# BIOCHEMICAL STUDIES ON THE ISOLATED FRACTIONS OF DIFFERENT VARIETIES OF RICE

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## Abstract

Rice is the staple food of the people of the world food grain. Besides bean the main source of calories and proteins, rice is an important cereal because it has the highest digestibility, biological value and protein efficiency ratio among all the cereals (KAUL et al. 1973).

Although rice is an important food in mid and upper Egypt, the isolated fractions of grain rice cultivated in Egypt need to be fully investigated. The objective of the present work was to study the proximate analysis, mineral content, lipids and the amino acid content of some varieties of rice and its isolated fractions.

## Introduction

Historically wild rice was a principal vegetative food of the American Indians who lived in an area where agriculture was limited. Earlier investigators (KENNEDY, 1924; CAPEN and LE CLERC, 1948) found that wild rice has a higher content of protein and vitamin $B_1$ than many cereals, and it contains common minerals in amount comparable to other cereals. Recent studies (LINDSAY et al., 1975), in addition to earlier findings, showed that fermentation has little effect upon the protein and mineral content of the wild rice compares favorably with the FAO Provisional Pattern (FAO-WHO, 1973). The amino acid analysis of rice and its major histological components are reported by (BRADBURY et al., 1980). The analyses of whole grain and of embryo have been recalculated on the basis of grams per 16.8 g of nitrogen and are similar to the values given by Juliano (1972). Because the starchy endosperm makes up about 91% by weight of the rice grain, its amino acid analysis is very similar to that of the whole grain. As might be expected, the amino acid analysis of embryo, aleurone cells plus grain coat, and of grain coat are considerably different from those of the whole grain. Lysine and threonine are the most interesting amino acids from the nutritional point of view because for humans they are the first and second limiting amino acids in rice (JULIANO 1972). Nearly 50% more protein and about 20% more lysine were found in

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high-protein brown rice than in ordinary brown rice and also in high-protein milled (white) rice as compared with ordinary milled rice; consumption of the former variety would be advantageous (BRADBURY et al., 1980).

## Materials and methods

*Seed samples:* Three different varieties of grain rice, one Filipino grain rice (Riho) and two local grain rice (Giza-171, and Giza-172), were obtained from Sakha Agricultural Research Station, Egypt. Samples of whole grain (250 g each) were isolated to six fractions, whole grain of rice, Brown rice, Milled rice, Husk of rice, Bran of rice and Embryo of rice and all fractions were ground to pass HO-mesh.

*Chemical analysis:* Protein content (% Nx6.25) was determined by the Kjeldahl method (AOAC, 1975). Moisture, fat and ash contents were determined by the AACC (1976) procedures, while fiber content was determined as described in the AOAC (1975). Mineral contents were determined by atomic absorption spectrophotometry according to the method described in the AACC (1969). Total sugar present in the ethanolic extract was determined by phenol-sulfuric acid method (DUBOIS et al., 1956) using glucose as a standard.

### *Amino acid analysis*

a) *Free amino acid extraction:* was carried out as described by AUDA et al. (1976).

b) *Protein amino acids:* were prepared by acid hydrolysis according to BLOCK et al. (1955).

c) *Separation of free and total amino acids:* The amino acids were separated from carbohydrates by passing through a column of Amberlite IR-120 ($H^+$) form (50 ~ 100 mesh). After washing with distilled water, the amino acids were eluated with 10% $NH_4OH$ followed by distilled water. The eluate was evaporated to dryness under reduced pressure and the residue was dissolved in 100 ml 10% aqueous iso-propanol solution and kept at 4 °C until used.

Paper chromatography technique where separation and identification of amino acids were carried out as described by BLOCK et al. (1955) using three different solvent systems and a ninhydrin-cadmium acetate in acetone as a reagent solution (HIELMAN et al. 1957).

Determination of tryptophan: Tryptophan was determined colorimetrically in an alkaline hydrolyzate according to method of PIOMBO and LOZANO (1980).

## Results and discussion

### *Proximate analysis*

Proximate analysis of three varieties of grain rice and its isolates are shown in Table 1. The variety Riho has the highest protein content followed by Giza-172, while Giza-171 has lower protein content. Small differences in moisture, fat, ash, carbohydrate, and fiber contents were also noted for the three varieties used in the present investigation.

It is obvious from Table 1 that the outer layer (bran) contains more of the essential nutrients than the endosperm (milled rice). According to JULIANO (1972), the quality of the protein (albumin) of the outer layer is superior to that of the protein in the endosperm. Major proportions of the fat, fiber, ash of cereal grains are removed with the bran (Table 1). The average content of moisture, nitrogen free extract, and carbohydrate of other fractions of rice were approximately the same. On the other hand, carbohydrate content/protein ratio was somewhat high. Furthermore, higher percentages of ash and fiber were recorded in husk of rice isolate.

