NUTRITIONAL AND COOKING QUALITY CHARACTERS OF SOME LOCAL RICE CULTIVARS OF BANGLADESH

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Abstract

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Fifty-four primitive (local) cultivars of rice and 6 high-yielding varieties: IR–8, IR–20, BR–4, Chandina, Iratom–24 and Iratom–38, from the germ plasma collection maintained at the Institute of Nuclear Agriculture, were compared for their nutritional and cooking quality. The following characters were studied: length-breadth ratio; hulling recovery per cent; 1000-kernel weight; protein content (Kjeldahl); protein quality (DBC); amylose content; alkali spreading value; and protein quality index. Four of the nutritionally superior types were further analysed for total amino acid content. Considerable variation was recorded for all the characters studied. All parameters of protein quantity and quality, particularly Kjeldahl protein per cent and DBC values were highly positively correlated with each other and highly negatively correlated with the amylose content. The Hbj. B–VI and Boiragi varieties retained high lysine and high tryptophan content at higher protein per cent. A microscopic protein characterization technique was used to screen all 60 varieties. The microscope section score was highly and positively correlated with the protein content ($r = +0.97^{**}$) and negatively with the amylose content ($r = -0.45^{**}$). The data obtained suggests that the indigenous cultivars of rice in Bangladesh can be effectively used as donors of good quality protein in the breeding programme. An inventory of the germ plasm should be made that would include information on the nutritional characters as well.

INTRODUCTION

Of the total cropping area of 29 million acres in Bangladesh, rice is grown on 24 million acres. This acreage is distributed over three cropping seasons, namely *Aus* (Summer), *Aman* (Autumn) and *Boro* (Winter). Due to the growing demand for food, uniform high-yielding varieties are being preferred over the traditional land races and cultivars, which are fast losing favour with the cultivators. This trend to the replacement of original variability with more uniform exotic types, is leading to very serious and rapid 'gene erosion'. It is noteworthy that Bangladesh falls in the general area considered to be the primary centre of the origin of rice by Vavilov [1].

The present study, conducted on a small number of randomly picked cultivars, was undertaken to prove that the natural germ plasm for rice in Bangladesh does contain a sizeable variation for both nutritional and consumer's quality characters, which needs to be urgently collected, screened, catalogued and utilized in the breeding programmes. Encouraged by the findings presented in this report, the Institute of Nuclear Agriculture has now initiated a programme on the collection and evaluation of rice germ plasm in Bangladesh. The characteristic most emphasized in this study is the histological characterization of proteins, which has been reported to be highly heritable by Kaul et al. [2].

MATERIALS AND METHODS

The rice genotypes screened were collected from various institutes in Bangladesh and through personal collection trips from the districts of Dacca, Mymensingh, Bogra, Patuakhali, Rajshahi and Sylhet (Fig.1). The varieties represented all three growing seasons mentioned above.

Preparation of samples

Samples collected were cleaned, dehulled with a Satake grain miller and stored in sealed containers at uniform temperature. For analysis, samples were powdered to 60 mesh using a Willy mill. Moisture was determined and all values are reported at 10% constant moisture basis [3].

Analytical methods

The following analyses were performed:

1. Length/breadth (L/B) ratio [4]
2. Hulling recovery (%)
3. Thousand-kernel weight (TKW) [5]
4. Amylose content (%) [6]
5. Alkali spreading value [7]
6. Protein content (%): macro-Kjeldahl [8]
7. Dye-binding capacity (DBC) value [9]
8. Dye-binding capacity (DBC) value [10]
9. Protein quality index [11]
10. Microscopic section score [2]
11. Amino acid determination (automated column chromatography).

