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Amino Acid Composition and *In vitro* Digestibility of Lentil and Rice Proteins and Their Mixture (*Koshary*)

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ABSTRACT

Amino acid composition and chemical and in vitro *digestibilities were determined for lentils, rice and their blend* (koshary), *which is commonly eaten in many countries of the Middle East. The* in vitro *digestibility was assessed by different enzymatic systems; namely, pepsin, pancreatin and pepsin followed by pancreatin. The data revealed that mixing lentils with rice raised the level of lysine which is limiting in rice in the same way as the level of the sulphur-containing amino acids is limiting in lentils. The chemical score for lentils, rice and* koshary *proteins was calculated before and after cooking. Both cooking and blending were found to increase the chemical score of the three materials. Casein was more digestible than the protein of raw lentils, rice and* koshary *as assessed by the three digestibility methods. Cooking raised the digestibility of lentils, rice and* koshary *proteins. Cooked rice and cooked* koshary *were found to possess higher digestibility than cooked lentils.*

INTRODUCTION

It is well known that legumes in general are deficient in sulphur-containing amino acids (Aykroyd & Doughty, 1964). The essential amino acids content of lentils was found to be 39·3 (grams of amino acid per 100 g of protein), tryptophan, followed by the sulphur-containing amino

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acids, being most deficient (Hanumatha & Subramanian, 1970). On the other hand, the lysine content of lentils was found to be similar to that of products of animal origin (Evdokimova *et al.*, 1974).

In rice, the essential amino acids, threonine and cystine, were present in considerable quantities whilst the lowest concentration was that of lysine (Juliano *et al.*, 1964; Hansen *et al.*, 1981).

Chemical scores were reported as 33 and 67 for lentils and rice, respectively. The limiting amino acids were found to be methionine and cystine for lentils and lysine for rice (FAO/WHO, 1973; Bhatty & Slinkard, 1979).

The present study was conducted on lentils, rice and their blend (*koshary*) to assess their nutritional value, both individually and mixed, as well as to elucidate the effects on that value of cooking.

MATERIALS AND METHODS

Materials

Decoated lentil seeds (Variety Giza 9), grown in Esna, Egypt, and rice grain (Variety Giza 172), grown in El-Behaira, Egypt, were used in this study. Lentils, rice and *koshary* were cooked as described previously (Shekib *et al.*, 1985).

Methods

Amino acids were determined in the hydrolysates according to the method of Moore (1958) using a Beckman Amino Acids Analyzer (Model 119CL).

In vitro digestion of lentils, rice and *koshary* proteins by proteolytic enzymes–pepsin digests

Pepsin digests were prepared by the method of Akeson & Stahmann (1964) in which a sample containing 500 mg of protein was incubated, with occasional shaking, with 12·5 mg of pepsin (ext. hog-stomach mucosa, Koch-Light laboratories, Great Britain) in 15 ml of 0·1 N HCl for 24 h at 37 °C. Enzyme and sample blanks were run under the described conditions.

In vitro digestion of lentils, rice and *koshary* proteins by proteolytic enzymes–pancreatin digests

The digests of pancreatin (ext. hog pancreas Koch-Light Laboratories, Great Britain) were prepared by incubating a weight of a sample containing 100 mg of lentils, rice and *koshary* proteins with 4 mg of pancreatin in 7·5 ml phosphate buffer, pH 8, at 37 °C for 24 h. Blanks for enzyme and substrate were also carried out.

In vitro digestion of lentils, rice and *koshary* proteins by proteolytic enzymes–pepsin followed by pancreatin digests

The method of Akeson & Stahmann (1964) was followed. In this method, a sample containing 100 mg of protein was incubated with 1·5 mg of pepsin in 15 ml 0·1N HCl at 37 °C for 3 h. This was followed by neutralisation with 7·5 ml 0·2M sodium hydroxide; 4 mg of pancreatin in 7·5 ml of pH 8·0 phosphate buffer were added. The digestion mixture was incubated for an additional 24 h at 37 °C. Enzymes and sample blanks were prepared under the same conditions. To all digests, 2 ml of toluene was added in order to prevent the growth of microorganisms (Venkatsan & Rege, 1968).

At the end of each digestion, 1·6M trichloroacetic acid (TCA) was added to the digest (1:1) which was left for 2 h and then centrifuged (2500 × *g*) for 20 min, the supernatant being analysed for TCA-soluble nitrogen using the micro-Kjeldahl method (AOAC, 1980). Percentage digestion was calculated with respect to the total nitrogen in the sample.

