家蚕幼虫血液の遊離アミノ酸組成にみられる蚕品種間の差異について

誌名	日本蠶絲學雜誌
ISSN	00372455
著者名	井口,民夫 伊藤,智夫
発行元	日本蠶絲學會
巻/号	42巻2号
掲載ページ	p. 105-116
発行年月	1973年4月

日蚕雑 **42**(2), 105~116, 1973
(J. Sericult. Sci. Japan)

Variations in Free Amino Acid Composition of Larval Hemolymph among Varieties of the Silkworm, *Bombyx mori*

Tamio INOKUCHI and Toshio ITO

Sericultural Experiment Station, Wada, Suginami-ku, Tokyo

(Received August 16, 1972)

There are a number of reports on the composition of free amino acids of the hemolymph of larvae of the silkworm, *Bombyx mori* (FUKUDA *et al.*, 1955; WYATT *et al.*, 1956; KONDO and WATANABE, 1957; BRICTEUX-GRÉGOIRE *et al.*, 1959; DUCHÂTEAU *et al.*, 1959; WATANABE, 1959; DUCHÂTEAU-BOSSON *et al.*, 1960a, b, 1961a, b; JEUNIAUX *et al.*, 1961; KAWASE, 1965; INOKUCHI, 1972a, b). Analysis has been made either by the microbiological method, by means of ion-exchange chromatography, or with an amino-acid analyzer. There are large variations in the contents of free amino acids among the reported data. This seems to be mainly due to the fact that the contents of free amino acids vary largely during growth and development of the silkworm. In addition to this, in the former studies the varieties of the silkworm used are different according to the authors, such as, various hybrid silkworms (KONDO and WATANABE, 1957; WATANABE, 1959; KAWASE, 1965; INOKUCHI, 1972a), a Chinese variety (FUKUDA *et al.*, 1955), and a European variety (JEUNIAUX *et al.*, 1961). It is probable that the divergence of varieties used causes a big variation in the analytical data. However, there has been so far no precise analysis on the variations in the free amino acid composition of the hemolymph among different varieties of the silkworm. The present paper is concerned with these variations, in which 18 silkworm varieties were used. Recently, INOKUCHI (1972a, b) reported that some amino acids differ in quantity between male and female silkworms. The sexual differences will also be examined in the present study.

Before going further, the authors wish to thank to Dr. S. UEDA and Mr. T. OTSUKA for their advice in the statistical method for evaluating the results. Thanks are also due to Mr. R. ÔNO for his help in obtaining the larvae used, and to Mr. S. YASUMURA for sending us the data on the cocoon quality of the 18 silkworm varieties.

MATERIALS and METHODS

Nine silkworm varieties belonging to Japanese races and 9 varieties classed

into Chinese races were used. Stocks of these varieties have been maintained for a long period of time at the Sericultural Experiment Station, Ministry of Agriculture and Forestry. In general, many of the Japanese and Chinese varieties do not necessarily retain the original Japanese and Chinese characteristics, therefore, a careful consideration was made in selecting the varieties for the present study. In other words, only the varieties which are considered to retain the pure original characters, judging from the previous records (HIRATSUKA, 1969), were used in this study. The larvae of the 18 varieties used for the analysis were reared on mulberry leaves in June, 1971, at the Kobuchizawa Silkworm-Egg Research Station (Yamanashi Pref.), the Sericultural Experiment Station. Table 1 shows a list of the varieties used.

Table 1. List of silkworm varieties used in the present study

Japanese variety		Chinese variety	
Name	Denotation	Name	Denotation
Dai-nyorai (大如来)	A	Hikô (緋 紅)	K
Sekai-ichi (世界一)	B	Ten-mon (天 門)	L
Daté-nishiki (伊達錦)	C	Kankô-shaken (漢口赭繭)	M
Aka-juku (赤 熟)	D	Sekkô (浙 江)	N
Koishi-maru (小石丸)	E	Nanko (南 湖)	P
Tadami-ko (只見蚕)	F	Beni-shina (紅 支 那)	Q
Kuni-ichi (国 一)	G	Kinkô (金 黄)	R
Ao-juku (A) (青熟A)	H	Dai-entô (大 円 頭)	S
Oni-chijimi (鬼 縮)	J	Uryû (烏 竜)	T