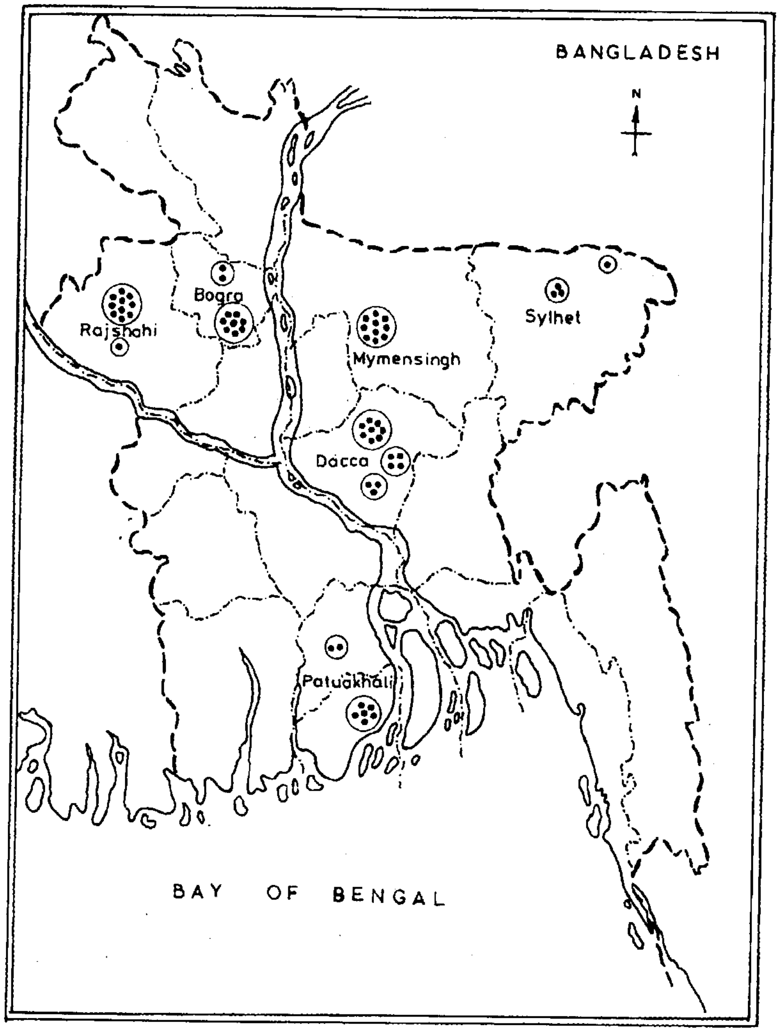
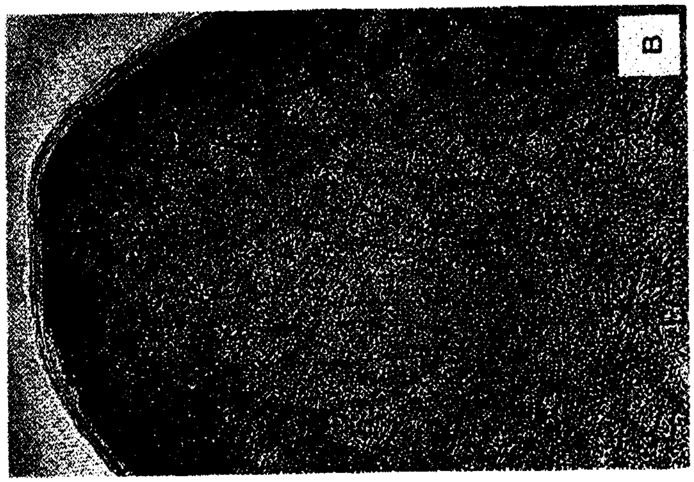


FIG.1. Sites from where rice cultivars were collected.