Some of the minerals known to be essential for human nutrition were determined and the results are presented in Table 2, which indicated the absence of zinc from the three varieties of rice. The highest level of iron was observed in Giza-172 and the lowest one was observed in Giza-171. The highest level of copper was observed in Giza-171, while no copper could be

Table 1

Proximate Analysis of grain Rice (%, dry wt. basis)

| Analysis | Variety/Composition[a] | | | | | |
|---|---|---|---|---|---|---|
| | Riho | | | | | |
| | Whole grain of rice | Brown rice | Milled rice | Husk of rice | Bran of rice | Embryo of rice |
| Moisture % | 9.24 | 8.74 | 8.97 | 7.16 | 7.92 | 4.38 |
| Fat % | 5.53 | 2.99 | 0.88 | 2.53 | 14.79 | 4.98 |
| Protein ( × 6.25)% | 8.75 | 7.69 | 9.13 | 1.75 | 23.38 | 21.06 |
| Ash % | 1.89 | 1.13 | 0.19 | 21.75 | 6.98 | 9.21 |
| Fiber % | 2.1 | 0.79 | 0.19 | 35.68 | 6.20 | 4.68 |
| NFE[b] | 72.49 | 77.9 | 80.87 | 31.13 | 46.87 | 55.69 |
| Carbohydrate[c] | 74.59 | 78.69 | 81.06 | 66.81 | 53.07 | 60.37 |
| Carbohy./Protein | 8.52 | 10.23 | 8.87 | 38.17 | 2.26 | 2.86 |
| Protein/fat | 1.58 | 2.57 | 10.37 | 0.69 | 1.58 | 4.22 |

[a] Percent of dry defatted grain Rice and its isolations.
[b] Nitrogen free extract, 100-(moisture + fat + protein + ash + fiber).
[c] Carbohydrate, 100-(moisture + fat + protein + ash).

**Table 1. (Contd)**

Proximate Analysis of grain Rice (%, dry wt. basis)

| Analysis | Variety/Composition[a] | | | | | |
|---|---|---|---|---|---|---|
| | Giza 171 | | | | | |
| | Whole grain of rice | Brown rice | Milled rice | Husk of rice | Bran of rice | Embryo of rice |
| Moisture % | 9.03 | 8.73 | 9.34 | 8.52 | 8.22 | 5.16 |
| Fat % | 4.00 | 4.14 | 0.68 | 2.57 | 16.61 | 12.85 |
| Protein ( × 6.25) % | 6.63 | 7.50 | 5.63 | 1.75 | 18.56 | 25.19 |
| Ash % | 1.95 | 1.00 | 0.98 | 18.35 | 7.74 | 7.47 |
| Fiber % | 1.82 | 0.76 | 0.36 | 40.39 | 6,10 | 5.12 |
| NFE[b] | 76.57 | 77.87 | 83.01 | 28.42 | 42.77 | 44.21 |
| Carbohydrate[c] | 78.39 | 78.63 | 83.37 | 68.81 | 48.87 | 49.33 |
| Carbohy./Protein | 11.82 | 10.48 | 14.80 | 39.32 | 2.63 | 1.95 |
| Protein/fat | 1.65 | 1.8 | 8.27 | 0.68 | 1.11 | 1.96 |

[a] Percent of dry defatted grain Rice and its isolations.
[b] Nitrogen free extract, 100-(moisture + fat + protein + ash + fiber).
[c] Carbohydrate, 100-(moisture + fat + protein + ash).

**Table 1. (Contd)**

Proximate Analysis of grain Rice (%, dry wt. basis)

| Analysis | Variety/Composition[a] | | | | | |
|---|---|---|---|---|---|---|
| | Giza 172 | | | | | |
| | Whole grain of rice | Brown rice | Milled rice | Husk of rice | Bran of rice | Embryo of rice |
| Moisture % | 8.72 | 9.16 | 9.23 | 7.46 | 8.17 | 4.82 |
| Fat % | 2.90 | 3.98 | 0.73 | 1.22 | 16.91 | 18.23 |
| Protein ( × 6.25) % | 7.19 | 9.81 | 6.31 | 1.38 | 24.38 | 29.29 |
| Ash % | 2.14 | 0.94 | 0.18 | 19.05 | 5.43 | 6.68 |
| Fiber % | 1.95 | 0.81 | 0.28 | 37.40 | 5.89 | 4.82 |
| NFE[b] | 77.1 | 75.3 | 83.27 | 33.42 | 39.22 | 36.16 |
| Carbohydrate[c] | 79.05 | 76.11 | 83.55 | 70.89 | 45.11 | 40.98 |
| Carbohy./Protein | 10.99 | 7.75 | 13.24 | 51.36 | 1.85 | 1.39 |
| Protein/fat | 2.47 | 2.46 | 8.64 | 1.13 | 1.44 | 1.60 |

[a] Percent of dry defatted grain Rice and its isolations.
[b] Nitrogen free extract, 100-(moisture + fat + protein + ash + fiber).
[c] Carbohydrate, 100-(moisture + fat + protein + ash).