Since the amino acid pattern of the hemolymph varies largely during growth and development, and since the growth rate is different among the silkworm varieties, the newly ecdysed, unfed fifth-instar larvae were used as experimental material. Sexing of the larvae at this stage could be done easily. The hemolymph was collected by cutting the abdominal legs from 15 to 25 individuals. Five m*l* of 10% trichloroacetic acid were added to 2 m*l* of the hemolymph, then centrifuged. Trichloroacetic acid in the supernate was removed with ethyl ether. An aliquot of the supernate was analyzed for amino acid content by means of an amino acid analyzer (Hitachi Model KLA-3B), in which a single column procedure was employed. The details of the analytical procedure have been given elsewhere (INOKUCHI, 1972b). In the present set of experiments critical separation of asparagine and glutamine from serine was impossible.

RESULTS

Amino acid compositions of the hemolymph determined in the 9 Japanese and the 9 Chinese varieties are shown in Tables 2 and 3, in which the varieties

Table 2. Composition of free amino acids of hemolymph of newly ecdysed fifth-instar larvae: Japanese varieties (μg amino acid/m*l* hemolymph)

Amino acid	Silkworm variety																	
	A		B		C		D		E		F		G		H		J	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Phosphoethanolamine	83	116	131	127	125	155	116	169	68	121	70	146	207	142	69	83	102	116
Aspartic acid	60	82	56	52	60	82	50	72	36	56	40	52	52	40	40	52	38	38
Threonine	281	447	197	222	166	218	130	207	91	159	209	243	138	100	126	100	105	48
Serine*	1010	1406	1021	996	731	1026	807	1212	550	946	742	1106	739	635	645	605	768	479
Glutamic acid	947	1245	976	898	684	995	726	779	514	830	583	797	757	658	602	565	413	433
Proline	69	123	235	159	117	176	102	313	168	259	64	202	176	392	73	86	78	123
Lanthionine	987	1540	950	1128	637	1112	906	886	644	1162	637	1025	1171	1000	492	625	403	743
Glycine	1257	1545	860	958	949	1289	556	496	724	1224	570	759	551	526	867	635	283	275
Alanine	107	127	158	182	119	170	235	208	92	151	119	160	86	79	89	90	104	139
Cystine	t **	47	t	t	t	t	t	32	t	32	t	t	t	t	t	t	t	t
Valine	262	341	302	332	341	506	352	337	193	380	204	227	127	148	260	257	193	179
Cystathionine	503	887	673	880	307	610	467	527	310	683	363	543	537	553	247	313	213	460
Methionine	112	179	116	159	76	130	69	107	63	128	85	107	76	90	41	40	49	47
Isoleucine	45	55	67	91	55	75	83	87	32	75	49	59	26	30	38	43	51	45
Leucine	39	41	91	108	49	67	73	85	34	77	49	63	32	37	32	34	41	41
Tyrosine	261	389	332	421	337	590	315	353	131	416	253	160	84	150	235	196	147	169
Phenylalanine	32	45	30	60	22	37	30	31	t	32	22	30	t	t	t	t	t	t
β-Alanine	48	55	75	58	t	t	35	t	t	t	t	39	36	t	t	t	t	t
Ornithine	t	t	111	149	339	500	551	696	543	920	56	65	422	504	370	293	337	319
Lysine	294	375	684	765	496	625	472	618	305	603	283	379	305	333	319	287	355	292
Ammonia	262	309	337	296	211	262	233	243	167	274	190	240	259	205	164	185	151	162
Histidine	1168	1569	1308	1271	1033	1366	882	1101	612	1124	840	1399	1145	947	919	850	770	568
Arginine	324	512	434	418	261	421	280	423	191	431	327	400	272	243	281	624	217	165
Tryptophan	168	159	104	104	70	98	107	64	86	104	83	178	113	70	92	52	43	52
Total	8319	11594	9248	9834	7185	10510	7577	9046	5554	10187	5838	8379	7311	6882	6001	6015	4861	4893

* See the text. ** Trace.

