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The amino acid composition and protein quality of biscuits

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With 2 tables

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Technological advance in food industry has stimulated considerable interest in the upgrading and conversion of wheat kernels into products of higher acceptability and greater market stability. However, the industry has displayed little interest in studying changes in the nutritional value of new products.

We have started a survey for assessing the effect of wheat processing on the protein quality and amino acid composition of the resulting products (7, 8).

Biscuits are the center of attraction in almost every home, the biscuits snitchers are usually the youngsters of the family, who are most vulnerable to protein deficiency, and their protein supply should be of highest quality. The present work deals with the amino acid composition of Mary's Biscuit, a very common type manufactured by Bisco Misr Co. The protein quality of the product was also assessed in rat feeding experiment.

Materials and methods

Sweetened biscuits used in this study were obtained commercially from Bisco Misr Co., they were prepared from white flour in which milk, eggs, sugar and baking powder were incorporated during the preparation of the dough (Mary's Biscuits).

Preparation of samples for analysis

Samples were prepared for analysis by grinding in an electric mill and were kept in an air-tight container until used. Milled samples were analyzed for crude protein by the semi-micro *Kjeldahl* method (1). The samples were analyzed for amino acids using automatic amino acid analyzer (4). The tryptophan content was assayed colorimetrically by the method of *Spies* (11). The results were expressed as g/100 g product. Chemical scores were calculated based on the lysine content of 344 mg/g introgen in the 1973 reference amino acid pattern (13).

Rat feeding experiment

Male Sprague-Dawley rats aged 21 ± 2 days at arrival were housed individually in wire floor cages in an animal room with environmental control. The experiment corresponded nearly with the experimental procedure described by the German group on the Protein Evaluation (9). For the first three days the rats were fed equal parts of a practical rat diet and of a mixture of equal parts of the experimental diet.

After three days the food was removed for 6 hours, and the rats were weighed and distributed over 6 blocks of rats of equal weights. Within each block the rats were randomised for diet and cage.

In this experiment one group received a protein-free diet which consisted of the following (in %): cottonseed oil, 5, salt mix (9), 6, vitamin mix (9), 2; cellulose, 4; cornstarch, 83. Three groups of six animals each received diets which contained three levels of casein + dl-methionine. At the lower dietary levels (3.5, 7.0%), the casein diets were supplemented with 0.3% dl-methionine, whereby at 10% dietary protein level, the casein diets were supplemented with 0.5% dl-methionine.

Two groups of six animals each received diets containing 3.5 and 6.7% protein derived from the biscuits. The diet was prepared by substituting biscuits for the starch in the protein-free diet, cellulose was also omitted in this case.

Food consumption was measured and nitrogen intake was calculated for each animal from the nitrogen content of the diet. The animals were weighed twice weekly although only the final weights have been utilized in the analysis. They were killed on the 21st day of the feeding, weighed and dried at 95 °C until constant weight was reached. The carcasses were then milled and the body water content (WB_T) was obtained by drying at 105 °C.

The body water content of a group of animals killed at the start of the experiment (BW_F) were used to calculate the gain in body water of each animal during the experiment thus improving the precision of the assay using body water (5). Protein Efficiency Ratio (PER) was calculated from the formula given by *Osborn* and *Mendel* (10).

The Net Protein Utilization (NPU) was calculated from the formula given by *Bender* and *Miller* (2).

The Relative Nutritive Value (RNV) of biscuit proteins was calculated by the method described by *Hegsted* et al. (5).

Regression equations were derived for both diets based on reference casein and those based on biscuits and the slope line in each case was computed.

Results and discussion

Protein content and amino acid composition of biscuits and its parent wheat kernel are presented in table 1. The results of the amino acid analysis indicate that lysine should be the first limiting amino acid in biscuits. According to the reference amino acid pattern of 1973 (12), the corresponding chemical score was 21% for biscuits. Biscuits had very inferior amino acid pattern, as evidenced from the very low lysine content of 82.1 mg/gN with over 50% lysine destruction, compared to the values obtained from its parent wheat (168.5 mg/gN). Threonine followed by isoleucine appear to be the next limiting amino acids after lysine. On the other side, biscuits are high in their tryptophan content with mean value 85 mg/gN, and the chemical score for this amino acid is 137% of the Reference Pattern.

The data obtained in the feeding experiment are presented in table 2. These data show the mean change in body weight, body water. No PER values could be obtained from rats fed biscuits as protein source, since these rats continued to lose weight throughout the whole feeding experiment, and the food consumption was too low.