The section scoring for protein distribution in the rice kernel was further quantified by computing the ratio between the stained area versus the radius of the grain, expressed in percentage. The simple formula used for the purpose was: Section score = $\frac{b}{a} \times 100$ where b = stained area, and a = radius of the kernel (Fig.2).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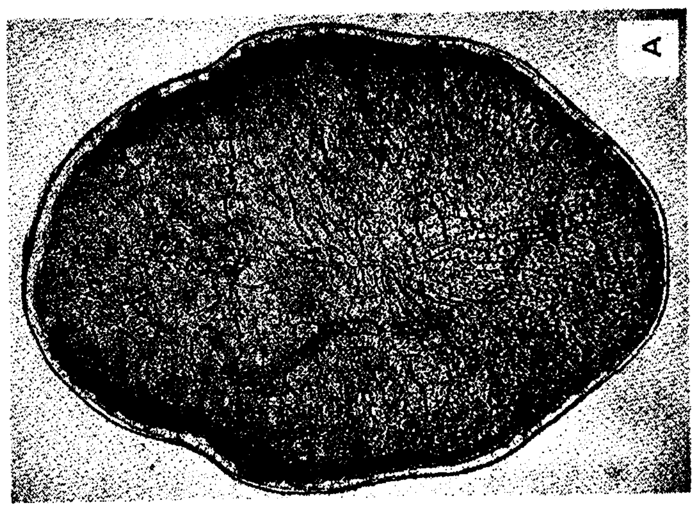
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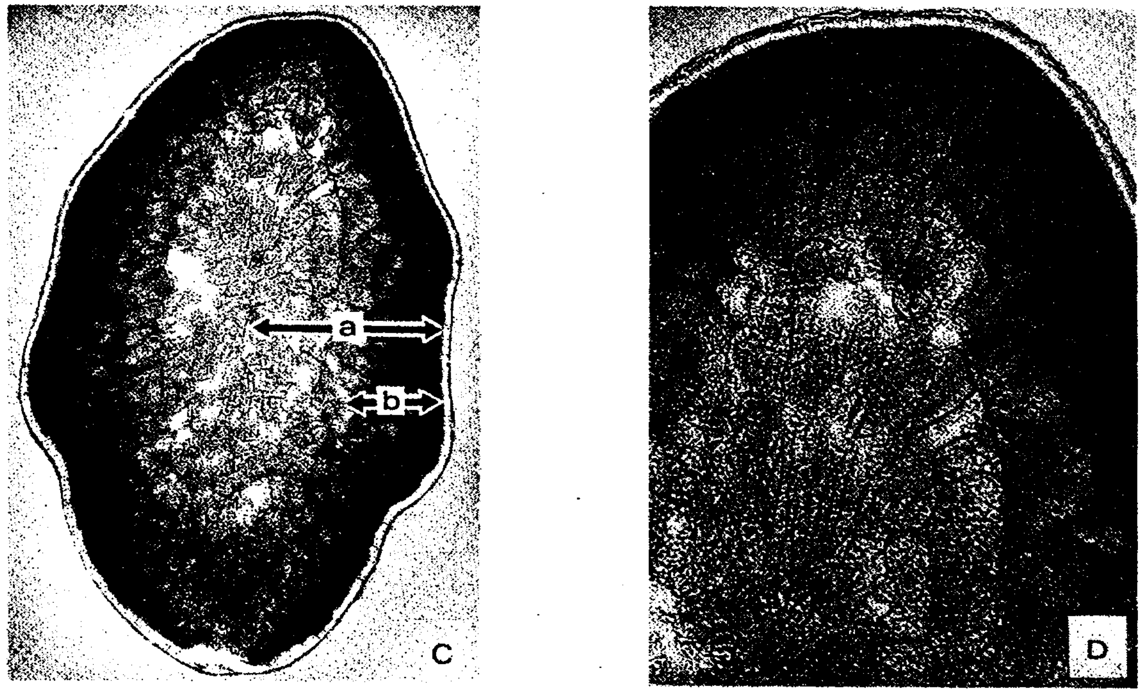

FIG.2. Differences in the depth of protein concentration in rice cultivars: A & B low-protein genotype, C & D high-protein genotype. In Fig.2(c) 'a' & 'b' refer to the formula given in the text for calculating the section score.

TABLE I. VARIABILITY FOR VARIOUS QUALITY CHARACTERS IN SIXTY RICE CULTIVARS

Statistical parameter	L/B ratio	Hulling recovery (%)	TKW (g)	Amylose content (%)	Spreading index	Protein (Kjeldahl) (%)	DBC value [9]	Protein index [5]	Section score
Range low	1.75	76	8.54	5.50	2.00	6.12	6.75	93	11.11
high	4.07	86	26.34	32.81	7.00	12.79	12.32	111	63.63
Mean	2.47	80	17.10	26.17	3.32	8.46	8.47	100.26	30.15
S.D.	0.43	2	3.83	4.02	0.97	1.33	1.18	4.77	12.00
C.V. (%)	17	3	22	15	29	16	14	5	40