RESULTS AND DISCUSSION

Amino acid composition and chemical scores

Amino acids composition of raw lentils, rice and *koshary* are given in Table 1. It can be seen that the major amino acids of lentils are glutamic acid, arginine, leucine and lysine while the minor amino acids are methionine, cystine and tryptophan. This is in accordance with the published data (Janicek & Hardlicka, 1969; Bhatty & Slinkard, 1979; Abu-Shakra & Tannous, 1981). Rice was found to be rich in glutamic acid, arginine, leucine, threonine, methionine and cystine, while lysine

TABLE 1
Amino Acids Content of Lentils, Rice and *Koshary* and Provisional FAO Patterns
(Expressed as grams of amino acid per 16 grams of protein N)

Amino acid	*Lentils*	*Rice*	Koshary	*FAO pattern*
Lysine	7·09	3·41	4·70	4·32
Histidine	3·36	2·90	3·05	—
Arginine	7·68	7·41	7·14	—
Aspartic acid	9·29	4·88	6·11	—
Threonine	3·78	4·20	4·00	2·88
Serine	4·88	3·79	4·05	—
Glutamic acid	14·45	7·71	9·06	—
Proline	3·52	3·68	3·38	—
Glycine	4·82	4·21	3·14	—
Alanine	4·82	4·64	3·14	—
Cystine	0·96	1·92	1·54	2·02
Methionine	0·94	2·62	2·01	2·30
Valine	4·92	6·28	5·32	4·32
Isoleucine	4·96	4·89	4·66	4·32
Leucine	7·28	8·24	7·96	4·90
Tyrosine	3·23	4·32	4·00	2·88
Phenylalanine	4·72	3·46	3·94	2·88
Tryptophan	0·72	1·32	1·05	1·44
Protein (%) (DWB)	26·9	8·25	16·1	

had the lowest concentrations of these amino acids. The *koshary* proteins were particularly rich in the essential amino acids: leucine, isoleucine, valine and threonine. Moreover, mixing lentils with rice in *koshary* raised the level of lysine which is limiting in rice, as well as the level of the sulphur-containing amino acids which are limiting in lentils. However, their level remained lower than those in both the FAO reference protein pattern and whole egg protein.

Table 2 gives the chemical scores of lentils, rice and *koshary* proteins as calculated by the methods suggested by the FAO/WHO (1982), namely, the A/E and A/T ratios. The chemical scores of lentils, rice and *koshary* were 47, 68 and 87 as the A/E ratio and 30, 48 and 64 as the A/T ratio.

In vitro enzymatic digestibility of lentils, rice and *koshary* proteins

The results in Table 3 indicate that casein was more easily digested with each pepsin, pancreatin and pepsin followed by pancreatin, than were

TABLE 2
The Chemical Scores of Lentils, Rice, *Koshary* and Whole Egg Proteins

Essential amino acids (EAA)	*A/E ratio*				*A/T ratio*		
	Whole egg	*Lentils*	*Rice*	Koshary	*Lentils*	*Rice*	Koshary
Isoleucine	129	128	123	131	75	74	75
Leucine	172	188	155	172	82	70	74
Lysine	125	183	85	124	110	48	73
Methionine	61	24	65	53	30	83	64
Cystine	46	25	47	41	40	80	64
Total-sulfur-containing amino acids	107	50	108	94	34	79	64
Phenylalanine	114	122	48	104	81	86	67
Tyrosine	81	84	107	106	77	103	95
Threonine	99	96	104	106	73	83	79
Tryptophan	31	19	32	27	45	82	65
Valine	141	128	156	135	127	87	71
Chemical score	100	47	68	87	30	48	64

A/E ratio: Milligrams of EAA per gram of total EAA of the same source.
A/T ratio: Each EAA is expressed as a percentage of the same acid in whole egg.

lentils, rice and *koshary* proteins. The digestibility of the three materials studied (before and after cooking) with pepsin was much higher than with pancreatin. This may be attributed to both the modes of action and specificities of pepsin and pancreatic enzymes as well as to the amino acid make up and sequence in the peptides of lentils, rice and *koshary* proteins. The results also show that the digestibility values were much higher with pepsin followed by pancreatin than with either pepsin or pancreatin alone. This is because the double enzyme treatment follows the natural

TABLE 3
In Vitro Enzymic Digestibility of Lentils, Rice and *Koshary* as Affected by Cooking

Protein	*Digestibility (per cent of total nitrogen)*		
	Pepsin	*Pancreatin*	*Pepsin followed by pancreatin*
Casein	64·7	82·9	98·9
Lentils (Raw)	41·5	25·0	49·6
Lentils (Cooked)	47·3	38·3	63·9
Rice (Raw)	47·4	43·2	61·5
Rice (Cooked)	53·2	50·9	73·5
Koshary (Raw)	49·3	38·8	62·2
Koshary (Cooked)	57·6	47·3	75·6

sequence prevailing in the gastrointestinal tract. Cooking in general raised the digestibility of the proteins of lentils, rice and *koshary*; the increases, expressed as a percentage of total nitrogen, were 25·8, 18·7 and 28·9%, respectively. These results may, for example, be attributed to the destruction of heat labile antinutritional factors which could depress the activity of one or more of the proteolytic enzymes (Tannous & Ullah, 1969; El-Mahdy, 1974).

In conclusion, blending lentils with rice (1:2 w/w) in formulating *koshary* raised the chemical score of its proteins above that of the proteins of either lentils or rice alone. Egyptians have been using a ratio of 1:2 (w/w) of lentils:rice for many years to produce *koshary* of high acceptability.

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