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# Availability of essential amino acids in corn flour and corn bread

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The availability of nitrogen, lysine and 9 essential amino acids was determined in corn before and after baking. Lysine availability was determined by the growth response method on weaning rats using regression analysis of body weight gain or moisture gain against lysine consumed from corn flour and corn bread. The results show a high correlation between lysine consumed and weight gain or moisture gain ($r = 0.95$) for rats fed the standard diets for 3 weeks. A good correlation was also obtained for corn bread. The results of lysine availability show that baking greatly improves availability by both ways of calculation.

The availability of nitrogen and essential amino acids were also investigated by the balance trials with rats. Results show that availability values for nitrogen and all amino acids except threonine increased by baking. Data for food intake, weight gain, food efficiency, PER, NPR and true digestibility revealed that baking had little or no effect on nutritive value of corn tested in this investigation.

There are few reports on the availability of lysine and essential amino acids in corn flour and corn bread. DESHPANDE et al. [7] found that only 30% of isoleucine in zein was available to the rat. GEIGER et al. [9] reported poor availability of valine in zein while LINKSWILER et al. [11] found it to be highly available in maize for man. GUPTA et al. [10] reported 49.0% availability of lysine as assessed by the rat growth method. DAKROURY [5] reported 76.0% availability of threonine by the same method. De MUELENAERE et al. [6] found 90.0% availability of isoleucine in corn as measured by fecal analysis method, also 89.5% of lysine and 88.8% of threonine. CALHOUN et al. [4] found 95.2% of methionine to be available by the growth method.

Corn bread presents a potential source of protein in nutrition of people and specially farmers living in lower Egypt. The objective of this investigation is to evaluate the nutritive value of corn and to assess the influence of baking on the availability of its essential amino acids.

## Materials and methods

American "badri" variety of corn was obtained through the Ministry of Agriculture, Cairo, Egypt from the 1978 crop, cleaned and milled. Whole corn flour was baked in a way simulating that practised at the Fayoum Governorate. It was then air dried in an oven at about 60 °C and finely ground in a mill. The protein contents of corn flour and corn

bread were determined by the micro-KJELDAHL procedure as described in the AOAC [1] using the nitrogen to protein factor of 6.25.

Basal diet, a protein free diet, diets for the standard curve and test diets were prepared as given in Table 1. Care and feeding of animals were undertaken as described earlier [7]. Lysine availability was estimated by the growth response method using regression analysis

Table 1
Percentage composition of experimental diets fed to rats for estimating amino acid availability of corn flour and corn bread

| Ingredient | Basal diet | Diets for Standard curve | | | Test diets (Basal to 8% N from test material) | | Protein free |
|---|---|---|---|---|---|---|---|
| | | | | | Corn | | |
| | | 0.15% Lysine | 0.30% Lysine | 0.45% Lysine | Flour | Bread | |
| L-Glutamic acid | 0.72 | 0.48 | 0.24 | — | 0.72 | 0.72 | — |
| L-Lysine HCl | — | 0.15 | 0.30 | 0.45 | — | — | — |
| Test material | — | — | — | — | 50.6 | 42.3 | — |
| Corn starch | 69.4 | 69.5 | 69.6 | 69.7 | 18.8 | 27.2 | 89.7 |

— all diets contained: 4.1% salt mixture; 0.5% vitamin mixture; 0.2% choline chloride; 0.5% cod liver oil and 5.0% corn oil.
— all diets except the protein free contained 19.6% crystalline amino acid mixture

relating change in weight or change in moisture to lysine consumed. Protein efficiency ratio (PER), net protein ratio (NPR) and true digestibility were also estimated. Availability of essential amino acids was estimated by the balance trial method [3]. Amino acid content of diets and feces were determined by amino acid analysis using the Technicon Automatic Amino Acid Analyzer [14].

## Results and discussion

Table 2 presents the essential amino acid contents of corn flour and corn bread. Baking increased the protein content by about 19%. Lysine and leucine seem to decrease by greater amounts after baking. Corn flour contained higher amounts of threonine, phenylalanine, histidine and arginine. On the other hand, corn bread was rich in valine, methionine and isoleucine.

The growth response based on average body weight during the experimental period obtained by feeding the basal diet added to it graded levels of lysine: 0.15, 0.30 and 0.45% showed increase in body weight with increasing the level of dietary lysine and with the advance of the experiment. Rats fed protein free diet lost about 27% of their initial body weight. Corn flour gave better growth response than corn bread. In general, growth response for diets containing corn flour or corn bread seem to be similar to that of rats fed the 0.15% lysine diet.