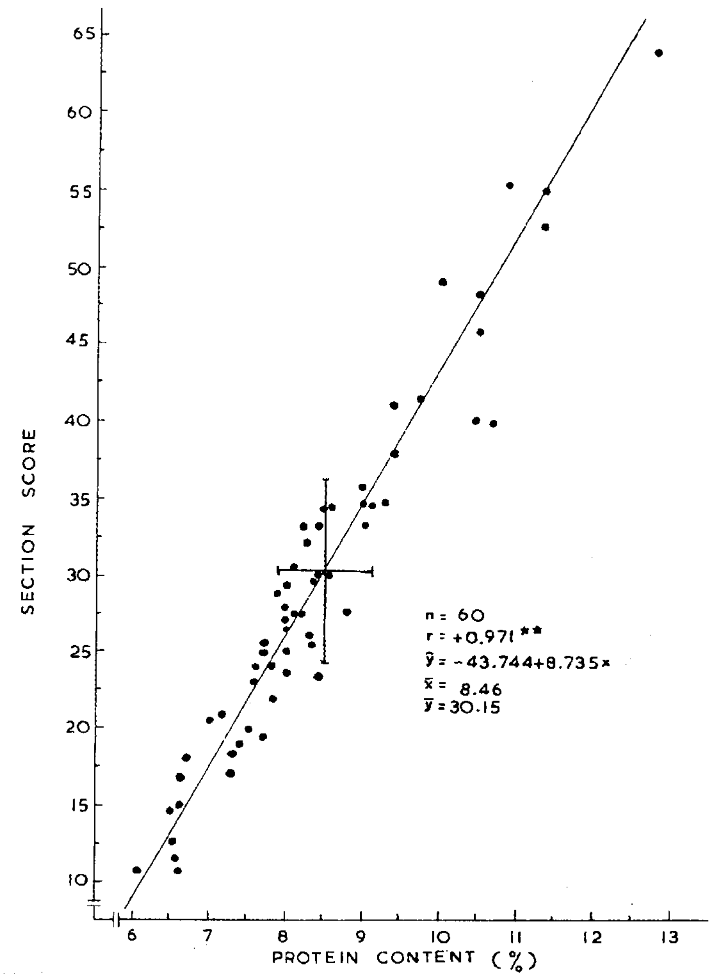

FIG.3. Scatter diagram showing the correlation between protein content and section score.

RESULTS AND DISCUSSION

The high degree of variation existing in the small number of genotypes analysed in the study is remarkable. For almost all the characters a good deal of variability was noted (Table I). Among the cooking characters studied, the variability in the length/breadth ratio, spreading index and amylose content are noteworthy. It is of interest that length/breadth ratio is neither positively nor

TABLE II. CORRELATION BETWEEN DIFFERENT NUTRITIONAL AND COOKING CHARACTERS OF RICE (data based on 60 varieties)

L/B ratio	Hulling recovery (%)	TKW	Amylose (%)	Spreading index	Protein (Kjeldahl) (%)	DBC [9]	Protein index [5]	Section score
L/B ratio	−0.09	0.02	−0.14	0.11	−0.24	−0.22	0.07	–
Hulling recovery		−0.22	−0.18	0.23	0.11	0.16	0.06	–
TKW			0.07	−0.07	0.08	0.05	−0.15	0.14
Amylose (%)				−0.87**	−0.50**	−0.52**	0.13	−0.46**
Spreading index					0.49**	0.45**	−0.30*	–
Protein % (Kjeldahl)						0.96**	−0.50**	0.97**
DBC value							−0.24	0.96**

* Significant at the 5% level; ** significant at the 1% level.