detected in Giza-172 and Riho. Small differences in potassium, manganese and phosphorous contents were also noted for the three varieties used in the present investigation. Substantial differences could be observed between the results obtained here and those reported in literature. The amount of zinc and iron reported by Underwood (1972) and Underwood (1977) were re-

**Table 2**

Mineral Content of Three Varieties of Grain Rice and its Fractions

| Mineral | Variety/content Riho | | | | | |
|---|---|---|---|---|---|---|
| | Whole grain of rice | Brown rice | Milled rice | Husk of rice | Bran of rice | Embryo of rice |
| Sodium[a] | 0.04 | 0.01 | 0.02 | 0.20 | 0.00 | 0.10 |
| Potassium[a] | 0.25 | 0.05 | 0.25 | 2.10 | 0.05 | 3.60 |
| Phosphorous[a] | 0.49 | 0.36 | 0.48 | 1.49 | 0.18 | 1.59 |
| Iron[b] | 82.0 | 32.0 | 42.0 | 222.0 | 547.0 | 117.0 |
| Manganese[b] | 32.0 | 0.00 | 12.5 | 117.5 | 375.0 | 165.0 |
| Zinc[b] | 0.00 | 0.00 | 0.00 | 23.5 | 0.00 | 72.0 |
| Copper[b] | 0.00 | 3.5 | 3.5 | 24.0 | 7.00 | 20.0 |

[a] Values in microgram/gram of whole seed, dry defatted basis.
[b] Values in % of whole seed, dry defatted basis.

**Table 2. (Contd)**

Mineral Content of Three Varieties of Grain Rice and its Fractions

| Mineral | Variety/content Giza 171 | | | | | |
|---|---|---|---|---|---|---|
| | Whole grain of rice | Brown rice | Milled rice | Husk of rice | Bran of rice | Embryo of rice |
| Sodium[a] | 0.02 | 0.02 | 0.02 | 0.05 | 0.00 | 2.02 |
| Potassium[a] | 0.30 | 0.15 | 0.25 | 1.7 | 0.20 | 1.95 |
| Phosphorous[a] | 0.43 | 0.35 | 0.49 | 1.47 | 0.06 | 1.47 |
| Iron[b] | 77.0 | 0.00 | 112.0 | 467.0 | 77.0 | 117.0 |
| Manganese[b] | 25.0 | 2.5 | 22.5 | 165.0 | 40.0 | 127.5 |
| Zinc[b] | 0.00 | 0.00 | 0.00 | 18.0 | 0.00 | 33.0 |
| Copper[b] | 7.0 | 3.5 | 3.5 | 43.0 | 0.00 | 14.0 |

[a] Values in microgram/gram of whole seed, dry defatted basis.
[b] Values in % of whole seed, dry defatted basis.

**Table 2. (Contd)**

Mineral Content of Three Varieties of Grain Rice and its Fractions

| Mineral | Variety/content Giza 172 | | | | | |
|---|---|---|---|---|---|---|
| | Whole grain of rice | Brown rice | Milled rice | Husk of rice | Bran of rice | Embryo of rice |
| Sodium[a] | 0.4 | 0.01 | 0.00 | 0.05 | 0.02 | 0.04 |
| Potassium[a] | 0.30 | 0.00 | 0.20 | 1.35 | 0.35 | 2.30 |
| Phosphorous[a] | 0.43 | 0.38 | 0.48 | 1.79 | 0.21 | 1.59 |
| Iron[b] | 42.0 | 0.00 | 152.0 | 477.0 | 72.0 | 197.0 |
| Manganese[b] | 25.0 | 0.00 | 20.0 | 105.0 | 17.0 | 210.0 |
| Zine[b] | 0.00 | 0.00 | 0.00 | 41.0 | 0.00 | 0.00 |
| Copper[b] | 0.00 | 7.0 | 3.5 | 24.0 | 3.5 | 10.0 |

[a] Values in microgram/gram of whole seed, dry defatted basis.
[b] Values in % of whole seed, dry defatted basis.

spectively identical to those found in local varieties. Because many of these essential minerals are located in the pericarp-aleurone area of the grain, further analysis of component parts could give more exact informations in this respect.

## Amino acid composition

The adequacy of a protein for man or farm animals depends upon its content of essential amino acids. Knowledge of the amino acids content of a protein-containing material would serve as an indication of its nutritional value. The total amino acids content of dry mature grain of three varieties of rice were determined.