Food intake, change in weight, food efficiency, PER, NPR and true digestibility are

Table 2
Protein and amino acid contents of corn flour and corn bread [g/100 g]

| Amino acid | Corn flour | Corn bread |
|---|---|---|
| Threonine | 0.428 | 0.368 |
| Valine | 0.077 | 0.121 |
| Methionine | 0.269 | 0.443 |
| Isoleucine | 0.404 | 0.675 |
| Leucine | 0.112 | 0.094 |
| Phenylalanine | 0.246 | 0.153 |
| Lysine | 0.128 | 0.086 |
| Histidine | 0.233 | 0.117 |
| Arginine | 0.175 | 0.088 |
| Protein | 6.86 | 8.21 |

Table 3
Food intake, change in weight, food efficiency; P.E.R., N.P.R. and true digestibility on 6 experimental diets (mean ± ISD)

| Treatment | Food intake [g] | Change in weight [g] | Food efficiency | P.E.R. | N.P.R. | True digestibility [%] |
|---|---|---|---|---|---|---|
| Basal | 149.5 ± 29.3 | 12.0 ± 6.1 | 0.78 ± 0.029 | 0.48 ± 0.18 | 1.32 ± 0.18 | 97.8 ± 0.57 |
| + 0.15% lysine | 171.6 ± 27.9 | 22.3 ± 8.6 | 0.129 ± 0.036 | 0.80 ± 0.22 | 1.52 ± 0.24 | 98.0 ± 0.69 |
| + 0.30% lysine | 178.2 ± 29.9 | 42.3 ± 11.1 | 0.235 ± 0.025 | 1.52 ± 0.14 | 2.16 ± 0.1 | 96.6 ± 1.2 |
| + 0.45% lysine | 203.3 ± 44.6 | 53.8 ± 15.4 | 0.264 ± 0.038 | 1.65 ± 0.22 | 2.27 ± 0.26 | 93.5 ± 2.9 |
| + corn flour | 170.6 ± 15.2 | 26.5 ± 8.6 | 0.155 ± 0.045 | 0.79 ± 0.23 | 1.37 ± 0.23 | 90.4 ± 1.5 |
| + corn bread | 160.0 ± 14.3 | 18.0 ± 2.8 | 0.112 ± 0.025 | 0.57 ± 0.08 | 1.19 ± 0.04 | 92.4 ± 0.91 |

presented in Table 3. Weight gain of rats fed corn flour was greater than that of those fed corn bread. Food efficiency of corn flour is higher than that of corn bread. Also PER values tend to be lower for corn bread but that difference is not significant. Neither the NPR nor the true digestibility values were affected significantly by baking. These values are in agreement with those reported by WATT et al. [15].

*Lysine availability values*

Determination of lysine availability was made by using the growth response method and applying regression analysis by relating weight gain or moisture gain to lysine consumed and utilizing the slope ratio technique of NETKE et al. [12].

The correlations between weight gain or moisture gain and lysine intake from lysine diets for the standard curve are high; 0.95 and 0.93 respectively. This is in agreement with the results obtained by CALHOUN et al. [4], BOCTOR et al. [2] and SARWAR et al. [13]. A good

correlation between lysine intake from corn bread and weight gain or moisture gain was also obtained; 0.76 and 0.82 respectively.

The results show that baking increases lysine availability. This difference is highly significant whether the weight gain or the moisture is used as a response parameter (Tables 4 and 5).

Table 4
Regression equations relating lysine consumption from corn protein tested and corresponding weight or moisture gain [13]

| Response parameter | Diets | Type of gain (Y) | Type of lysine consumed (X) | Regression equation | Lysine availability |
|---|---|---|---|---|---|
| Weight gain | Basal + 0.15, 0.30 & 0.45% lysine | Total | Crystalline | $Y = -4.46 + 0.04283X$ | 100 |
| | Basal + corn flour | Due to corn lysine consumed | Corn | $Y = 8.79 + 0.0112X$ | 26 |
| | Basal + corn bread | Due to corn lysine consumed | Bread | $Y = 3.28 + 0.02497$ | 58 |
| Moisture gain | Basal + 0.15, 0.30 & 0.40% lysine | Total | Crystalline | $Y = 3.15 + 0.02565X$ | 100 |
| | Basal + corn flour | Due to corn lysine consumed | Corn | $Y = 4.78 + 0.00413X$ | 16 |
| | Basal + corn bread | Due to corn lysine consumed | Bread | $Y = 0.20 + 0.01692X$ | 66 |

Table 5
Percent nitrogen and amino acid availability by balance trial method

| Amino acid | Corn flour | Corn bread |
|---|---|---|
| Nitrogen | 94.3 | 96.7 |
| Threonine | 101.6 | 99.3 |
| Valine | 98.0 | 102.7 |
| Methionine | 101.4 | 102.2 |
| Isoleucine | 99.8 | 100.5 |
| Leucine | 98.8 | 102.8 |
| Phenylalanine | 99.3 | 99.7 |
| Lysine | 98.6 | 102.0 |
| Histidine | 98.3 | 100.6 |
| Arginine | 98.6 | 100.2 |

There are many discrepancies between the lysine availability values obtained in the different studies under various environmental conditions. Thus it is difficult to compare these results with those obtained by other investigators. Different methods with different basal

diets have been used for the calculation of availability values reported for cereal lysine. Such values ranged from 49 to 126% for corn.

