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EFFECT OF PARBOILING AND MILLING PROCESS ON AMINO ACIDS CONTENT AND BIOLOGICAL EVALUATION OF RICE PROTEIN

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ABSTRACT

Rice variety Sakha 104 (Japonica) was parboiled to study the effect of parboiling and milling processing on amino acids content and protein quality of all rice samples. The obtained results showed that most of the amino acids content of rice samples (Sakha 104 variety) were decline as a function of parboiling process. On the other hand, special amino acids such as lysine, threonine, alanine and glycine were increased as a result of parboiling.

In addition, milled rice protein has a lower lysine content than that of brown rice protein. Lysine was found to be the first limiting indispensable amino acids in all rice samples (Sakha 104 variety).

Corrected protein efficiency ratio was 2.19 for brown rice, 2.35 for parboiled brown rice, 2.14 for white rice and 2.28 for parboiled white rice as compared to 2.5 for casein. The net protein retention (NPR) was highest for casein (3.25), followed by parboiled brown rice (3.12) and least for white rice (2.95). Apparent digestibility was varied according to the treatments used (Sakha 104 variety).Furthermore, parboiling process helped to increase the protein digestibility of the different rice samples of (Sakha 104 variety). Furthermore, apparent digestibility of white rice was higher than that of brown rice protein.

INTRODUCTION

Rice is an important source of protein, supplying more than 50% of the total protein consumed in some countries. Even a modest increase in protein levels in rice would provide a significant nutritional boost to the hundreds of millions of people who depend upon it (Begum and Bhattacharyya, 2000).

The high protein quality of rice is due to its high gluteline to prolamine ratio (Huebner *et al.*, 1990).

Rice proteins are high in essential amino acids lysine and methionine while the common cereal grains are low. On the other side, glutamic acid is very low in rice protein content (Dharmaputra, 1997).

Protein quality can be defined as the ability of a protein to supply the essential amino acid requirements of the animal (Steinke, 1976).

Biological evaluation of food is essential, because chemical analyses do not always reveal the presence of antinutrients (or toxins) or how much of a nutrient (although present) is biologically available (Eggum, 1979).

Recent studies have shown that the protein of raw milled rice is more digestible in rats, than wheat flour protein, with true digestibility 100% and 90%, respectively (FAO, 1993).

Parboiling of IR480-5-9 rice variety before milling resulted in lower true digestibility values (uncooked or cooked rice) as compared to raw rice (Eggum, 1979).

MATERIALS AND METHODS

Materials:

Variety of rice (*Oryza sativa* L.) namely Sakha 104 (short grain Japonica) was employed in this study. Rice was obtained from the Rice Research and Training Center (RRTC) located in Sakha at the Kafr El-Sheikh Governorate, Egypt, during the season(2004).

Methods:

Preparation of parboiled paddy rice:

Parboiled rice was prepared by using Sakha 104 variety following the procedure (El-Bana *et al.*, 2000). After drying paddy rice and parboiled paddy rice were dehulled and milled using ASATAKE testing machine (Sotelo *et al.*, 1990).

Nutritional evaluation of rice samples:

Protein content (%): of rice samples was determined as described in the A.O.A.C. (1990).

Amino acids content: of rice samples were performed in the Central Laboratory of the Faculty of Agriculture, Alexandria University. Samples were subjected to acid hydrolysis using 6 N HCl and few drops of mercaptoethanol. The hydrolyzate was recovered by removing the acid by evaporating the acid in a rotary evaporator.

Amino acids were estimated in the hydrolyzate using amino acid analyzer (Beckman amino acid analyzer, Model 119 CL) as described by Sadasivam and Manickam (1992).

Tryptophan content:of rice samples was determined colorimetrically after subjecting to alkaline hydrolysis as outlined by Blauth *et al.* (1963).

Chemical score :of indispensable amino acids was calculated using the equations of Pellett and Young (1980).

Biological evaluation of protein quality:

Preparation of protein concentrate:

Rice protein concentrates were prepared by using (brown rice, parboiled brown rice, milled rice and parboiled milled rice) Sakha 104 variety following the procedure of (Connor *et al.*, 1976).

Preparation of dietary diets:

Four test protein diets (brown rice, parboiled brown rice, white rice and parboiled white rice protein concentrate). Standard protein diet (casein) and non-protein diet were prepared by mixing the protein source, corn oil, mineral mix. vitamin mix and corn starch, standard and test protein diets were adjusted to 10% protein, whereas, non-protein diet was devoid of protein as described in the A.O.A.C. (1990).