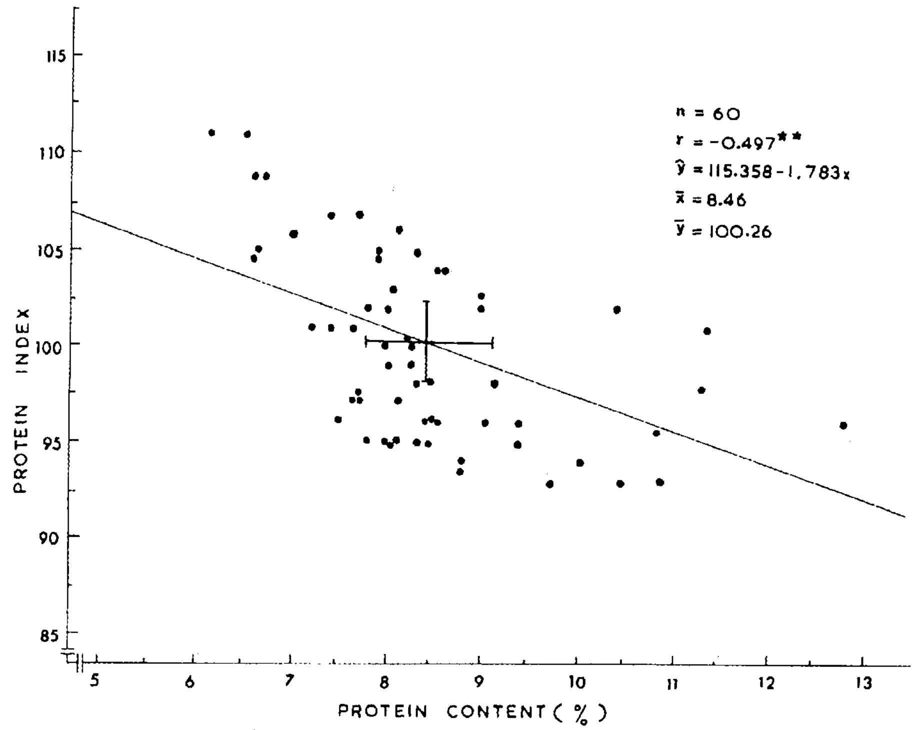

FIG.4. Correlation between protein content and Protein Index Value.

negatively correlated with any of the other cooking characteristics or with the nutritional characters. However, by itself, this character is of importance since consumers in different areas of the Indian subcontinent have different preferences. Indian rice consumers generally prefer varieties with a higher length/breadth ratio, which in Bangladesh cooking characteristics other than the length/breadth ratio are of greater importance. Preference is usually given to low thousand-kernel weight (TKW) varieties which have high amylose content and a low spreading index. In other words, small-grain 'non-sticky' varieties are preferred over the 'sticky' high-amylopectin varieties. No special attention is paid to the nutritive value or the distribution of proteins in the grain.

The range of crude protein content, from 6 to 13% recorded in the material studied, is of great significance, especially since high-protein types are the ones that have been found to have a deep-seated distribution of protein bodies (r = 0.97** for protein content versus section score) (Figs 2 and 3).

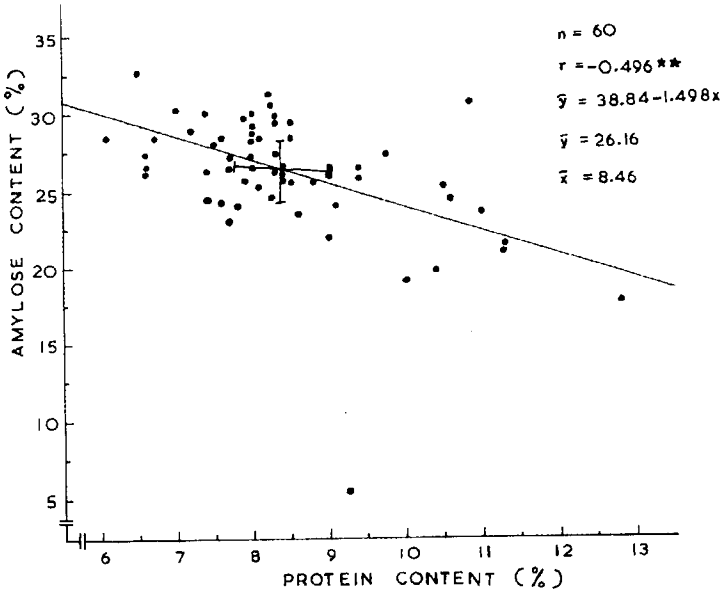

FIG.5. Correlation between amylose content and protein content.

The significance of the variation in the protein distribution in the rice grain has not yet been fully recognized. The fact that machine polishing of rice is becoming more and more popular in the developing countries is alarming. Because rice is the staple source of protein in most of the South Asian countries, undue loss of its protein-rich outer layers through milling must be avoided. Selection for more deep-seated protein lines in the hybridization programmes would indirectly help to conserve the valuable protein. It may be mentioned here that the rice proteins are considered to have the highest biological value among all the cereals [12]. Now that a simple non-expensive and rapid screening test is available, it should be possible to select superior genotypes in small plant-breeding laboratories that lack sophisticated equipment. Using the microscopic method in association with the simple DBC method, as modified by Kaul et al. [2] and used in this study, a breeder can effectively handle up to 30 samples a day. It should be mentioned here that simple techniques of screening for starch as well as protein characteristics mentioned here have been specially adopted to suit the needs of those plant breeders who may have limited resources at their disposal.