**Table 3**

Total Amino Acids Content of Three Varieties of Grain Rice and other varieties (expressed as g AA/16 g N)

| Amino acid | Riho[a] | | | | | | Reported av. of other varieties | |
|---|---|---|---|---|---|---|---|---|
| | Whole grain of rice | Brown rice | Milled rice | Husk of rice | Bran of rice | Embryo of rice | Wild rice[b] | Mild rice[c] |
| *Essential amino acids*: | | | | | | | | |
| Cystine | 1.86 | 1.75 | 1.60 | 2.80 | 3.92 | 3.8 | 1.2 | 1.2 |
| Methionine | 3.86 | 3.75 | 3.90 | 3.60 | 4.61 | 4.52 | 3.2 | 2.19 |
| Threonine | 4.62 | 4.44 | 4.42 | 7.90 | 7.61 | 7.76 | 3.6 | 3.86 |
| Isoleucine + Leucine | 11.50 | 11.44 | 11.30 | 11.05 | 13.35 | 13.18 | 11.7 | 12.76 |
| Lysine | 4.20 | 4.10 | 4.00 | 4.00 | 6.12 | 6.06 | 4.5 | 3.8 |
| Phenylalanine | 5.00 | 4.98 | 4.81 | 5.57 | 6.62 | 6.81 | 5.3 | 5.46 |
| Tyrosine | 4.53 | 4.20 | 4.15 | 8.66 | 8.40 | 5.50 | 4.9 | 3.67 |
| Valine | 5.43 | 5.35 | 5.20 | 7.00 | 7.40 | 7.62 | 6.0 | 6.22 |
| Tryptophan | 1.42 | 1.36 | 1.28 | 2.01 | 4.05 | 4.10 | n.d. | 1.3 |
| *Non-essential amino acids*: | | | | | | | | |
| Alanine | 5.56 | 5.54 | 5.50 | 6.50 | 7.91 | 7.81 | 5.7 | 5.84 |
| Arginine | 8.40 | 8.30 | 8.15 | 5.25 | 6.60 | 6.81 | 8.2 | 7.99 |
| Aspartic acid | 9.81 | 8.93 | 8.35 | 10.50 | 11.80 | 14.05 | 9.9 | 9.42 |
| Glutamic acid | 14.42 | 14.38 | 14.30 | 7.91 | 7.68 | 7.71 | 17.6 | 20.0 |
| Glycine | 4.64 | 4.50 | 4.50 | 7.60 | 7.41 | 7.50 | 4.8 | 4.47 |
| Histidine | 2.42 | 2.40 | 2.30 | 3.50 | 4.89 | 5.00 | 2.2 | 2.24 |
| Proline | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| Serine | 6.00 | 5.94 | 5.90 | 8.71 | 9.10 | 9.12 | 5.7 | 5.86 |
| TAA[d] | 93.66 | 91.36 | 89.66 | 102.56 | 117.47 | 120.35 | 94.5 | 96.28 |
| TEA[e] | 42.41 | 41.37 | 40.66 | 52.59 | 62.08 | 62.35 | 40.4 | 40.46 |
| TNE[f] | 51.25 | 49.99 | 49.0 | 49.97 | 55.39 | 58.0 | 54.1 | 55.82 |
| TEA : TAA[g] | 45.28 | 45.27 | 45.34 | 51.27 | 52.84 | 51.80 | 42.75 | 42.02 |
| TNA : TAA[h] | 54.71 | 54.71 | 54.65 | 48.72 | 47.15 | 48.19 | 57.24 | 57.97 |
| TEA : TNA[y] | 82.75 | 82.75 | 82.96 | 105.24 | 112.07 | 107.5 | 74.67 | 72.28 |

[a] This study. [b] Eggum et al. (1977). [c] Wang et al. (1978). [d] Total amino acids. [e] Total essential amino acids. [f] Total non-essential amino acids. [g] Ratio of essential amino acids to total amino acids. [h] Ratio of non-essential amino acids to total amino acids. [y] Ratio of essential amino acids to total non-essential amino acids. n.d., not detected.

**Table 3. (Contd)**

Total Amino Acids Content of Three Varieties of Grain Rice and other varieties (expressed as g AA/16 g N)