Table 3. Composition of free amino acids of hemolymph of newly ecdysed fifth-instar larvae: Chinese varieties (μg amino acid/m*l* hemolymph)

Amino acid	Silkworm variety																	
	K		L		M		N		P		Q		R		S		T	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Phosphoethanolamine	150	159	324	289	121	153	311	291	108	150	305	325	89	187	195	302	140	212
Aspartic acid	48	58	42	36	30	40	84	50	56	36	48	50	20	46	26	46	28	30
Threonine	236	270	195	234	252	440	254	161	202	257	116	170	100	166	177	302	122	164
Serine*	1080	1138	545	610	741	980	933	692	763	908	479	537	589	1002	432	734	558	783
Glutamic acid	865	1097	720	702	554	713	958	733	640	748	510	614	402	843	466	717	406	501
Proline	97	50	138	124	69	55	115	104	88	159	216	126	97	79	211	240	211	228
Lanthionine	394	725	665	831	331	590	312	550	256	406	537	662	387	803	384	722	350	650
Glycine	815	747	841	862	736	992	815	693	453	472	214	238	633	929	302	482	297	301
Alanine	156	159	41	57	90	152	44	63	123	144	61	91	52	98	37	82	56	92
Cystine	t **	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t
Valine	202	260	169	200	158	239	74	62	151	146	225	179	176	255	79	156	102	95
Cystathionine	313	687	477	667	243	397	447	423	177	333	437	570	257	510	363	747	293	513
Methionine	36	83	20	58	67	99	40	47	63	90	16	40	16	20	18	56	31	52
Isoleucine	39	71	36	49	28	43	39	41	55	55	51	41	22	43	18	43	24	39
Leucine	55	81	35	49	55	63	39	41	71	81	65	85	47	94	24	49	20	30
Tyrosine	144	277	71	220	56	217	245	329	484	641	139	351	111	280	68	204	223	443
Phenylalanine	20	32	7	22	10	15	27	20	32	42	12	20	7	12	7	12	10	22
β-Alanine	71	78	55	62	52	83	62	62	45	59	49	24	33	56	49	75	40	43
Ornithine	670	698	444	593	551	652	28	26	260	272	14	20	77	123	26	58	337	309
Lysine	535	596	296	307	423	596	452	399	496	564	664	779	200	393	404	524	215	382
Ammonia	262	378	229	319	177	292	275	322	206	381	175	292	147	303	159	238	170	287
Histidine	687	754	826	873	442	610	950	691	512	722	870	905	503	840	384	687	517	715
Arginine	269	368	546	580	199	311	402	311	235	287	447	544	240	499	350	557	214	290
Tryptophan	55	101	70	77	89	74	107	83	70	61	86	80	64	89	70	101	86	77
Total	7199	8867	6792	7821	5474	7806	7013	6194	5546	7014	5736	6743	4269	7670	4249	7134	4450	6258

*, ** See Table 2.

Table 4. Analysis of variance of analytical data

Comparison between Japanese and Chinese races

Source of variance	Concentration of free amino acids
Main effects:	
Races	* *
Sexes	* *
Amino acids	* *
Interactions:	
Races vs. sexes	——
Races vs. amino acids	* *
Sexes vs. amino acids	* *
Races vs. sexes vs. amino acids	——

Comparison among Japanese varieties and among Chinese varieties

Source of variance	Concentration of free amino acids	
	Japanese varieties	Chinese varieties
Main effects:		
Varieties	* *	* *
Sexes	* *	* *
Amino acids	* *	* *
Interactions:		
Varieties vs. sexes	* *	* *
Varieties vs. amino acids	* *	* *
Sexes vs. amino acids	* *	* *

* * Significant at 1 per cent. —— Not significant.

are arranged in descending order of the total amino acid content per m*l* of hemolymph (an average of male and female values, including phosphoethanolamine and ammonia). There were large variations in the total amino acid contents among silkworm varieties, and the largest value observed was about twice as high as the smallest one in both Japanese and Chinese varieties. The amino acids which occurred in high concentrations in every variety tested were histidine, lanthionine, glycine, and glutamic acid, followed by cystathionine and lysine. Serine was also high in this analysis, but it cannot be concluded that the actual concentration of serine is this high, because of the lack of separation from asparagine and glutamine as mentioned above. On the other hand, cystine, phenylalanine, β-alanine, aspartic acid, leucine, and isoleucine were small components. Cystine especially was only present in trace amounts in most of the Japanese and all of the Chinese varieties. Traces of β-alanine and phenylalanine were also detected in some Japanese varieties. Among the 18 varieties, variety-A contained only a trace of ornithine in both sexes.