The correlation coefficients recorded between various cooking and protein characteristics, given in Table II, are self-explanatory. The high correlation coefficients obtained between various indices of protein quantity and quality were

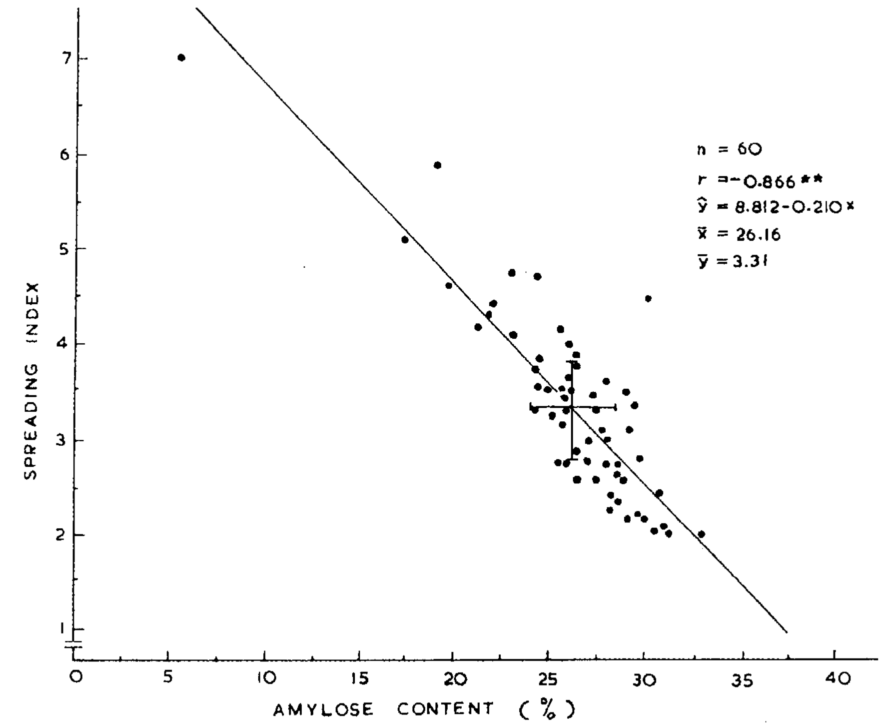

FIG.6. Correlation between amylose content and spreading value.

expected (Fig.4). The high degree of correlations recorded between the section score with Kjeldahl protein content and DBC value is noteworthy and so is the negative correlation obtained between section score and amylose content ($r = -0.45^{**}$). Amylose content has been found to be negatively, though highly significantly, correlated with protein content (Fig.5). The spreading index was negatively correlated ($r = -0.87^{**}$) with amylose content (Fig.6), but positively with the protein content ($r = 0.48^{**}$) and DBC value ($r = 0.45^{**}$). This relationship between starch and protein properties has not been reported earlier.

Two high-protein and two medium-protein varieties of rice were analysed for total amino acid content (Table III). The results obtained indicate that lysine and other essential amino acids were not negatively associated with the total protein content. In orther words, with 25% more protein in the grain the proportion of essential amino acids in the protein remains constant. In the case of wheat protein content has generally been reported to be negatively correlated with the amino acid content [13]. In rice detailed studies need to be conducted on a very

TABLE III. AMINO ACID CONTENT OF FOUR LOCAL RICE VARIETIES OF BANGLADESH

Amino acid (g/16 g N)	Varieties			
	Hbj. B–VI (White core)	Tepi boro (White core)	Boiragi (White core)	Binni (Waxy)
Aspartic acid	8.89	8.87	8.89	8.19
Threonine	3.03	3.18	3.25	3.11
Serine	4.17	4.10	4.27	4.02
Glutamic acid	17.43	16.61	17.40	17.57
Proline	4.76	4.95	4.98	5.10
Glycine	4.27	4.54	4.41	4.22
Alanine	5.63	5.67	5.72	5.65
Valine	6.09	6.11	6.18	5.82
Isoleucine	4.08	4.01	4.11	4.04
Leucine	8.44	7.85	8.16	8.12
Tyrosine	5.36	4.74	5.01	4.73
Phenylalanine	5.03	4.75	4.91	4.82
Lysine	3.34	3.94	3.51	3.34
Histidine	2.10	2.31	2.25	2.10
Ammonia	2.31	2.08	2.21	2.36
Arginine	8.08	8.23	8.14	7.64
Methionine	1.80	2.31	2.35	2.85
Cystine	1.50	1.88	1.95	2.37
Tryptophan	1.27	1.15	1.35	1.23
Protein content (%) at 10% moisture level	12.69	8.61	11.09	9.54

large number of samples to verify this relationship. From this study there is no indication that amino acid concentration depends in any way on the crude protein content, except for the sulphur-containing amino acids, which seem to have been slightly reduced in the high-protein variety Hbj. B–VI (Table III).

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