Amino Acids of Processed Seed Meal Proteins

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In a search for new sources of protein, amino acids from the processed seed meals of 29 species belonging to different natural orders have been analyzed by two-dimensional paper chromatography. Comparative data show that most of these seed meals are equally rich in essential amino acids as are edible oilseed meals and can be used as cattle and/or poultry feed. Protein content of the Meliaceae and Cruciferae seed meals compare well with the leguminous seed meals. *Jatropha curcas* (Euphorbiaceae) seed meal showed the presence of 58.1% protein.

In the scheme of utilization of the lipid-bearing seeds, judicial use of the seed meal is as important as use of the fat, seed meal constituting at least half of the raw materials processed. In general, the seed meals or the so-called cakes of the edible fat-bearing seeds such as those of soybean (*Glycine soja*), rape-mustard (*Brassica indica*, *Brassica napus*, and *Eruca sativa*), groundnut (*Arachis hypogea*), and sesame (*Sesamum indicum*) are being used either to meet part of the nutritional requirements for human consumption or most of those of cattle feed. Simultaneously, a considerable quantity of the crude oil cakes is being put to use for manurial purposes. Whatever little quantity of the cakes from the so-called nonedible oilseeds is available goes for supplementing the farm manures and fertilizers irrespective of their assessed value for the purpose.

Considerable work has already been done with certain oilseed cakes for processing their protein so that they may be useful for human nutrition (Altschul, 1958; Phansalkar, 1960; Bannerjee, 1960). Many so-called nonedible oilseed cakes cannot be used because of toxic compounds and other impurities—for example, saponins in *Madhuca indica* (Mitra and Awasthi, 1962), ricin in castor (*Ricinus communis*) (Kunitz and McDonald, 1948), gossypol in cotton seed (*Gossypium indicum*) (Liener, 1953), malodorous and bitter terpenic constituents in *Melia indica* (Mitra, 1951), 4-phenylcoumarins and a polyene acid in *Calophyllum inophyllum* (Mitra, 1957b), and a number of partially characterized compounds in certain others (Mitra, 1954). In general, compounds are associated with the seed lipid—i.e., lipid associates (Mitra, 1963)—but they can be removed by water-miscible solvents, such as dilute alcohol which would not otherwise affect the glycerides or the protein (Siddiqui and Mitra, 1945, 1947; Mitra, 1951, 1952, 1957a, 1959, 1960; Awasthi *et al.*, 1960, 1962).

Amino acid analysis of 29 seed meals, belonging to various botanical families and having divergent groups of lipid associates, show that most of these seed proteins are composed of usual amino acids and are comparable with those present in the edible oilseed cakes. Processed seed meals, pending studies to assess the cumulative toxicity, if any, to humans, are proposed for cattle and poultry feeds. This use improves the economy of the process for the utilization of these undeveloped fat and protein resources. Preliminary experiments with the processed *Madhuca indica* and *Salvadora oleoides* and *persica* seed meals were encouraging for their use as cattle feed (Mahadevan, 1960).

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Materials and Methods

The seed meals from authentic materials used during the investigation were defatted and freed of the alcohol-soluble lipid associates and other compounds, if any, which contribute towards toxicity. Analyses of groundnut, sesame, tamarind, and polyalthia seeds also have been done for comparative studies on the fat-rich seeds and those containing poor fat. Except for *Pithecolobium dulce* and *Abelmoschus moschatus* seeds, which could hardly be decorticated, seed meals have been obtained by processing the decorticated seeds. While alcohol-soluble lipid associates and nonfatty constituents were removed with dilute alcohol, soluble albumins and globulins also might have been lost to some extent. To determine the extent of loss of soluble nitrogenous material, including the nonprotein amines present in the seed, nitrogen determinations were carried out separately with the total seed, kernel, and husk as well as with the alcohol-soluble residues of the meals in a certain number of cases. In *Melia indica* and *Jatropha curcas*, the loss of nitrogen in alcoholic extracts was negligible (0.3 and 0.1%, respectively).

Nitrogen determinations in various samples of seed meals or extracts were carried out by a modified Kjeldahl method (Jackson, 1958).

The solutions of amino acids for analysis were prepared by hydrolyzing the tared quantities of processed meals (powdered 40-mesh BSI) with 6*N* hydrochloric acid in sealed tubes at 100° C. for about 30 hours (Block *et al.*, 1955).

The two-dimensional paper chromatograms were eluted first in the solvent system, butanol–acetic acid–water (4:1:1, v./v.) and then in phenol–water (4:1, v./v.). They were developed by spraying with ninhydrin reagent 0.2% in aqueous butanol solution. All the chromatograms were of descending type which ensured better resolution of certain groups of amino acids (Ramakrishnan and Subbramaniam, 1965). The quantitative estimation of the respective amino acids was made by the method of Fisher *et al.* (1948). The calculated data (Leopold, 1955; Bennet-Clark and Kefford, 1953) are presented in Table I.