Table 5. Comparison of concentration of each free amino acid of hemolymph between Japanese and Chinese races and between male and female

Amino acid	Mean of 9 varieties; male and female (μg amino acid/ml hemolymph)		Mean of 18 varieties (μg amino acid/ml hemolymph)	
	Japanese race	Chinese race	Male	Female
Phosphoethanolamine	119. 2	211. 7**	150. 8	180. 2*
Aspartic acid	53. 2	43. 0	45. 2	51. 0
Threonine	177. 1	212. 1	172. 1	217. 1*
Serine	856. 9	750. 2	729. 6	877. 5*
Glutamic acid	744. 6	677. 2	651. 3	770. 4*
Proline	161. 9	133. 7	129. 1	166. 6
Lanthionine	891. 6	530. 8**	580. 2	842. 2**
Glycine	795. 8	606. 8	651. 3	745. 7*
Alanine	134. 2	88. 8**	98. 3	124. 7**
Cystine	6. 2	t [1)]	t	6. 2
Valine	274. 5	162. 7**	192. 8	238. 8*
Cystathionine	504. 2	436. 3	368. 2	572. 4**
Methionine	84. 2	47. 3*	52. 4	79. 2*
Isoleucine	55. 9	40. 9*	42. 1	54. 7**
Leucine	94. 7	54. 7*	64. 4	84. 9*
Tyrosine	274. 4	250. 2	202. 0	322. 6**
Phenylalanine	20. 6	18. 3	14. 9	23. 4**
β-Alanine	19. 2	55. 4**	36. 1	38. 6
Ornithine	343. 1	286. 6	285. 3	344. 3*
Lysine	449. 4	456. 9	399. 9	506. 5**
Ammonia	230. 6	256. 2	209. 7	277. 1**
Histidine	1048. 4	693. 8**	798. 2	944. 0*
Arginine	345. 8	369. 4	304. 9	410. 2**
Tryptophan	80. 0	97. 1	86. 8	90. 2
Total	7735. 2	6457. 5*	6256. 8	7935. 9**

* Significant at 5 per cent. ** Significant at 1 per cent. [1)] Trace.

Computations on the analysis of variance were made with the analytical results in three cases; (i) when all of the Japanese and Chinese varieties were grouped into Japanese and Chinese races, respectively, (ii) with the 9 Japanese varieties, and (iii) with the 9 Chinese varieties. Table 4 contains the completed analysis of variance. In all three cases the amino acid content was significantly different in main effects (races or varieties; sexes; kinds of amino acids). Furthermore, interactions between these categories (races or varieties vs. sexes; races or varieties vs. amino acids; sexes vs. amino acids) were significant. Subsequently, the mean values were calculated as comparison in the respective amino acid contents between Japanese and Chinese races and between males and females (Table 5). The total amino acid concentration (an average of male and

female values, including phosphoethanolamine and ammonia) was significantly higher in the Japanese race than in the Chinese race. A significant difference between both races was found for the concentrations of each of lanthionine, alanine, valine, methionine, isoleucine, leucine, and histidine (higher in the Japanese race as a whole) as well as for β-alanine (higher in the Chinese race as a whole). Phosphoethanolamine was also significantly higher in the Chinese race.

The least significant difference (5 %) was calculated in order to examine the existence of a significant difference in the total amino acid concentrations (an average of male and female values, including phosphoethanolamine and ammonia) among the 9 Japanese varieties and among the 9 Chinese varieties, respectively. In Figure 1 the silkworm varieties are shown in order of average amino acid concentrations, and the varieties are linked by underlines, when the differences between them is below the *l. s. d.* calculated at the 5 % level. For instance, the varieties which are significantly lower in concentration than variety-A are variety-D, variety-E, and those following.

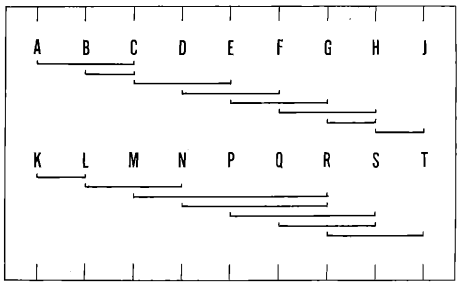

Fig. 1. Comparison of free amino acid concentrations of larval hemolymph among the Japanese and Chinese varieties. The underlines indicate that there are no significant differences in the concentration among varieties linked by respective underlines.