Feeding trail:

Male albino rats (40-50) gm were housed individually in a wire bottom cages under normal healthy laboratory conditions. Temperature and humidity were ranged from 20-25°C and 60-65%, respectively. The animals were fed with standard rat diet for 5 days. The animals were segregated into six groups, allocating five rats, with similar mean body weights to each group, namely test protein group (TPG), standard protein group (SPG) and non-protein group (NPG). Diets were moistened and fed to the respective groups of animals for 4 weeks. Observations on daily feed intake and weekly weight changes were made as given in the A.O.A.C. (1990) procedure.

Nutritional indices:

The amount of the feed given on dry weight basis was computed, based on moisture content while moisture free refusal was obtained by drying overnight at 100°C. The difference between diet given and refusals was taken as feed intake, which was further used to compute protein intake, feed intake, protein intake and body weight gain were used to compute the following nutritional indices:

- Feed efficiency (FE) = gain in body weight (g)/feed intake (g).
- Feed utilization (FU = Feed intake (g)/gain in body weight (g).
- Protein efficiency ratio (PER) = gain in body weight (g)/protein intake (g).
- Corrected protein efficiency ratio (C-PER) = PER of casein(2.5) x PER of Test Protein/Exp. PER of casein.
- Protein utilization (PU) = protein intake (g)/gain in body weight (g).
- Net protein retention (NPR) = wt gain of TPG (g) + wt loss of NPG (g)/protein intake of TPG (g).
- Apparent digestibility: (nitrogen %) = (N intake - Fe cal N)/N intake x 100 were calculated as described by Pellett and Young (1980).

Statistical analysis:

Data of nutrition indices was subjected to analysis of variance and the means were further tested using the least significant difference test (LSD) as outlined by Stell and Torrie (1980).

RESULTS AND DISCUSSIONS

1. Amino acids composition:

Rice protein is considered the most important component that has the highest nutritive value among all of the cereal proteins.

The indispensable and dispensable amino acids content of brown and white rice samples for the variety of Sakha 104 are given in Table (1). The results of amino acids composition of brown rice reveal that contained 3.86%, 2.26% and 1.7% for lysine methionine and tryptophan indispensable amino acids. These values are higher than those of white rice. As for dispensable amino acids, the results indicated that, white rice contained 8.83%, 8.88%, 19.7% and 4.89% of arginine, a--artic acid, glutamic acid and proline respectively.

Apparent also from t. ‚ table that, amino acids content of white rice were higher than those of ‚wn rice. Brown rice protein has higher lysine content than that of white rice protein. Similar results were found elsewhere (Cagampang *et al.*, 1976 and Luh, 1980). It should be noted also from the same table that, parboiling process caused a decrement in amino acids content of both brown and white rice except lysine, threonine, alanine and glycine. The obtained results are in agreement with those obtained by (Eggum, 1979 and El-Akary, 1992). It is worthy to mention that such increase in amino acids content caused as a result of parboiling can be explained on the basis that the inner bran and scutellum became embedded in the endosperm as a result of starch gelatinization as reported by Hamed (1995).

Table (1): Effect of parboiling process on the amino acids content of brown and white rice flour (Sakha 104 variety).

Amino acids	B	PB	W	PW
Indispensable amino acids:				
Leucin	6.90	6.56	7.22	7.90
Isoleucin	4.10	3.96	4.14	4.34
Lysine	3.86	3.91	3.41	3.44
Methionine	2.26	2.01	1.42	1.31
Cystine	1.12	1.22	1.21	1.1
Phenylalanine	4.36	3.22	4.9	4.68
Tyrosine	2.64	2.11	2.94	2.23
Threonine	4.16	4.37	4.36	4.33
Valine	5.06	4.91	5.5	5.8
Tryptophan*	1.7	1.55	1.32	1.1
Dispensable amino acids:				
Alanine	5.36	5.52	5.31	5.62
Arginine	7.49	6.65	8.83	8.55
Aspartic acid	8.40	8.34	8.88	8.50
Glutamic acid	19.21	18.10	19.7	19.00
Glycine	4.74	4.91	4.35	4.02
Histidine	2.50	2.48	2.11	2.00
Proline	4.28	3.11	4.89	4.77
Serine	5.41	5.27	5.15	5.31

B : Brown rice **PB : Parboiled brown rice**
W : White rice **PW : Parboiled white rice**
*** Tryptophan was determined colorimetrically**

Chemical score of indispensable amino acids:

Indispensable amino acid composition in Table (1) was further used to calculate the chemical score (Pellett and Young, 1980). Chemical scores of indispensable amino acids found in brown, parboiled brown, white and parboiled white rice of Sakha 104 are given in Table (2).

Data showed that, lysine was found to be the first limiting indispensable amino acids in all rice samples. Although the chemical score of parboiled white rice showed some improvement. The sulfur containing amino acids were the second limiting amino acids in all rice samples except parboiling brown rice. The results of (Eggum, 1979 and FAO, 1993) supported our findings.