Results and Discussion

The literature survey shows that the amino acids reported are generally from the conventional cakes having

Table I. Amino Acid Composition (Per

Processed Meal	Protein Content, % ($N_2 \times 6.25$)	Glycine	Alanine	Aspartic Acid	Glutamic Acid	Serine	Threonine	Valine–Methionine
Arachis hypogea (Leguminosae)	53.1	10.7	6.2	12.5	7.3	5.0	3.9	6.5
Pithecolobium dulce (Leguminosae)	37.5	6.1	7.5	9.4	9.4	6.6	6.1	6.3
Pongamia glabra (Leguminosae)	29.4	8.0	7.4	13.0	11.2	6.8	6.5	4.3
Leucenia glauca (Leguminosae)	46.9	7.1	5.5	10.6	8.6	5.4	5.9	7.3
Tamarindus indica (Leguminosae)	15.6	9.0	7.7	13.7	11.2	6.7	4.9	7.0
Calophyllum inophyllum (Guttiferae)	23.1	7.3	5.0	13.4	13.2	5.2	6.4	9.5
Calophyllum tomentosum (Guttiferae)	6.9	11.6	9.0	9.6	10.1	9.0	5.9	6.7
Mesua ferrae (Guttiferae)	26.3	8.0	7.4	12.0	10.0	6.2	5.0	6.6, 3.3
Garcinia indica (Guttiferae)	11.9	9.7	6.2	13.9	12.1	7.0	5.5	5.0, 4.4
Madhuca latifolia (Sapotaceae)	31.3	4.5	7.7	6.4	10.8	4.7	5.6	6.3
Mimusops elengii (Sapotaceae)	10.6	8.1	8.7	9.3	8.5	8.1	6.2	8.5
Mimusops hexandra (Sapotaceae)	29.4	9.2	8.3	10.1	11.1	6.4	6.4	8.0
Schlelichera oleosa (Sapindaceae)	40.6	9.2	6.0	8.5	12.6	4.5	7.3	6.5
Blighia sapida (Sapindaceae)	12.5	10.4	6.3	10.3	11.8	7.9	5.8	7.0
Putranjiva roxhburgii (Euphorbiaceae)	24.4	8.6	8.4	9.0	11.0	5.4	6.8	7.7
Jatropha curcus (Euphorbiaceae)	58.1	5.2	6.7	12.0	9.4	6.9	7.2	7.6
Melia indica (Meliaceae)	...	9.4	5.3	6.8	11.8	7.6	5.3	4.5
Melia indica (Fresh) (Meliaceae)	43.8	8.0	8.5	11.8	11.3	5.9	5.9	6.7
Sesamum indicum (Pedaliaceae)	37.5	6.8	7.3	9.2	11.1	5.3	6.2	13.7
Salvadora oleoides (Salvadorceae)	31.3	8.9	6.6	8.5	14.0	8.3	6.0	5.8
Hydnocarpus weightiana (Flacourtaceae)	27.5	10.0	6.4	11.2	9.9	9.4	5.7	6.5
Actinodaphne Hookerii (Lauraceae)	37.5	7.1	7.4	12.3	10.3	7.8	5.3	6.9
Sarcostigma klenii (Icacinaceae)	36.9	7.4	4.9	11.3	8.4	8.1	5.1	8.1
Abelmoschus moschatus (Malvaceae)	23.1	9.1	5.5	10.8	11.6	7.0	6.5	7.5
Lipidium sativum (Cruciferae)	43.8	10.0	7.0	8.5	9.3	7.7	5.9	6.0
Lawsonia alba (Lythraceae)	8.8	9.6	4.7	12.6	11.6	7.7	5.9	7.5
Shorea robusta (Dipterocarpaceae)	10.6	6.5	6.3	6.6	10.3	6.0	7.8	7.0
Polyalthia longifolia (Anonaceae)	...	7.1	7.9	8.3	11.2	5.6	7.8	4.0
Mangifera indica (Anacardiaceae)	7.5	8.8	7.6	12.4	9.7	7.8	7.2	6.8