The import of the significant difference of the total amino acid concentration between the sexes is that females are higher than males in the mean concentration of all 18 varieties of the Japanese and Chinese races (Table 5). When examined individually, however, in two varieties (G and N) males showed a higher value than females. Individual values for amino acids, phosphoethanolamine, and ammonia were significantly higher in females than in males, and aspartic acid, proline, cystine, β-alanine, and tryptophan were exceptions.

INOKUCHI (1972a) has previously compared the amino acid pattern of females with that of males in the silkworm by applying an equation proposed for comparing amino acid patterns of foods. The values calculated in the 18 varieties according

Table 6. Comparison of patterns of free amino acids of hemolymph between male and female

Variety	Coefficient of pattern similarity	Variety	Coefficient of pattern similarity
A	0. 995	K	0. 977
B	0. 993	L	0. 991
C	0. 994	M	0. 992
D	0. 983	N	0. 977
E	0. 993	P	0. 990
F	0. 990	Q	0. 988
G	0. 987	R	0. 989
H	0. 966	S	0. 989
J	0. 921	T	0. 980

Calculated according to the formula (TAMURA and OSAWA, 1969):
$S(A, B)=\frac{\sum a_i b_i}{\sqrt{\sum a_i^2}\sqrt{\sum b_i^2}}$, where pattern $A(a_1,a_2,\cdots\cdots,a_n)$ and pattern $B(b_1,b_2,\cdots\cdots,b_n)$ are compared.

Table 7. Comparison of cocoon quality among silkworm varieties used

Variety	Mean cocoon weight (g)	Mean cocoon-shell weight (cg)	Mean cocoon-shell ratio (%)	Year of rearing	No. of replicates
A	1. 149	13. 9	12. 1	1952-53, 1960-66, 1970	10
B	1. 674	26. 8	16. 0	1948-70	23
C	1. 767	26. 9	15. 2	1947-70	24
D	1. 682	25. 0	14. 9	1948-70	23
E	1. 443	19. 3	13. 4	1952-70	19
F	1. 524	20. 7	13. 6	1948-66, 1969-70	21
G	1. 614	22. 7	14. 1	1952-70	19
H	1. 638	23. 5	14. 3	1944-48, 1952-70	24
J	1. 648	22. 4	13. 6	1950-70	21
(Mean)		(22. 36)			
K	1. 422	20. 4	14. 3	1960-71	12
L	1. 662	21. 6	13. 0	1959-71	13
M	1. 299	18. 2	14. 0	1959-66, 1970-71	10
N	1. 430	19. 2	13. 4	1959-71	13
P	1. 552	20. 1	13. 0	1959-71	13
Q	1. 205	15. 6	12. 9	1959-66, 1970-71	10
R	1. 744	27. 2	15. 6	1959-71	13
S	1. 424	18. 9	13. 3	1959-71	13
T	1. 371	20. 4	14. 9	1959-66, 1970-71	10
(Mean)		(20. 18)			

Rearing was carried out once a year mostly in spring, at the Branch Stations or Silkworm-Egg Experiment Stations, the Sericultural Experiment Station.

to this method are shown in Table 6. It is seen that the coefficient of pattern similarity was 0.980 or more in most cases, although the values in two Japanese (H and J) and one Chinese (N) variety were less than 0.980. In the newly ecdysed fifth-instar larvae of a hybrid silkworm (Nichi-124×Shi-124) as high a value as 0.995 has been reported.

As mentioned above, the silkworm varieties used in the present experiment were especially selected for their characteristics of the Japanese or Chinese race from among the strains which had been kept pure in the Sericultural Experiment Station. These larvae have been reared once a year to examine the details of larval growth and characters of cocoons. Average values of cocoon characters in the past were calculated from these records for each variety and summarized in Table 7. From among the cocoon characters examined, the cocoon-shell weight was taken to determine its relation to the concentration of free amino acids of hemolymph (an average of male and female values), but no correlation was found between them ($r=0.067$). However, it is evident from Table 7 that the mean value of cocoon-shell weight of the 9 Japanese varieties is higher than that of the 9 Chinese varieties.

DISCUSSION

The present study revealed that the compositions of the free amino acids of hemolymph vary significantly among silkworm varieties in an analysis of newly ecdysed fifth-instar larvae. It is probable that the difference among varieties would be enlarged in the mid- and late-fifth instar. When examined with the 18 varieties, no correlation was found between free amino acid concentration and cocoon-shell weight. This might be expected, because the amount of the silk produced is highly influenced by the ability of larva to synthesize silk-protein, especially in the mid- and late-fifth instar.