Rats fed diets based on biscuits as protein source showed very slight increase in body water (1.9 g) through the three-week-feeding experiment as compared to a value of 16.0 g in rats fed casein at the same dietary protein level.

Table 1. Amino acid composition of biscuits in relation to wheat proteins and FAO/WHO Reference Pattern (1973).

Amino acid	Whole wheat	Biscuits	FAO/WHO
Essentials			
Lysine	168.5	82.1	344.0
Methionine	92.8	89.4	
Cystine	150.1	148.2	
Total sulfur			219.0
Isoleucine	200.7	215.5	250.0
Leucine	412.5	443.3	437.0
Total aromatic	263.4	280.4	375.0
Tryptophan	70.2	84.6	62.0
Threonine	171.6	155.6	250.0
Valine	262.0	264.9	312.0
Total	1791.8	1764.0	2249.0
Nonessentials			
Aspartic	237.0	268.9	
Glutamic	1763.0	1974.6	
Alanine	217.6	181.3	
Proline	286.6	286.6	
Serine	606.8	666.2	
Glycine	249.9	200.5	
Arginine	281.5	197.5	
Histidine			
NH_3	242.1	265.3	
Total	3984.5	4040.9	

Chemical score =

The results obtained in the present study indicate a very inferior protein quality of the biscuits under investigation. This could be attributed to the low availability of lysine and to the presence of high concentrations of reducing sugars. In this respect *Clegg* (3) claimed that the availability of lysine in biscuits was largely destroyed. Sucrose and the lactose of milk react also very actively with epsilon amino group of lysine, thus forming carbonyl compounds which are resistant to the action of the digestive proteolytic enzymes rendering this amino acid not utilized by the animal (11).

For this reason, the food industry is producing nowadays glucose-free egg powder, which stands the storage temperatures with no adverse effect on its protein quality (6). Similarly sugars other than sucrose should be tried in the preparation of biscuits to improve its protein quality.

Conclusion derived from the feeding results show that the index of Net Protein Utilization (NPU) gives erroneous misleading results for quality proteins. Feeding proteins at two different protein levels or more seem to be highly recommended.

Table 2. Mean change in body weight, body water, Protein Efficiency Ratio (PER), Net Protein Utilization (NPU), and Relative Nutritive Value (RNV) of weanling rats fed biscuits at different protein dietary levels.

Protein in diet %	Intake				Change in body				PER		NPU		RNV
	Food		Nitrogen		Weight		Water						
	$\bar{x}_{(g)}$	$S_{\bar{x}}$	$\bar{x}_{(g)}$	$S_{\bar{x}}$	$\bar{x}_{(g)}$	$S_{\bar{x}}$	$\bar{x}_{(g)}$	$S_{\bar{x}}$	$\bar{x}$	$S_{\bar{x}}$	$\bar{x}$	$S_{\bar{x}}$	
Reference casein													100
3.5	80	2.2	400	10	2.6	1.1	5.5	0.2	1.02	0.43	101.7	3.8	
7.0	117	14.7	1260	160	20.2	3.9	16.0	1.1	1.0	0.21	73.2	7.2	
10.0	153	6.7	2270	120	45.0	3.1	32.1	2.0	3.1	0.08	67.2	5.1	
Biscuits													12.5
3.5	70	9.1	390	20	-1.2	0.9	0.7	0.8	−ve	-	66.4	12.4	
6.7	75	7.4	890	70	-0.3	0.9	1.9	1.1	−ve	-	32.4	4.6	

New food products, in particular those consumed abundantly by the children, should be tested for quality control before their introduction to the market.

Summary

The protein quality of biscuits (Mary's Biscuit), a product largely consumed by infant and children in this country proved to be of very inferior quality, with very low lysine content, which is obviously completely destroyed during the baking process.

Rats fed biscuits as protein source lost weight during the experimentation period and their food consumption was too low. Rats fed this diet showed also very slight increase in body water (1.9 g), in comparison to a value of 16.0 g in rats fed casein at the same dietary protein level.

Zusammenfassung

Der Lysingehalt der untersuchten Biskuite betrug nur 82 mg/g Stickstoff, im Vergleich zu einem Wert von 168 mg/g Stickstoff im Weizenkernel. In Rattenverfütterungsversuchen konnte kein PER-Wert ermittelt werden, da die Ratten ständig an Gewicht abnahmen.

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