

## AMINO ACID COMPOSITION OF VEGETABLES AND FRUITS FROM THE PHILIPPINES

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### ABSTRACT

Vegetables and fruits commonly consumed in the Philippines were analyzed for their amino acid composition. In all, thirty-three samples were pulverized, lyophilised and then were subjected to acid and alkaline hydrolyses. On the amino acid compositional basis, these foodstuffs would provide a balanced source of dietary protein in general, if supplemented by synthetic phenylalanine and methionine. The minimum amounts of proteins from these foodstuffs needed to provide sufficient essential amino acids to maintain nitrogen balance were computed. The quality of proteins was also estimated by their chemical scores. The significance of these results is discussed.

### INTRODUCTION

Fruits and vegetables constitute staple foodstuffs in most Asian countries including the Philippines. Although they are thought to be good sources of vitamins, minerals and fibre, their importance in providing a balanced diet of protein is usually overlooked. Ample research effort has however shown that plant materials can also offer proteins of high nutritional value.

Soya beans and other legumes enjoy great success as major protein sources. Leaf protein concentrates from a variety of plants were found to give favorable balance of essential and nonessential amino acids, comparable to animal products (1, 2). Even the potato tuber, which is commonly considered an "energy food", has also been found to contain protein of high biological value (3, 4). Since the amino acid composition and the biological value of a protein are related, we report here the content of eighteen common amino acids found in thirty-three native Philippine fruits and vegetables.

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## MATERIALS AND METHODS

Fresh fruits and vegetables flown in from the Philippines were cut into small pieces, ground in pestle and mortar and lyophilized. The freeze-dried samples were further pulverised and strained through an 80-mesh sieve before use.

Total nitrogen content was determined by sulfuric acid hydrolysis in the presence of selenium dioxide (5) and nesslerisation with a modified Nessler reagent according to Middleton (6). Crude protein was estimated by multiplying 6.25 the nitrogen concentration and is reported on an as-is basis (lyophilized samples).

Sample hydrolysis prior to amino acid analysis was carried out at 110°C with 6 M HCl for 24 hours using the heat-sealed, vacuum tube method of Savoy et al. (7). In some samples, internal standard norleucine was included in the hydrolysis and calculation was done on the basis of the recovery of norleucine. To avoid interference due to the large amount of carbohydrates present in the plant materials, all hydrolysates were chromatographed on a Dowex 2-X8, 200-400 mesh column in order to remove humin (8). The column was run with 25 mM sodium citrate buffer, pH 2.2. The column effluent containing the amino acids was lyophilized, redissolved in enough distilled water to a volume which gave the final citrate concentration of 0.2M, and chromatographed in an LKB 4400 automatic amino acid analyser. The resulting chromatograms were quantitated by comparison with that obtained from a standard amino acid calibration mixture.

Tryptophan, which was destroyed during acid hydrolysis, was determined by 5 M NaOH hydrolysis, also in a sealed, vacuum tube method according to the Method W of Spies (9).

Sulfur-containing amino acids were not determined separately. They were estimated from the acid hydrolysis chromatograms by assuming that the average loss of methionine in unoxidized samples was 52.3% and that of cysteine + cystine was 62.2%, according to the data obtained by Kaldly and Markakis (3).

## RESULTS AND DISCUSSION

The total protein content on a dry weight basis as an average of two determinations showed a range of 11.6% (sayote) to 47.7% (kangkong) with a mean value of 24.9% (Table 1). Although on a wet weight basis the total percentage of protein is normally quite small, the process of lyophilisation obviously concentrated the protein. This was borne out in the potato tuber, whose apparent protein concentration was increased six-fold in one study, from 1.9% to 11.2% (12) or about five-fold from 2.1% to 10.3% in another study (3).

In all the foodstuffs tested, the amounts of glutamic acid and aspartic acid dominated all other amino acids. With the exception of alugbati, cabbage, iba, squash and sayote, aspartic acid constituted more than 10% of the total amino acids of each sample. Glutamic acid constituted more than 10% in all samples other than kangkong, katuray, saluyot and sampaloc.

On the contrary, sulfur-containing amino acids were present at much lower levels. The essential amino acid methionine was especially poor in almost all samples tested. In fact, the amount of methionine in cabbage, camote tops, eggplant, malunggay fruit, pechay and sampaloc fruit was extremely small, less than one percent of total amino acid in each case. Methionine has also been found to be limiting in many plant foodstuffs such as legumes (13), leaf protein concentrates (14) and potato (3).