| Amino acid | Giza[a] 171 | | | | | | Reported av. of other varieties | |
|---|---|---|---|---|---|---|---|---|
| | Whole grain of rice | Brown rice | Milled rice | Husk of rice | Bran of rice | Embryo of rice | Wild rice[b] | Mild rice[c] |
| *Essential amino acids*: | | | | | | | | |
| Cystine | 1.30 | 1.20 | 1.05 | 1.89 | 3.41 | 3.41 | 1.2 | 1.2 |
| Methionine | 3.20 | 3.15 | 3.12 | 3.92 | 5.81 | 5.6 | 3.2 | 2.19 |
| Threonine | 3.91 | 3.88 | 3.80 | 7.25 | 8.36 | 8.46 | 3.6 | 3.86 |
| Isoleucine + Leucine | 10.63 | 9.81 | 9.75 | 8.50 | 11.6 | 12.56 | 11.7 | 12.76 |
| Lysine | 3.90 | 3.81 | 3.78 | 4.98 | 6.20 | 6.05 | 4.5 | 3.8 |
| Phenylalanine | 5.10 | 5.00 | 4.82 | 5.00 | 6.12 | 6.20 | 5.3 | 5.46 |
| Tyrosine | 4.10 | 4.00 | 3.87 | 8.00 | 7.81 | 4.9 | 3.67 | |
| Valine | 5.00 | 4.82 | 4.72 | 7.6 | 8.10 | 8.00 | 6.0 | 6.22 |
| Tryptophan | 1.30 | 1.29 | 1.23 | 1.87 | 3.38 | 3.40 | n.d. | 1.3 |
| *Non-essential amino acids*: | | | | | | | | |
| Alanine | 5.36 | 5.25 | 5.20 | 6.62 | 7.81 | 7.91 | 5.7 | 5.84 |
| Arginine | 7.45 | 7.35 | 7.10 | 4.81 | 5.72 | 5.50 | 8.2 | 7.99 |
| Aspartic acid | 9.93 | 9.51 | 9.25 | 11.63 | 12.8 | 13.64 | 9.9 | 9.42 |
| Glutamic acid | 14.60 | 14.58 | 14.45 | 7.92 | 7.79 | 7.81 | 17.6 | 20.0 |
| Glycine | 4.62 | 4.55 | 4.45 | 6.80 | 7.84 | 8.10 | 4.8 | 4.47 |
| Histidine | 2.10 | 2.05 | 2.00 | 3.81 | 4.71 | 4.63 | 2.2 | 2.24 |
| Proline | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| Serine | 5.92 | 5.86 | 5.78 | 7.50 | 7.89 | 8.22 | 5.7 | 5.86 |
| TAA[d] | 88.42 | 86.11 | 84.37 | 95.10 | 104.85 | 117.30 | 94.5 | 96.28 |
| TEA[e] | 38.44 | 36.96 | 36.14 | 49.01 | 60.29 | 61.49 | 40.4 | 40.46 |
| TNE[f] | 49.98 | 49.15 | 48.23 | 46.09 | 51.56 | 55.81 | 54.1 | 55.82 |
| TEA : TAA[g] | 43.47 | 42.92 | 42.83 | 51.53 | 57.50 | 52.42 | 42.75 | 42.02 |
| TNA : TAA[h] | 56.52 | 57.07 | 57.16 | 48.46 | 52.03 | 47.58 | 57.24 | 57.97 |
| TEA : TNA[y] | 76.9 | 75.19 | 74.93 | 106.33 | 110.50 | 110.18 | 74.67 | 72.28 |

[a] This study. [b] Eggum et al. (1977). [c] Wang et al. (1978). [d] Total amino acids. [e] Total essential amino acids. [f] Total non-essential amino acids. [g] Ratio of essential amino acids to total amino acids. [h] Ratio of non-essential amino acids to total amino acids. [y] Ratio of essential amino acids to total non-essential amino acids. n.d., not detected.

Table 3 shows the total amino acid content of these varieties, together with the average values for the other isolated varieties of rice reported by EGGUM et al. (1977) and WANG et al. (1978). Some differences could be observed in the amino acid contents of the varieties used in the present work (Table 4). Some of the non-essential amino acids like, glutamic acid, aspartic acid, arginine and serine were found to be present in high concentrations whereas,

**Table 3. (Contd)**

Total Amino Acids Content of Three Varieties of Grain Rice and other varieties (expressed as g AA/16 g N)

| Amino acid | Giza[a] 172 | | | | | | Reported av. of other varieties | |
|---|---|---|---|---|---|---|---|---|
| | Whole grain of rice | Brown rice | Milled rice | Husk of rice | Bran of rice | Embryo of rice | Wild rice[b] | Mild rice[c] |
| *Essential amino acids*: | | | | | | | | |
| Cystine | 1.20 | 1.20 | 1.18 | 2.10 | 3.60 | 3.20 | 1.2 | 1.2 |
| Methionine | 3.41 | 3.35 | 3.22 | 4.05 | 4.93 | 4.80 | 3.2 | 2.19 |
| Threonine | 3.82 | 8.81 | 8.60 | 7.41 | 7.70 | 7.94 | 3.6 | 3.86 |
| Isoleucine + Leucine | 10.81 | 10.71 | 10.60 | 9.33 | 12.90 | 12.93 | 11.7 | 12.76 |
| Lysine | 4.30 | 4.25 | 4.10 | 4.35 | 5.41 | 5.60 | 4.5 | 3.8 |
| Phenylalanine | 5.47 | 5.30 | 5.20 | 5.30 | 7.42 | 7.51 | 5.3 | 5.46 |
| Tyrosine | 4.63 | 4.41 | 4.00 | 7.90 | 7.60 | 7.10 | 4.9 | 3.67 |
| Valine | 5.25 | 5.10 | 5.00 | 7.92 | 8.6 | 8.50 | 6.0 | 6.22 |
| Tryptophan | 1.35 | 1.33 | 1.24 | 1.89 | 3.71 | 3.81 | n.d. | 1.3 |
| *Non-essential amino acids*: | | | | | | | | |
| Alanine | 5.40 | 5.30 | 5.00 | 6.20 | 6.80 | 6.46 | 5.7 | 5.84 |
| Arginine | 7.30 | 7.12 | 7.00 | 4.61 | 4.81 | 3.06 | 8.2 | 7.99 |
| Aspartic acid | 10.04 | 9.56 | 9.42 | 11.6 | 13.40 | 13.87 | 9.9 | 9.42 |
| Glutamic acid | 14.66 | 14.62 | 14.56 | 9.90 | 7.45 | 7.64 | 17.6 | 20.0 |
| Glycine | 4.40 | 4.30 | 4.35 | 7.50 | 7.77 | 7.81 | 4.8 | 4.47 |
| Histidine | 2.00 | 1.89 | 1.72 | 3.25 | 4.72 | 4.83 | 2.2 | 2.24 |
| Proline | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| Serine | 5.95 | 5.81 | 5.80 | 7.46 | 8.96 | 9.10 | 5.7 | 5.86 |
| TAA[d] | 89.99 | 93.05 | 90.99 | 98.77 | 115.78 | 114.16 | 94.5 | 96.28 |
| TEA[e] | 40.24 | 44.46 | 43.14 | 50.25 | 61.87 | 61.39 | 40.4 | 40.46 |
| TNE[f] | 49.75 | 48.59 | 47.85 | 48.52 | 53.91 | 52.77 | 54.1 | 55.82 |
| TEA : TAA[g] | 44.71 | 47.78 | 47.41 | 50.87 | 53.43 | 53.77 | 42.75 | 42.02 |
| TNA : TAA[h] | 55.28 | 52.21 | 52.59 | 49.12 | 46.56 | 46.22 | 57.24 | 57.97 |
| TEA : Tna[y] | 80.88 | 91.50 | 90.15 | 103.56 | 114.76 | 116.33 | 74.67 | 72.28 |