Nutrition indices:

Feed, protein intake:

The feed intake was 268.3 g for casein, 259.42 g for brown rice, 266.70 g for parboiled brown rice, 257.70 g for white rice, 261.80 g for parboiling white rice and 112.1 g for non-protein diets on dry weight basis, respectively

(Table 3). It was observed that the casein diet was consumed maximally, followed by the parboiled brown rice diet while the non-protein diet was consumed the least. Protein intakes of casein, brown, parboiled brown, white, parboiling white rice and non-protein diets were 26.83, 25, 94, 26.67, 25.77, 26.18 and 0.0, respectively.

Table (2): Chemical scoring of the indispensable amino acids of brown and white rice (Sakha 104 variety).

Indispensable amino acids	B	PB	W	PW	FAO/WHO pattern (1973) (g/16 g N)
Leucin	98.57	93.70	103.14	112.86	7.00
Isoleucin	102.5	99.00	103.50	108.50	4.00
Lysine	70.18	71.09	62.00	62.54	5.50
Methionine + Cystine	96.57	92.28	75.14	68.86	3.50
Phenylalanine + Tyrosine	116.66	88.83	130.67	115.17	6.00
Threonine	104.00	109.25	109.00	108.25	4.00
Valine	101.2	98.2	110.00	116.00	5.00
Tryptophan	170.00	100.00	132.00	110.00	1.00

B : Brown rice **PB : Parboiled brown rice**
W : White rice **PW : Parboiled white rice**

Table (3): Nutrition indices of brown, parboiled brown, white and parboiled white rice (Sakha 104 variety).

Parameters	Casein	B	P.B	W	P.W	N.P
Feed intake (g)	268.3b ± 5.13	259.42b± 4.52	266.7b± 4.89	257.7b± 4.99	261.8b ± 4.59	135.1a ± 4.75
Protein intake (g)	26.83a± 0.51	25.94a ± 0.45	26.67a ± 0.49	25.77a ± 0.50	26.18a ± 0.46	0.0
Weight gain (g)	63.2e ± 1.28	53.7bc ± 1.13	59.2d ± 1.22	52.00b ± 1.25	56.3c ± 1.14	-23.99a ± 1.18
Feed efficiency	0.24a ± 0.02	0.21a ± 0.01	0.22a ± 0.01	0.20a ± 0.01	0.22a ± 0.01	
Feed utilization	4.25a ± 0.07	4.83cd ± 0.08	4.50b ± 0.08	4.95d ± 0.09	4.65bc ± 0.08	
Protein efficiency ratio	2.36d ± 0.01	2.07ab ± 0.02	2.22c ± 0.01	2.02a ± 0.02	2.15b ± 0.01	
Corrected protein efficiency ratio	2.50c ± 0.00	2.19a ± 0.02	2.35b ± 0.01	2.14a ± 0.02	2.28b ± 0.01	
Protein utilization	0.42a ± 0.01	0.48ab ± 0.01	0.45ab ± 0.00	0.50b ± 0.01	0.47ab ± 0.01	
Net protein retention	3.25c ± 0.03	2.99a ± 0.04	3.12b ± 0.03	2.95a ± 0.03	3.07a ± 0.003	
Apparent digestibility (N%)	88.88c ± 1.04	77.5a ± 1.09	79.3ab ± 0.92	80.4ab ± 0.98	82.6b ± 1.04	

Each value was an average of five determinations + standard error
+ Values followed by the same letter in rows are not significant at $P \leq 0.05$
B : Brown rice protein diet **PB: Parboiled brown rice protein diet**
W : White rice protein diet **PW : Parboiled white rice protein diet**
N.P. : Non-protein diet

Weight gain:

The average body weight gain after four weeks was 63.20 g for standard diet, 53.70 g for brown rice, 59.20 g for parboiled brown rice, 52.0 for white rice and 56.30 g for parboiled white rice, while average loss of weight was 23.99 g in the non-protein diet (Table 3). The results in this table indicated that weight gain for the casein diet was higher than for all tested protein. The weight gain was lower for white rice but was higher in the case of parboiled brown rice and parboiled white rice among the test proteins. The non-protein diet showed lower weight gains than standard and test diets.

Feed efficiency:

Feed efficiency is the gain in body weight per unit feed intake. Results revealed that maximum feed efficiency for casein(0.24) was and minimum for white rice (0.20) diet. The same table showed that test diets had lower feed efficiencies than casein diet, parboiling process increase the feed efficiency in test diets.

Feed utilization:

Feed utilization is the ratio of feed intake to the gain in body weight. Results revealed 4.25 feed utilization for casein , 4.83 for brown rice, 4.50 for parboiled brown rice, 4.95 for white rice and 4.65 for parboiled white rice (Table 3). Hence, maximum feed utilization was for white rice followed by brown rice.