The next essential amino acid that seemed to be present in low amount was phenylalanine. The deficiencies of methionine and phenylalanine were not apparent in terms of percentage of total amino acids as shown in Table 1. However, when the daily amounts of proteins needed to maintain nitrogen balance are computed as shown in Table 2, it was obvious that methionine as well as phenylalanine supplementation would be needed, in general, to give a balanced protein diet. Exceptions were found in cadyos and mongo where tryptophan was limiting, in sampaloc fruit and singkamas where isoleucine was limiting and in bamboo shoots where lysine was limiting. This was in addition to methionine deficiencies in the said materials.

Although the computations given in Table 2 indicated obvious deficiencies in the foodstuffs tested, their biological values could be compared in a different manner. The quality of the proteins and therefore the first approximation of their biological values was scored as a "percentage of adequacy" against a reference "ideal protein" recommended by FAO/WHO and is given in Table 3. Tyrosine and cysteine + cystine were included because of their sparing action on phenylalanine and methionine, respectively. The protein score, based on the limiting amino acids, was very widely spread between 17 for upo, and 100 for alugbati and sayote. The deficient amounts of methionine could not be compensated for by cysteine + cystine and therefore limited the biological value of most samples tested. On the other hand, tyrosine did indeed correct some limitations due to phenylalanine. In addition some inadequacies in lysine, or leucine could be demonstrated using calculations of this kind. For comparison, we cite other protein scores from the same FAO/WHO Report: whole egg, 100; human milk, 100; cow's milk 95; soya bean 74, sesame 50, groundnut 65, cottonseed 81, maize 49, millet 63, polished rice 67 and whole wheat, 53. Therefore, it could be seen that many of the fruits and vegetables listed in Table 3 compared favorably in terms of their protein scores.

It might be concluded on the basis of the amino acid compositions obtained that most of the samples tested had proteins of high nutritional

Table 1. Amino acid composition of freeze-dried fruits and vegetables.