[a] This study. [b] Eggum et al. (1977). [c] Wang et al. (1978). [d] Total amino acids. [e] Total essential amino acids. [f] Total non-essential amino acids. [g] Ratio of essential amino acids to total amino acids. [h] Ratio of non-essential amino acids to total amino acids. [y] Ratio of essential amino acids to total non-essential amino acids. n.d., not detected.

others like, alanine, glycine and histidine were present in lower levels. Similar findings were also observed by several workers (EGGUM et al., 1977; WANG et al., 1978). Considerable differences could be also noted in the amino acids profiles of our local varieties and those reported by EGGUM et al. (1977) and WANG et al. (1978). They found that the levels of glutamic acid, aspartic acid and arginine were higher, while glycine and histidine contents were lower.

**Table 4**

Essential Amino Acids Content (mg/g of protein) and Amino Acid Score of Three Varieties of Whole grain Rice and the FAO/WHO/UNU 1984 Scoring Pattern

| Amino acid | Variety[a] | | | | | | Scoring pattern, child 2—5 yrs[b] |
|---|---|---|---|---|---|---|---|
| | Riho | | Giza 171 | | Giza 172 | | |
| | AAC | AAS | AAC | AAS | AAC | AAS | |
| Isoleucine + Leucine | 115.0 | 114 | 106.3 | 106 | 108.1 | 108 | 100.2 |
| Lysine | 42.0 | 67 | 39.0 | 63 | 43.0 | 69 | 62.1 |
| Total S-containing amino acids | 57.2 | 220 | 45.0 | 173 | 46.1 | 177 | 26.0 |
| Cystine | 18.6 | | 13.0 | | 12.0 | | |
| Methionine | 38.6 | | 32.0 | | 34.1 | | |
| Total aromatic amino acids: | 95.3 | 144 | 92.0 | 139 | 101.0 | 153 | 66.1 |
| Phenylalanine | 50.0 | | 51.0 | | 54.7 | | |
| Tyrosine | 45.3 | | 41.0 | | 46.3 | | |
| Threonine | 46.2 | 128 | 39.1 | 108 | 38.2 | 106 | 36.0 |
| Tryptophan | 14.1 | 117 | 13.0 | 108 | 13.5 | 112 | 12.0 |
| Valine | 54.3 | 147 | 50.0 | 135 | 52.5 | 142 | 37.0 |

[a] This study
[b] FAO/WHO/UNU (1984),
AAC: Amino acid content.
AAS: Amino acid score.

## Essential amino acids

The essential amino acid concentrations were varied considerably within the three varieties and their isolates. Tryptophan was present in small amounts (1.3–1.9%) in whole grain of Giza-172, Giza-171 (Table 4). It accounted for 1.3–1.5% of the total amino acids. Among the essential amino acids leucine + isoleucine were the major and amounted for 12.01–12.27% of total amino acids (Table 4). These values were considered close to that reported in literature (EGGUM et al., 1977 and WANG et al., 1978). Threonine, S-containing amino acids (cystine and methionine), and aromatic amino acids phenylalanine and tyrosine were present in higher concentrations than those of valine and lysine. The amount of threonine was about 3 times higher, while the levels of the aromatic amino acids were about half of those previously reported (WANG et al. 1970). The remaining essential amino acids were found to be present approximately in close levels (Table 3).

The nutritional quality of grain rice protein was evaluated by comparing the essential amino acid composition with the amino acid patterns suggested by FAO/WHO/UNU (1984). The chemical score of the essential amino acids, shown in Table 4, indicated that lysine was the first limiting amino acid.