centage) of Processed Seed Meal Protein

Norleucine–Leucine–Isoleucine	Arginine	Histidine	Lysine	Proline	Tyrosine	Phenylalanine–Tryptophane	Cystine	Hydroxyproline	Glutamine	Unidentified
8.3	5.6	4.2	4.0	3.8	4.5	6.2	1.6	...	...	...
6.0	5.9	3.4	4.1	4.3	3.4	4.8	7.8	2.6	...	2.8, 3.4
5.5	4.8	3.1	5.4	5.3	5.2	5.7	2.8	...	1.6	1.3, 1.8
8.4	4.6	4.4	3.9	6.1	5.2	6.6	2.1	...	1.9	1.7, 4.6
8.7	3.8	3.0	5.6	5.3	4.9	4.5	3.3	...	1.6	...
9.8	4.8	4.4	2.8	5.5	3.2	4.3	4.8	...	...	...
9.4	4.6	5.4	5.9	9.2	...	...	...	...	2.6	...
8.2	5.0	3.6	5.1	4.0	4.5	4.9	2.6	...	1.3	2.3
8.1	5.3	2.4	3.4	6.8	3.3	4.7	2.2	...	...	...
8.0	5.6	6.7	4.9	7.5	4.2	6.9	3.9	...	4.5	1.6
11.5	5.2	4.4	6.2	6.6	...	...	...	...	8.7	...
12.6	5.0	3.8	4.1	7.7	5.4	...	1.6	...	...	...
10.4	4.6	5.4	4.2	6.0	5.6	3.8	2.9	...	...	2.3
8.0	3.0	2.8	2.9	3.5	2.6	5.0	2.5	...	...	5.6, 2.4, 1.7
7.8	5.2	4.1	4.3	5.2	4.8	6.0	4.1	...	1.6	...
8.7	5.0	3.2	5.6	6.7	3.8	4.9	2.8	4.4	...	...
8.0	6.3	3.4	3.9	5.9	3.4	5.3	3.1	...	1.6	3.9, 4.6
8.9	6.7	3.2	3.7	5.5	5.3	4.6	4.1	...	...	...
8.2	...	3.6	6.4	3.5	6.0	6.8	3.4	...	2.8	...
14.5	6.6	3.9	5.5	5.6	3.8	...	2.4	...	...	...
7.6	6.6	4.0	6.0	5.1	...	5.4	2.5	...	...	3.7
8.1	4.6	3.9	2.5	4.9	6.8	6.1	3.8	...	2.5	...
7.2	6.1	4.0	3.7	3.7	3.6	5.5	3.0	...	...	2.0, 2.9, 2.6, 2.5
8.3	7.3	4.2	4.9	8.7	3.8	...	3.3	...	...	2.0
8.7	5.3	5.5	6.5	5.6	4.4	6.0	...	...	...	3.3, 2.5
12.8	6.3	5.1	4.9	7.3	...	...	4.1	...	...	...
12.0	6.8	4.8	5.7	6.6	4.3	3.4	2.2	...	...	1.6, 2.1
8.4	3.9	3.1	5.1	5.1	5.5	6.1	3.7	...	...	...
7.1	4.0	5.1	6.8	4.8	...	3.9	1.9	4.1	2.1	...

residual fat and not from the meals completely defatted and freed of toxic and physiologically active components as in the present case. To that extent, the values reported here may be at variance with those in the literature. However, little work on the component amino acids of these processed oilseed meals has been done previously.

In the majority of the chromatograms, groups of amino acids—such as valine–methionine, norleucine–leucine–isoleucine, and phenyl alanine–tryptophane—did not undergo sufficient resolution to clearly differentiate their individual spots. This finding was re-examined by running the chromatograms with the authentic samples of the relevant amino acids in predetermined concentrations, with the same solvent systems and under analogous conditions as were used with the unknown samples. The presence of these amino acids in the protein hydrolyzates of peanut and sesame were reported previously.

While cysteine is not being reported, the other sulfur-containing amino acid, cystine, could be detected by an individual spot comparing the chromatogram with the known sample. Although glutamine would undergo hydrolysis to yield glutamic acid, in many samples of seed meal proteins, the chromatograms revealed distinct separate spots for glutamine and glutamic acid, and hence their analytical data are being included.

While the analytical data (Table I) show a pattern similar to the common edible oilseeds, peanut and sesame, certain variations may be of interest. Seed meals of *Shorea robusta* and *Mangifera indica* showed a comparatively poor content of tryptophane–phenyl alanine, while those of *Calophyllum tomentosum*, *Mimusops elengii*, *Mimusops hexandra*, *Salvadora oleoides*, *Abelmoschus moschatus*, and *Lawsonia alba* did not reveal the presence of this group of amino acids. The feed values of these oilseed meals are expected to be comparable in general with those of edible oilseeds insofar as their methionine–valine and lysine contents are concerned. The leucine group of amino acids also should be comparable. The contents of both glutamic and aspartic acids have been noted to be predominantly high in the component amino acids of the seed proteins.

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