| Protein Source                    |   | % Protein | Amino Acids <sup>a</sup> |     |                  |      |     |     |     |     |     |               |     |                  |      |     |      |      |      |      |
|-----------------------------------|---|-----------|--------------------------|-----|------------------|------|-----|-----|-----|-----|-----|---------------|-----|------------------|------|-----|------|------|------|------|
| Common Name                       | Botanical Name                                |           | Essential <sup>b</sup>   |     |                  |      |     |     |     |     |     | Non Essential |     |                  |      |     |      |      |      |      |
|                                   |   |           | Lys                      | Phe | Met <sup>c</sup> | Thr  | Leu | Ile | Val | Try | Arg | His           | Tyr | Cys <sup>c</sup> | Asp  | Ser | Glu  | Pro  | Gly  | Ala  |
| Alugbati                          | <i>Basella alba</i>                           | 30.2      | 5.8                      | 4.5 | 0.8              | 5.0  | 7.7 | 4.4 | 6.4 | 1.6 | 5.5 | 2.1           | 2.0 | 3.0              | 9.0  | 5.4 | 13.3 | 5.6  | 9.4  | 8.3  |
| Ampalaya Leaves                   | <i>Momordica charantia</i>                    | 30.7      | 5.4                      | 4.2 | 2.6              | 4.6  | 7.3 | 4.2 | 5.8 | 3.1 | 4.6 | 2.1           | 2.5 | 1.2              | 13.5 | 5.9 | 11.8 | 5.0  | 8.5  | 7.7  |
| Baguio Beans (Kentucky Beans)     | <i>Phaseolus vulgaris</i> Linn.               | 19.9      | 5.2                      | 3.3 | 1.5              | 4.7  | 6.6 | 4.0 | 5.4 | 1.4 | 3.8 | 2.0           | 1.9 | 0.63             | 19.2 | 7.1 | 12.7 | 6.0  | 6.9  | 7.7  |
| Bamboo Shoots                     | <i>Bambusa blumeana</i>                       | 26.5      | 2.0                      | 3.3 | 3.4              | 5.0  | 7.6 | 3.5 | 5.3 | 2.8 | 3.4 | 1.5           | 2.7 | 1.3              | 11.3 | 7.3 | 12.6 | 5.9  | 10.4 | 10.5 |
| Cabbage                           | <i>Brassica oleracea</i> var. <i>capitata</i> | 28.7      | 2.7                      | 1.5 | 0.4              | 2.4  | 2.7 | 1.6 | 2.1 | 1.0 | 3.2 | 1.8           | 1.0 | 0.4              | 7.0  | 3.6 | 12.9 | 48.7 | 3.4  | 3.6  |
| Cadyos (Pigeon Pea)               | <i>Cajanus cajan</i>                          | 27.8      | 6.0                      | 5.9 | 1.9              | 3.9  | 7.5 | 3.7 | 4.4 | 0.5 | 4.2 | 3.3           | 1.8 | 0.83             | 11.1 | 5.4 | 19.2 | 5.8  | 6.1  | 8.5  |
| Camote Tops (Sweet Potato Leaves) | <i>Ipomoea batatas</i> Lam.                   | 26.0      | 4.9                      | 4.2 | 0.6              | 10.4 | 7.3 | 4.0 | 5.4 | 3.7 | 4.1 | 1.8           | 1.9 | 2.0              | 12.7 | 5.5 | 10.4 | 5.2  | 8.2  | 7.5  |
| Cucumber                          |   | 37.4      | 6.5                      | 2.8 | 1.9              | 3.5  | 5.6 | 3.5 | 4.4 | 1.0 | 4.4 | 1.8           | 1.8 | 1.9              | 11.9 | 6.3 | 20.8 | 3.0  | 9.1  | 10.0 |
| Eggplant                          | <i>Solanum melongina</i>                      | 18.7      | 5.6                      | 3.3 | 0.7              | 4.6  | 5.5 | 3.2 | 4.4 | 3.5 | 5.5 | 2.5           | 2.2 | 0.7              | 15.1 | 5.8 | 20.1 | 4.1  | 6.8  | 6.2  |
| Gabi Leaves (Taro)                | <i>Colocasia esculenta</i>                    | 23.5      | 5.4                      | 4.1 | 2.4              | 4.5  | 6.7 | 4.0 | 6.3 | 2.5 | 5.0 | 2.1           | 2.6 | 1.5              | 12.5 | 5.0 | 13.5 | 4.7  | 8.5  | 8.6  |
| Gabi Rhizomes (Takway)            | <i>Colocasia esculenta</i>                    | 22.0      | 5.0                      | 3.0 | 2.1              | 4.3  | 6.3 | 3.7 | 5.3 | 2.1 | 4.4 | 1.8           | 1.9 | 1.1              | 20.2 | 6.7 | 11.3 | 4.5  | 7.4  | 8.9  |