It is evident from Table 4, that the amount of phenylalanine exceeded the respective level of FAO scoring pattern, whereas the chemical score for the total aromatic amino acids were found to be 139–153 for the varieties used in the present work.

It is worthy to mention that the phenylalanine is the precursor of tyrosine and converted to it by the action of phenylalanine hydroxylase present in liver (METZLER, 1977). Total amino acid proportions that must be supplied

**Table 5**

Free Amino Acid Content of Three Varieties of Grain Rice

| Amino acid | Riho[a] | | | | | |
|---|---|---|---|---|---|---|
| | Whole grain | Brown rice | Milled rice | Husk rice | Bran rice | Embryo |
| *Essential amino acids*: | | | | | | |
| Cystine | Trace | Trace | Trace | Trace | 0.16 | 0.25 |
| Methionine | 0.61 | 0.60 | 0.54 | Trace | 0.70 | 0.50 |
| Threonine | 0.76 | 0.74 | 0.72 | 1.10 | 1.20 | 1.24 |
| Isoleucine + Leucine | 0.32 | 0.27 | 0.29 | Trace | 0.36 | 0.29 |
| Lysine | 0.29 | 0.40 | Trace | Trace | 1.35 | 0.79 |
| Phenylalanine | 0.57 | 0.40 | 0.22 | 0.60 | Trace | 0.87 |
| Tyrosine | 0.97 | 0.78 | 0.54 | 1.05 | 1.15 | 1.24 |
| Valine | 0.57 | 0.40 | 0.22 | Trace | Trace | 0.95 |
| Tryptophan. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| *Non-essential amino acids*: | | | | | | |
| Alanine | 0.38 | 0.35 | Trace | 0.28 | 1.32 | 1.82 |
| Arginine | Trace | 0.20 | Trace | Trace | 0.76 | 0.36 |
| Aspartic acid | 0.75 | 0.72 | 0.73 | 1.15 | 1.35 | 1.49 |
| Glutamic acid | 0.79 | 0.68 | Trace | 0.78 | 1.80 | Trace |
| Glycine | 0.57 | 0.54 | 0.50 | 0.50 | 0.74 | 0.78 |
| Histidine | Trace | Trace | Trace | Trace | 0.26 | 0.41 |
| Proline | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| Serine | 1.8 | 0.89 | 0.82 | 2.01 | 1.40 | 1.45 |
| TFA[a] | 8.38 | 7.97 | 4.58 | 7.47 | 12.55 | 12.44 |
| TEA | 4.09 | 3.59 | 2.53 | 2.75 | 4.92 | 6.13 |
| TNE | 4.29 | 3.38 | 2.05 | 4.72 | 7.63 | 6.31 |
| TEA : TFA[b] | 48.80 | 45.04 | 55.24 | 36.81 | 39.20 | 49.28 |
| TEA : TNE | 95.33 | 106.21 | 125.24 | 58.26 | 64.48 | 97.15 |

[a] TFA total free amino acids. [b] TEA : TFA, ratio of total essential free amino acids to total free amino acids. n.d., not detected.

**Table 5. (Contd)**

Free Amino Acid Content of Three Varieties of Grain Rice

| Amino acid | Giza[a] 171 | | | | | |
|---|---|---|---|---|---|---|
| | Whole grain | Brown rice | Milled rice | Husk rice | Bran rice | Embryo |
| *Essential amino acids*: | | | | | | |
| Cystine | Trace | Trace | Trace | Trace | 0.18 | 0.28 |
| Methionine | 0.36 | 0.28 | 0.24 | Trace | 0.33 | 0.44 |
| Threonine | 0.76 | 0.70 | Trace | 1.00 | 1.15 | 1.30 |
| Isoleucine + Leucine | 0.61 | 0.55 | 0.47 | Trace | 0.56 | 0.38 |
| Lysine | 0.25 | 0.36 | Trace | Trace | 1.26 | 0.68 |
| Phenylalanine | 0.60 | 0.57 | 0.39 | 0.40 | 0.28 | 0.91 |
| Tyrosine | 1.00 | 0.86 | 0.64 | 1.15 | 1.08 | 1.38 |
| Valine | 0.65 | 0.49 | 0.38 | Trace | 0.25 | 1.30 |
| Tryptophan | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| *Non-essential amino acids*: | | | | | | |
| Alanine | 0.45 | 0.46 | Trace | 0.15 | 1.56 | 1.78 |
| Arginine | Trace | 0.21 | Trace | Trace | 0.35 | 0.25 |
| Aspartic acid | 0.82 | 0.81 | 0.86 | 1.05 | 1.22 | 1.20 |
| Glutamic acid | 0.81 | 0.75 | Trace | 0.89 | 1.61 | 0.28 |
| Glycine | 0.60 | 0.54 | Trace | Trace | 0.65 | 0.71 |
| Hisidine | 0.23 | 0.21 | Trace | Trace | 0.14 | 0.29 |
| Proline | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| Serine | 1.66 | 0.78 | 0.74 | 1.89 | 1.71 | 1.68 |
| TFA[a] | 8.80 | 7.77 | 3.72 | 6.53 | 12.33 | 12.82 |
| TEA | 4.23 | 3.81 | 2.12 | 2.55 | 5.09 | 6.67 |
| TNE | 4.57 | 3.76 | 1.60 | 3.98 | 7.24 | 6.15 |
| TEA : TFA[b] | 48.06 | 49.03 | 56.98 | 39.05 | 41.28 | 52.02 |
| TEA : TNE | 92.56 | 92.56 | 132.5 | 64.07 | 70.30 | 108.46 |