Although the total concentration of free amino acids is higher in the Japanese than in the Chinese race as a whole, there are some Chinese varieties possessing larger amounts and some Japanese varieties containing smaller amounts of free amino acids. Incidentally, the mean of cocoon-shell weight of all the Japanese varieties together was higher than that of all the Chinese varieties. However, it is too early to conclude that this relates to higher amino acid concentration in the Japanese varieties. There are many reports or descriptions on the racial characteristics in the silkworm, but little effort has so far been made for a quantitative physiological analysis to racial differences. While the present study revealed part of them, the details of other physiological differences still remain unclarified.

The existence of the overall sexual difference in amino acid concentration, higher in females than in males, is quite interesting. In some varieties, however, males contained more amino acids than females. Furthermore, it was shown that

females as a whole exceeded males significantly in the amount of individual amino acids with only a few exceptions. In hybrid larvae of the silkworm (INOKUCHI, 1972a), once the fifth-instar larvae had started feeding on mulberry leaves, the concentration of some amino acids dropped either rapidly or gradually, whereas that of others increased rapidly or gradually, or remained almost unchanged. The amino acid composition of female hemolymph is characterized by a high concentration of sulfur amino acids, cystathionine and lanthionine (INOKUCHI, 1972a, b). It has also been shown that the sexual difference in the amino acid pattern becomes larger during growth in hybrid larvae of the silkworm (INOKUCHI, 1972a). Thus, such a relationship as found between sexes in the newly ecdysed larvae will probably not remain unchanged during subsequent growth in the pure varieties, as well. Although the amino acid pattern of males rather resembled that of females in the newly ecdysed larvae, it was evident from this study that the sexual difference at this time is nevertheless significant.

Judging from the dramatic changes in the free amino acid pattern during the fifth instar, it is not necessarily proper to compare the present data with former studies, in which primarily the feeding fifth-instar larvae have been analyzed. Former data showed that histidine occurs in high concentration in the mid-fifth instar, followed by lysine. In the newly ecdysed larvae histidine occurred at a high level, but only a few recent studies (INOKUCHI, 1972a, b) have referred to the concentration of cystathionine and lanthionine in hemolymph. The present data revealed that glutamic acid is present at a substantial level. This is rather is accord with some of the previous reports (KONDO and WATANABE, 1957; INOKUCHI, 1972a), but in disagreement with others (FUKUDA *et al.*, 1955; BRICTEUX-GRÉGOIRE *et al.*, 1959), in which the concentration of glutamic acid is rather low even in the early fifth instar.

The silkworm varieties used here are not like the practical ones which are commonly used for sericulture, as is evident from the low cocoon yield shown in Table 7. However, it is expected that a significant difference will also be found in practical silkworm varieties. It is generally considered that the differences in amino acid patterns reflect some changes in amino acid metabolism in the silkworm larva, and recently data are accumulating on the effect of nutrition on the free amino acid pattern (INOKUCHI, 1972b; ITO, 1972). The differences in the patterns between races, varieties, and sexes are considered to indicate some differences in physiology and biochemistry among them.

SUMMARY

Newly ecdysed, unfed fifth-instar larvae of the silkworm, *Bombyx mori*, of 9 Japanese and 9 Chinese varieties, which had been kept pure in their characteristics at the Sericultural Experiment Station, were analyzed for free amino acid

composition of hemolymph (22 amino acids, phosphoethanolamine, and ammonia).

There was a significant difference in the concentration of total free amino acids between Japanese and Chinese races as a whole, higher in the former than in the latter. Significant differences were found in 8 free amino acids between both races, seven of them being higher in the Japanese race. Furthermore, there were significant differences in amino acid concentrations among 9 Japanese varieties and among 9 Chinese varieties, respectively. The highest value was about twice that of the lowest. The difference between sexes in the total amino acid concentration was significant, being higher in females than in males. A significant difference was observed in the content of 17 individual amino acids, phosphoethanolamine, and ammonia, all being higher in female. Amino acid patterns were also different between sexes in all of the varieties used. The physiological meaning of the differences in amino acid composition was discussed briefly.

REFERENCES

BRICTEUX-GRÉGOIRE, S., G. DUCHÂTEAU, M. FLORKIN and C. JEUNIAUX (1959): Arch. Internat. Physiol. Biochim., **67**, 586-596.