|                                |  |      |     |     |     |     |     |     |     |     |     |     |     |      |      |     |      |      |      |     |
|--------------------------------|--|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----|------|------|------|-----|
| Iba<br>(Camayas)               | <i>Averrhoa<br/>bilimbi</i> Linn. v        | 17.9 | 3.6 | 3.3 | 1.4 | 4.7 | 5.7 | 3.0 | 4.2 | 9.0 | 8.6 | 2.0 | 2.1 | 3.0  | 9.7  | 6.7 | 22.6 | 7.5  | 7.0  | 6.7 |
| Kalabasa<br>Leaves<br>(Squash) | <i>Cucurbita<br/>maxima</i>                | 27.6 | 5.1 | 4.3 | 3.5 | 3.2 | 6.6 | 4.7 | 6.4 | 2.9 | 4.9 | 2.1 | 2.2 | 1.5  | 15.5 | 3.7 | 10.7 | 3.7  | 9.1  | 9.7 |
| Kalabasa<br>Fruit<br>(Squash)  | <i>Cucurbita<br/>maxima</i>                | 20.5 | 3.9 | 3.0 | 1.8 | 3.1 | 5.2 | 2.9 | 4.9 | 0.7 | 3.4 | 1.6 | 1.4 | 2.1  | 9.4  | 5.2 | 10.2 | 5.0  | 29.2 | 7.0 |
| Kangkong                       | <i>Ipomoea<br/>aquatica</i>                | 47.7 | 5.3 | 4.1 | 1.5 | 4.6 | 6.8 | 3.8 | 5.2 | 2.0 | 4.8 | 2.2 | 2.2 | 0.4  | 21.1 | 5.2 | 9.8  | 4.6  | 8.1  | 8.2 |
| Kulitis                        | <i>Amanthus<br/>spinosus</i>               | 34.8 | 4.8 | 4.3 | 3.5 | 5.0 | 8.3 | 4.7 | 5.7 | 2.9 | 4.1 | 1.7 | 2.7 | 1.3  | 10.5 | 5.9 | 10.7 | 5.1  | 9.6  | 9.5 |
| Katuray                        | <i>Sesbania<br/>grandiflora</i><br>Linn.   | 33.2 | 4.3 | 3.1 | 2.2 | 4.0 | 5.2 | 3.2 | 4.4 | 1.3 | 3.4 | 1.6 | 1.9 | 1.0  | 30.5 | 6.3 | 8.4  | 4.2  | 6.3  | 8.8 |
| Malunggay<br>Leaves            | <i>Moringa<br/>oleifera</i>                | 23.8 | 4.2 | 5.2 | 1.3 | 4.9 | 7.0 | 4.0 | 6.5 | 1.5 | 4.9 | 2.2 | 1.8 | 1.5  | 11.6 | 7.0 | 18.2 | 3.8  | 7.0  | 7.2 |
| Malunggay<br>Fruit             | <i>Moringa<br/>oleifera</i>                | 29.0 | 3.9 | 2.3 | 0.6 | 3.8 | 4.2 | 2.3 | 3.0 | 4.3 | 3.1 | 1.6 | 1.5 | 0.23 | 10.2 | 6.0 | 23.6 | 6.8  | 16.8 | 5.6 |
| Mongo                          | <i>Phaseolus<br/>radiatus</i> Linn.        | 24.0 | 6.2 | 4.8 | 2.0 | 3.7 | 7.4 | 4.6 | 5.4 | 1.0 | 5.3 | 2.6 | 2.2 | 0.4  | 10.6 | 6.0 | 15.4 | 10.4 | 6.2  | 5.8 |
| Okra                           | <i>Abelmoschus<br/>esculentus</i><br>Linn. | 23.8 | 4.3 | 2.7 | 1.9 | 3.9 | 4.9 | 3.0 | 3.9 | 4.4 | 3.8 | 2.0 | 1.7 | 0.8  | 21.1 | 5.4 | 19.7 | 3.7  | 6.1  | 6.6 |
| Patani                         | <i>Phaseolus<br/>lunatus</i> Linn.         | 22.0 | 6.7 | 4.8 | 0.9 | 5.0 | 6.9 | 4.1 | 4.7 | 1.4 | 4.6 | 2.7 | 2.6 | 1.5  | 12.3 | 7.3 | 13.0 | 8.2  | 7.5  | 6.5 |
| Patola                         | <i>Luffa<br/>acutangula</i><br>Linn.       | 17.8 | 6.4 | 3.0 | 2.6 | 4.8 | 7.9 | 3.4 | 6.2 | 1.7 | 3.2 | 2.4 | 2.6 | 0.7  | 12.6 | 6.9 | 14.1 | 4.6  | 9.1  | 8.9 |

(continued next page)