*Availability of nitrogen and essential amino acids by balance trials*

Availability of nitrogen and 9 essential amino acids was determined in diets containing the basal diet plus 0.8% nitrogen from corn flour or corn bread. The availability was calculated by using the equations described by BRAGG et al. [3]. Baking of corn does not affect its amino acid availability. The availability values of nitrogen and amino acids (Table 5) were high and similar, indicating that corn amino acids are highly available. Lysine availability values obtained by the growth method were calculated as a percentage of that calculated for the reference standard. Therefore, they are not directly comparable to the values calculated by balance trials. The balance trials method has been criticized on account of the possible influence of microbiological activity. If the amino acid is synthesized or destroyed by the intestinal microflora, it would cause lower or higher values respectively for availability. Growth method is also criticized in its ability to estimate only one amino acid at a time.

The present finding that lysine availability values calculated by the balance trials are higher than those calculated by the growth method is supported by the work of CALHOUN et al. [4] and GUPTA et al. [10]. The possibility of differences in response of animal species on amino acid availability from the same protein source cannot be eliminated [13]. Therefore, there is the need to determine amino acid availability of corn with man instead of rat or other animals.

**Zusammenfassung**

M. M. EL-SHAFEI, M. H. ABBASSI, N. S. BASSILY und A. K. SAID: Zur Verfügbarkeit essentieller Aminosäuren in Maismehl und Maisbrot

Es wurde die Verfügbarkeit von Stickstoff, von Lysin sowie von 9 essentiellen Aminosäuren in Mais vor und nach dem Backen bestimmt. Die Lysin-Verfügbarkeit wurde anhand des Wachstums entwöhnter Ratten bestimmt, und zwar durch Regressionsanalyse der Körpergewichts- oder Körperwasserzunahme, bezogen auf das mit Maismehl oder Maisbrot aufgenommene Lysin. Die Ergebnisse zeigen eine hohe Korrelation zwischen Lysinzufuhr und Gewichts- oder Wasserzunahme für Ratten ($r$ = 0,95), die 3 Wochen lang die Standarddiät erhalten hatten. Auch bei Maisbrot war eine gute Korrelation zu verzeichnen. Die nach beiden Berechnungsarten erhaltenen Ergebnisse zeigen, daß die Lysin-Verfügbarkeit durch den Backprozeß stark verbessert wird.

Die Verfügbarkeit von Stickstoff und essentiellen Aminosäuren wurde mittels der Bilanzmethode an Ratten bestimmt. Die Ergebnisse zeigen, daß die Verfügbarkeit für Stickstoff und alle Aminosäuren (mit Ausnahme von Threonin) durch das Backen gesteigert wird. Die Daten für Nahrungsaufnahme, Gewichtszunahme, Nahrungseffizienz, PER, NPR und wahre Verdaulichkeit lassen erkennen, daß das Backen keinen oder nur einen geringen Einfluß auf den Nährwert des untersuchten Maises ausübt.

**Резюме**

М. М. Ель-Шафей, М. Н. Абасси, Н. С. Бассилы и А. К. Саид: К проблеме доступности незаменимых аминокислот в кукурузной муке и кукурозном хлебе

Определялась доступность азота, лизина и 9 незаменимых аминокислот в кукурузе перед и после выпечки. Доступность лизина определялась на основе роста крыс-отъемышей путем регрессионного анализа прибавления веса тела или воды тела, отнесенного к поступившему с кукурузной мукой или кукурузным хлебом лизину. Результаты показывают высокую корреляцию между поступлением лизина и прибавлением веса тела или воды тела для крыс ($r$ = 0,95), получивших в течение 3 недель стандартную диету. И в отношении кукурузного хлеба наблюдалась хорошая корреляция. Полученные обоими способами расчета результаты показывают, что доступность лизина процессом выпечки значительно улучшается. Доступность азота и незаменимых аминокислот определялась с помощью балансового метода у крыс. Результаты показывают, что доступность азота и всех аминокислот (за исключением треонина) увеличивается при выпечке. Данные по потеблению пищи, увеличения веса, эффективности пищи, коэффициент эффективности белков, коэффициент чистого белка и истинная переваримость указывают на то, что выпечка не влияет или только незначительно влияет на пищевую ценность исследованной кукурузы.

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