[a] TFA total free amino acids. [b] TEA : TFA, ratio of total essential free amino acids to total free amino acids. n.d., not detected.

as essential amino acid (the total essential amino acid) total amino acid (TEA/TAA) was suggested to be 36% of the protein amino acid composition (FAO/WHO, 1973). In Grain Rice used in this paper, that total essential amino acid averaged 40.27% indicating a good TEA/TAA ratio (Table 4).

### *Free amino acids*

The formation and degradation of both protein and peptides are related to non-protein fraction, which has the greater portion of the free amino acids and amides serving as a reservoir for the amino acids utilized in protein metabolism. Thus, it is worthwhile to look at the level of free amino acids

**Table 5. (Contd)**

Free Amino Acid Content of Three Varieties of Grain Rice

| Amino acid | Giza[a] 172 | | | | | |
|---|---|---|---|---|---|---|
| | Whole grain | Brown rice | Milled rice | Husk rice | Bran rice | Embryo |
| *Essential amino acids*: | | | | | | |
| Cystine | Trace | Trace | Trace | Trace | 0.12 | 0.21 |
| Methionine | 0.47 | 0.40 | 0.28 | Trace | 0.50 | 0.56 |
| Threonine | 0.68 | 0.62 | 0.40 | 1.08 | 1.35 | 1.60 |
| Isoleucine + Leucine | 0.54 | 0.49 | 0.36 | Trace | 0.36 | 0.44 |
| Lysine | 0.33 | 0.48 | Trace | Trace | 1.30 | 0.81 |
| Phenylalanine | 0.52 | 0.50 | 0.46 | 0.36 | 0.26 | 0.76 |
| Tyrosine | 0.86 | 0.84 | 0.75 | 0.88 | 1.34 | 1.50 |
| Valine | 0.71 | 0.60 | 0.28 | Trace | 0.61 | 1.33 |
| Tryptophan | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| *Non-essential amino acids*: | | | | | | |
| Alanine | 0.48 | 0.40 | Trace | Trace | 1.50 | 1.70 |
| Arginine | Trace | Trace | Trace | Trace | 0.26 | 0.24 |
| Aspartic acid | 0.78 | 0.73 | 0.78 | 1.12 | 1.25 | 1.35 |
| Glutamic acid | 0.86 | 0.78 | Trace | 1.05 | 1.55 | 0.35 |
| Glycine | 0.50 | 0.42 | 0.22 | Trace | 0.66 | 0.82 |
| Histidine | 0.12 | Trace | Trace | Trace | 0.22 | 0.26 |
| Proline | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| Serine | 1.93 | 0.95 | 0.86 | 2.10 | 1.72 | 1.92 |
| TFA[a] | 8.78 | 7.21 | 4.39 | 6.59 | 12.39 | 13.85 |
| TEA | 4.11 | 3.93 | 2.53 | 2.32 | 5.23 | 7.21 |
| TNE | 4.67 | 3.28 | 1.86 | 4.27 | 7.16 | 6.64 |
| TEA : TFA[b] | 46.81 | 54.50 | 57.63 | 35.20 | 42.21 | 52.05 |
| TEA : TNE | 88.0 | 119.81 | 136.02 | 54.33 | 73.04 | 108.58 |

[a] TFA total free amino acids. [b] TEA : TFA, ratio of total essential free amino acids to total free amino acids. n.d., not detected.

content which is considered to be as an important index for quality of plant products.

The highest level of total free amino acids was recorded in Riho whole grain of rice, whereas Giza-171 and Giza-172 contained lower contents (Table 5).

Marked differences in free amino acid content were observed in the varieties investigated.

The three varieties contained higher concentration of tyrosine, threonine and methionine respectively. On the other hand, the lowest levels of isoleucine + leucine were found in Riho, less than Giza-171 and Giza-172. All three varieties had traces amount of free cystine.

Regarding NEFA, serine was the predominating free amino acid followed by glutamic and aspartic acid.

No considerable differences were observed in the concentration of the other free non-essential amino acids. It could be concluded from the data obtained from the present work that isolation of grain rice cultivated in Egypt are good sources of many essential amino acids like, leucine + isoleucine, threonine, S-containing amino acids and phenylalanine. Furthermore, the grain and its isolated fractions should be either fortified with tryptophan and lysine or fed with other protein sources rich in those amino acids.

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