Table 1 continued

|                           |                                     |      |     |     |     |     |     |     |     |     |     |     |     |      |      |     |      |      |     |     |
|---------------------------|-------------------------------------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----|------|------|-----|-----|
| Pechay                    | <i>Brassica chineisis</i> Linn.     | 26.6 | 6.0 | 4.7 | 0.4 | 5.1 | 6.8 | 3.6 | 5.5 | 2.4 | 5.0 | 2.2 | 0.5 | 0.4  | 13.1 | 6.0 | 15.9 | 5.4  | 9.3 | 7.7 |
| Puso (Banana Blossom)     | <i>Musa paradisiaca</i>             | 21.1 | 4.7 | 3.0 | 2.3 | 4.1 | 6.0 | 4.0 | 5.2 | 4.8 | 5.0 | 2.0 | 1.9 | 0.73 | 12.6 | 5.5 | 16.1 | 6.6  | 7.7 | 7.8 |
| Saluyot                   | <i>Oochorus oletorius</i> Linn.     | 27.8 | 4.9 | 4.4 | 2.5 | 4.2 | 7.1 | 4.1 | 6.1 | 3.1 | 4.9 | 2.1 | 2.4 | 2.7  | 15.4 | 4.7 | 9.9  | 4.6  | 8.2 | 8.6 |
| Sampaloc Fruit (Tamarino) | <i>Tamarindus indica</i> Linn       | 15.8 | 6.0 | 5.0 | 0.7 | 5.0 | 5.3 | 2.7 | 3.9 | 5.0 | 3.7 | 2.3 | 2.8 | 1.3  | 16.2 | 7.9 | 9.7  | 6.7  | 8.7 | 7.3 |
| Sayote (Chayote)          | <i>Sechium edule</i> (Jacq.) Swartz | 11.6 | 7.4 | 4.2 | 1.5 | 5.4 | 8.1 | 4.7 | 5.7 | 2.6 | 4.1 | 2.5 | 3.5 | 2.1  | 10.4 | 6.3 | 10.8 | 5.8  | 8.3 | 6.6 |
| Singkamas                 | <i>Brassica rapa</i>                | 19.0 | 5.3 | 5.1 | 1.3 | 3.9 | 5.2 | 3.0 | 4.7 | 1.6 | 3.1 | 2.4 | 2.2 | 10.9 | 19.7 | 4.0 | 11.0 | 4.2  | 6.1 | 6.3 |
| Sitao (String Beans)      | <i>Vigna sesquipedalis</i>          | 24.5 | 5.5 | 3.8 | 1.9 | 4.3 | 6.5 | 3.9 | 5.5 | 1.0 | 3.8 | 3.1 | 1.9 | 0.9  | 14.4 | 6.7 | 15.3 | 6.7  | 6.9 | 8.5 |
| Tanglad                   | <i>Andropogon citratatus</i> DC     | 19.6 | 5.3 | 3.0 | 1.9 | 4.5 | 6.6 | 3.9 | 5.8 | 2.1 | 5.0 | 2.0 | 2.0 | 1.0  | 19.0 | 7.0 | 13.5 | 12.5 | 8.1 | 9.0 |
| Ubi (Yam)                 | <i>Dioscorea alata</i> Linn.        | 19.8 | 4.3 | 3.8 | 8.8 | 3.2 | 6.1 | 3.3 | 4.3 | 1.6 | 3.9 | 1.6 | 2.7 | 10.1 | 11.7 | 6.7 | 10.6 | 4.7  | 6.6 | 6.0 |
| Upo (Bottlegourd)         | <i>Legenaria siceraria</i>          | 22.3 | 4.4 | 4.6 | 0.6 | 5.3 | 6.9 | 4.3 | 5.0 | 4.0 | 4.0 | 2.5 | 2.6 | 0    | 14.1 | 7.3 | 14.2 | 5.0  | 8.4 | 6.7 |

<sup>a</sup>Amino acids expressed as per cent calculated from total amino acids recovered. When calculations were based on crude protein (N x 6.25), differences were within experimental error. Since amino acid content and not total nitrogen limits nutritive value of crude proteins, and little nonprotein nitrogen was present, protein content was expressed as total amino acid residues.

<sup>b</sup>Required by adult man (10, 15).

<sup>c</sup>Total methionine content and cysteine + cystine content were adjusted respectively, by assuming that 52.3% and 62.2% of these amino acids had been lost during acid hydrolysis according to Kaldy and Menkakis (3).

AMINO ACIDS OF FRUITS AND VEGETABLES

Table 2. Amount of protein in food stuffs providing recommended level of each essential amino acid to maintain nitrogen balance in adult man.