Protein efficiency ratio (PER):

Protein efficiency ratio is the gain in body weight per unit protein intake. The results revealed that the PER value for casein was 2.36, for brown rice 2.07, for parboiling brown rice 2.22, for white rice 2.02, and for parboiled white rice 2.15 (Table 3).

Generally, the PER values of the different rice samples were increased upon subjecting rice to thermal processing (parboiling). These increases may be due to increase of digestibility that occurred as a function of parboiling. These results are in accordance with those reported by (Pederson and Eggum, 1983 and Sotelo *et al.*, 1994).

Corrected protein efficiency ratio (C-PER):

Corrected protein efficiency ratio is defined as the ratio of PER of test protein to that of standard protein multiplied by standard value of reference proteins. The standard PER of casein is taken as 2.5 (Pellett and Young, 1980). The corrected PER was 2.19 for brown rice diet, 2.35 for parboiled brown rice, 2.14 for white rice and 2.28 for parboiled white rice diet. Plant proteins can be categorized into three groups (Hsu *et al.*, 1978), high PER (cotton seed meal 2.3, rice 1.7, red gram 1.7, peanut 1.6), medium PER (oat 1.5, soybean flour 1.5, corn 1.4, wheat 1.3, sesame seed 1.2, maize 1.0) and low PER (peas 0.7, rape seed meal 1.41). The present study revealed that brown, parboiled brown, white, parboiled white rice and standard protein diets all had high PER.

The C-PER values of all rice samples contained high quality plant proteins. These results are in accordance with those reported by Sotelo *et al.* (1994).

Protein utilization (PU):

Protein utilization is the ratio of protein intake to gain in body weight. The results revealed that the PU values were for casein 0.42, brown rice diet 0.48, parboiled brown rice 0.45, white rice 0.50 and parboiled white rice 0.47 (Table 3). PU of white rice diet was maximum, followed by brown rice diet. The data in the same table showed higher PU in the test protein diets than casein diet. These results are in line with those of Prakash and Ramanatham (1995).Who reported that, net protein ratio and nitrogen utilization from both protein concentrates were also high and not significantly different from the standard protein.

Net protein retention (NPR):

Data presented in Table (3) show that, NPR was maximum for casein (3.25) and minimum for white rice diet. Apparent also from the same table that NPR increased as a function of parboiled process for brown and white rice diet. The results of Eggum *et al.* (1984) and Eggum *et al.* (1987) supported our findings.

Apparent digestibility (% of N intake):

The results of Table (3) indicated that, casein protein was more digestible than the other rice proteins. It should be observed also from the same table that, protein of white rice samples were more susceptible to the digestion than that of brown rice. This result may be due to the fact that white rice contain lower fiber and tannin than those of brown rice (El-Bana *et al.*, 2000). However, thermal processing (parboiling) raised the digestibility of rice proteins, this may be due to the denaturation that occurred as a function of subjecting rice proteins to parboiling process. WU and Inglett (1974) defined the denaturation as modification of the secondary and tertiary structures of the protein molecular, which does not involve breaking of the covalent band, hence, the active sites of amino acids will be more available. This will lead to increase the susceptibility of protein molecular to digestion by enzymes. It can be concluded that parboiling treatment led to improve the protein quality of rice.

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تأثير عمليتي الغلي والضرب والتبييض على الأحماض الأمينية والتقييم البيولوجي لبروتينات الأرز

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أجريت هذه الدراسة بهدف معرفة تأثير عمليتي الغلي والضرب والتبييض على الأحماض الأمينية وجودة البروتين لعينات الأرز المختلفة لصنف الأرز سخا ١٠٤ وذلك بإجراء تجارب تغذية على الفئران وكانت النتائج المتحصل عليها كالآتي:

- أدت عملية الغلي إلى تقليل الأحماض الأمينية بصفة عامة في عينات الأرز المختلفة ولكنها تزيد من محتوى بعض الأحماض الأمينية مثل الليسين والثريونين والآلانين والجليسين.
- وأن كميه الحامض الأميني (الليسين) تزداد في الأرز البني عن الأرز الأبيض وأن الحامض الأميني المحدد في عينات الأرز المختلفة هو الليسين.
- ومن خلال تجارب التغذية على الفئران وجد أن عملية الغلي أدت إلى زيادة كفاءة البروتين وأن بروتينات الأرز البني كانت أفضل من الأرز الأبيض كما أدت عملية الغلي إلى زيادة هضمية البروتين لعينات الأرز المختلفة وكانت الهضمية لبروتينات الأرز الأبيض أفضل من الأرز البني.

مما سبق نستخلص ان عمليه الغلي تؤدى الى تحسين جوده بروتين الارز.