve for Bertie County produced a different trend and may have resulted from insufficient diggings or drought conditions or the early planting.

The changing patterns of all components observed as days of harvest or digging progressed were generally similar. They either sharply or gradually decreased at the early diggings, reached the minimal amount near the predicted harvest date, and slowly increased thereafter. The decline in free amino acids corresponded to the deposition of total protein in the cotyledons (2) and it is interesting to note that the components reported in this study are minimal at or near the optimum harvest date predicted by the AMI method (12).

Thirty samples from both this study and a previous study (10) now have been selected for use in an ongoing study to elucidate the relationship of these data to roasted peanut flavor.

Acknowledgements

The financial assistance of the North Carolina Peanut Growers Association is greatly apprecited.

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Accepted June 28, 1980