|                  | Amino Acids <sup>a</sup>  |     |     |     |     |     |     |     | Minimum<br>Amount<br>needed <sup>b</sup> |
|------------------|---------------------------|-----|-----|-----|-----|-----|-----|-----|--|
|                  | Lys                       | Phe | Met | Thr | Leu | Ile | Val | Try |  |
|                  | Recommended Grams Per Day |     |     |     |     |     |     |     |  |
|                  | 1.6                       | 2.2 | 2.2 | 1.0 | 2.2 | 1.4 | 1.6 | 0.5 |  |
| Alugbati         | 28                        | 49  | 275 | 20  | 29  | 32  | 25  | 31  | 49                                       |
| Ampalaya leaves  | 30                        | 52  | 84  | 22  | 30  | 33  | 28  | 16  | 52                                       |
| Baguio Beans     | 31                        | 67  | 146 | 21  | 33  | 35  | 30  | 36  | 67                                       |
| Bamboo Shoots    | 80                        | 67  | 65  | 20  | 29  | 40  | 30  | 18  | 80                                       |
| Cabbage          | 60                        | 147 | 550 | 41  | 83  | 88  | 75  | 51  | 147                                      |
| Cadyos           | 27                        | 37  | 116 | 26  | 29  | 38  | 36  | 100 | 100                                      |
| Camote Tops      | 32                        | 52  | 367 | 10  | 30  | 35  | 30  | 13  | 52                                       |
| Cucumber         | 24                        | 79  | 116 | 29  | 39  | 40  | 36  | 50  | 79                                       |
| Eggplant         | 29                        | 63  | 314 | 22  | 40  | 43  | 37  | 14  | 63                                       |
| Gabi Leaves      | 30                        | 54  | 92  | 22  | 33  | 35  | 25  | 20  | 54                                       |
| Gabi Rhizomes    | 32                        | 73  | 104 | 23  | 35  | 38  | 30  | 24  | 73                                       |
| Iba              | 44                        | 66  | 157 | 21  | 39  | 47  | 38  | 6   | 66                                       |
| Kalabasa Leaves  | 32                        | 51  | 62  | 31  | 33  | 30  | 25  | 17  | 51                                       |
| Kalabasa Fruit   | 41                        | 73  | 122 | 32  | 42  | 48  | 33  | 71  | 73                                       |
| Kangkong         | 30                        | 54  | 146 | 22  | 32  | 37  | 31  | 25  | 54                                       |
| Kulitis          | 33                        | 52  | 63  | 20  | 27  | 30  | 28  | 18  | 52                                       |
| Katuray          | 38                        | 71  | 100 | 25  | 43  | 44  | 36  | 38  | 71                                       |
| Malunggay Leaves | 38                        | 42  | 164 | 21  | 31  | 35  | 24  | 33  | 42                                       |
| Malunggay Fruit  | 41                        | 94  | 454 | 27  | 52  | 60  | 53  | 12  | 94                                       |
| Mongo            | 26                        | 45  | 108 | 27  | 30  | 30  | 30  | 50  | 50                                       |
| Okra             | 37                        | 81  | 115 | 25  | 45  | 47  | 41  | 11  | 81                                       |
| Patani           | 24                        | 46  | 245 | 20  | 32  | 34  | 34  | 36  | 46                                       |
| Patola           | 25                        | 73  | 85  | 21  | 28  | 41  | 26  | 29  | 73                                       |
| Pechay           | 27                        | 47  | 550 | 20  | 32  | 39  | 29  | 21  | 47                                       |
| Puso             | 34                        | 73  | 96  | 24  | 37  | 35  | 31  | 10  | 73                                       |
| Saluyot          | 22                        | 53  | 144 | 19  | 27  | 30  | 28  | 20  | 53                                       |
| Sampaloc Fruit   | 27                        | 44  | 318 | 20  | 42  | 53  | 41  | 10  | 53                                       |
| Sayote           | 22                        | 54  | 79  | 18  | 24  | 25  | 25  | 19  | 54                                       |
| Singkamas        | 30                        | 43  | 168 | 26  | 42  | 47  | 34  | 31  | 47                                       |
| Sitao            | 29                        | 58  | 116 | 23  | 34  | 36  | 29  | 50  | 58                                       |
| Tanglad          | 30                        | 72  | 118 | 22  | 33  | 36  | 28  | 23  | 72                                       |
| Ubi              | 38                        | 58  | 25  | 31  | 36  | 43  | 37  | 31  | 58                                       |
| Upo              | 36                        | 48  | 371 | 19  | 32  | 32  | 32  | 12  | 125                                      |

<sup>a</sup>Grams of protein needed to provide amino acid to maintain nitrogen balance in adult man. Dietary levels according to Rose (10).

<sup>b</sup>Total grams protein needed to provide sufficient essential amino acids (except methionine) to maintain nitrogen balance in adult man. Methionine supplementation assumed.