DUCHÂTEAU, G., M. FLORKIN and C. JEUNIAUX (1959): ibid., **67**, 173-181.

DUCHÂTEAU-BOSSON, G., S. BRICTEUX-GRÉGOIRE, M. FLORKIN and C. JEUNIAUX (1960a): ibid., **68**, 275-280.

DUCHÂTEAU-BOSSON, G., M. FLORKIN and C. JEUNIAUX (1960b): ibid., **68**, 327-338.

DACHÂTEAU-BOSSON, G., C. JEUNIAUX and M. FLORKIN (1961a): ibid., **69**, 369-373.

DUCHÂTEAU-BOSSON, G., C. JEUNIAUX and M. FLORKIN (1961b): ibid., **69**, 485-492.

FUKUDA, T., J. KIRIMURA, M. MATUDA and T. SUZUKI (1955): Nature, **175**, 1041.

HIRATSUKA, E. (1969): Historical Review of Silkworm Varieties in Japan. pp. 335, Silk Sci. Res. Inst., Dainippon Raw Silk Foundation, Tokyo.

INOKUCHI, T. (1972a): J. Seric. Sci. Japan, **41**, 44-50.

INOKUCHI, T. (1972b): Bull. Seric. Exp. Sta., **25**, 169-197.

ITO, T. (1972): Israel J. Entomol. (In the press)

JEUNIAUX, C., G. DUCHÂTEAU-BOSSON, and M. FLORKIN (1961): Arch. Internat. Physiol. Biochim., **69**, 617-627.

KAWASE, S. (1965): J. Invert. Pathol., **7**, 113-116.

KONDO, Y. and T. WATANABE (1957): J. Seric. Sci. Japan, **26**, 298-305.

TAMURA, S. and F. OSAWA (1969): J. Jap. Soc. Food & Nutri., **22**, 494-496.

WATANABE, T. (1959): J. Seric. Sci. Japan, **28**, 251-256.

WYATT, G.R., T.C. LOUGHHEED and S.S. WYATT (1956): J. Gen. Physiol., **39**, 853-868.

摘　要

家蚕幼虫血液の遊離アミノ酸組成にみられる蚕品種間の差異について

井口民夫・伊藤智夫

（農林省蚕糸試験場）

農林省蚕糸試験場において純粋に系統保存されてきた家蚕の日本種9品種，支那種9品種の5齢起蚕を供試し，血液の遊離アミノ酸組成（22種類のアミノ酸とフォスフォエタノールアミンならびにアンモニア）を，蚕品種別および雌雄別に測定した。分析値については分散分析その他の統計学的解析を行な

った。すなわち分散分析においては，主効果（系統または品種，雌雄，アミノ酸の種類）およびその交互作用の両者が，アミノ酸濃度に及ぼす影響を明らかにした。

遊離アミノ酸の全体の濃度（合計値，ただしフォスフォエタノールアミンとアンモニアを含む）には，日本種と支那種の間に有意差が認められ，全体としては日本種が高い濃度を示した。両者間に有意差の認められたアミノ酸は8種類であり，1種類を除きいずれも日本種において濃度が高かった。なおフォスフォエタノールアミンは支那種のほうが高い濃度であり，有意差が認められた。

また日本種系統および支那種系統のそれぞれの品種間において遊離アミノ酸濃度に有意差が認められた。日支両系統において，最高濃度の品種と最低濃度の品種との間には，2倍またはそれに近い開きがあった。

日支両系統の品種を通じ，遊離アミノ酸全体の濃度には雌雄間に有意差があり，雌のほうが高い値を示した。雌雄間で有意差の認められたアミノ酸は17種類もあり，いずれも雌が高い値であった。なおフォスフォエタノールアミンとアンモニアの濃度も雌が高く，雄との間に有意差があった。またアミノ酸パターンが雌雄間で異なっていることも，供試品種すべてにおいて認められた。雌雄間におけるアミノ酸組成の相違の傾向は既報（井口，1972）のそれとよく似ていた。

起蚕時に比較的多量に存在するアミノ酸は，ヒスチジン，ランチオニン，グリシン，グルタミン酸であった。またとくに少なかったものはシスチン，β-アラニン，フェニルアラニンであった。

起蚕時の遊離アミノ酸濃度と当該品種の繭層重との間には相関は認められなかった。ただし，日本種9品種の繭層重平均値は，支那種9品種の繭層重平均値よりも高い値であった。