Table 3. Protein scores of freeze-dried fruits and vegetables based on reference amino acid pattern<sup>a</sup>.

| Foodstuffs       | Lys  | Phe<br>+<br>Tyr | Met<br>+<br>Cys | Thr  | Leu  | Ile  | Val  | Try  | Protein<br>Score <sup>b</sup> |
|------------------|------|-----------------|-----------------|------|------|------|------|------|-------------------------------|
| Alugbati         | >100 | >100            | >100            | >100 | >100 | >100 | >100 | >100 | >100                          |
| Ampalaya Leaves  | 98   | >100            | >100            | >100 | >100 | >100 | >100 | >100 | 98                            |
| Baguio Beans     | 94   | 87              | 61              | >100 | 94   | >100 | >100 | >100 | 61                            |
| Bamboo Shoots    | 36   | >100            | >100            | >100 | >100 | 88   | >100 | >100 | 36                            |
| Cabbage          | 49   | 42              | 23              | 60   | 45   | 40   | 42   | >100 | 23                            |
| Cadyos           | >100 | >100            | 78              | 98   | >100 | 93   | 88   | 50   | 50                            |
| Camote Tops      | 89   | >100            | 74              | >100 | >100 | >100 | >100 | >100 | 74                            |
| Cucumber         | >100 | 77              | >100            | 88   | >100 | 88   | 88   | >100 | 77                            |
| Eggplant         | >100 | 92              | 40              | >100 | 79   | 80   | 88   | >100 | 40                            |
| Gabi Leaves      | 98   | >100            | >100            | >100 | 96   | >100 | >100 | >100 | 96                            |
| Gabi Rhizomes    | 91   | 82              | 91              | >100 | 90   | 93   | >100 | >100 | 82                            |
| Iba              | 65   | 90              | >100            | >100 | 81   | 75   | 84   | >100 | 65                            |
| Kalabasa Leaves  | 93   | 72              | >100            | 80   | 94   | >100 | >100 | >100 | 72                            |
| Kalabasa Fruit   | 78   | 73              | >100            | 78   | 74   | 73   | 98   | 70   | 70                            |
| Mongo            | >100 | >100            | 69              | 93   | >100 | >100 | >100 | >100 | 69                            |
| Kangkong         | 96   | >100            | 54              | >100 | 97   | 95   | >100 | >100 | 54                            |
| Kulitis          | 87   | >100            | >100            | >100 | >100 | >100 | >100 | >100 | 87                            |
| Katuray          | 78   | 83              | 91              | >100 | 74   | 80   | 88   | >100 | 74                            |
| Malunggay Leaves | 76   | >100            | 80              | >100 | >100 | >100 | >100 | >100 | 76                            |
| Malunggay Fruit  | 71   | 63              | 24              | 95   | 60   | 58   | 60   | >100 | 24                            |
| Mongo            | >100 | >100            | 69              | 93   | >100 | >100 | >100 | >100 | 69                            |
| Okra             | 78   | 73              | 77              | 98   | 70   | 75   | 78   | >100 | 70                            |
| Patani           | >100 | >100            | 69              | >100 | 99   | >100 | 94   | >100 | 69                            |
| Patola           | >100 | 93              | 94              | >100 | >100 | 85   | >100 | >100 | 85                            |
| Pechay           | >100 | 87              | 23              | >100 | 97   | 90   | >100 | >100 | 23                            |
| Puso             | 85   | 82              | 86              | >100 | 86   | >100 | >100 | >100 | 82                            |
| Saluyot          | 89   | >100            | >100            | >100 | >100 | >100 | >100 | >100 | 89                            |
| Sampaloc Fruit   | >100 | >100            | 57              | >100 | 76   | 68   | 78   | >100 | 57                            |
| Sayote           | >100 | >100            | >100            | >100 | >100 | >100 | >100 | >100 | >100                          |
| Singkamas        | 96   | 100             | 100             | 98   | 74   | 75   | 94   | 100  | 74                            |
| Sitao            | >100 | 95              | 80              | >100 | 93   | 98   | >100 | >100 | 80                            |
| Tanglad          | 96   | 83              | 83              | >100 | 94   | 98   | >100 | >100 | 83                            |
| Ubi              | 78   | >100            | >100            | 80   | 87   | 83   | 86   | >100 | 78                            |
| Upo              | 80   | >100            | 17              | >100 | 99   | >100 | >100 | >100 | 17                            |

<sup>a</sup>Provisional amino acid scoring pattern according to FAO/WHO, 1973 (11).

<sup>b</sup>Protein score is based on the lowest score obtained for any of the essential amino acid (i.e. the "most limiting amino acid") according to FAO/WHO, 1973 (11).

quality, if methionine and phenylalanine were supplemented to a lesser extent. Although the amino acid composition alone does not infer biological value and that digestibility and feeding experiments have to be carried out to realize this, the present study indicates that these plant foodstuffs may be useful in helping to alleviate demand on much more expensive animal proteins.



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