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POTENTIAL OF INDONESIAN COMMON MAIZE AS STAPLE FOOD COMPARE WITH QUALITY PROTEIN MAIZE (QPM) BASED ON THEIR PROTEIN QUALITY

(Potensi Jagung Indonesia sebagai Makanan Pokok dibandingkan dengan Jagung Quality Protein Maize (QPM) berdasarkan kualitas proteinnya)

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ABSTRAK. Telah dilakukan evaluasi terhadap kualitas protein dua varietas jagung QPM (Srikandi Kuning dan Srikandi Putih) dan dua varietas jagung Indonesia. Sebanyak 40 tikus Sprague-Dawley berumur 3 minggu dibagi secara acak menjadi 5 kelompok sebagai berikut (1) kelompok tikus yang diberi pakan dengan bahan dasar jagung Srikandi kuning, (2) kelompok tikus yang diberi pakan dengan bahan dasar jagung Srikandi putih, (3) kelompok tikus yang diberi pakan dengan bahan dasar jagung Bisi-2, (4) kelompok tikus yang diberi pakan dengan bahan dasar jagung Lamuru, dan (5) kelompok tikus yang diberi pakan yang defisien protein, masing-masing selama 13 hari. Berat badan tikus ditimbang setiap 2 hari dan jumlah konsumsi makan ditimbang setiap hari. Feses yang telah dipisahkan dari kotoran dikumpulkan setiap hari. Hasil penelitian menunjukkan bahwa asam amino pembatas dari keempat varietas jagung adalah lisin. Jagung Lamuru memiliki nilai daya cerna protein yang dikoreksi dengan skor asam amino tertinggi, tetapi tidak berbeda dengan jagung Srikandi kuning. Hasil ini menunjukkan bahwa jagung Lamuru, yang merupakan jagung Indonesia, berdasarkan kualitas proteinnya tidak lebih rendah mutunya dibandingkan dengan jagung QPM dan berpotensi untuk dijadikan sebagai makanan pokok.

Key words: QPM, maize, protein quality, PDCAAS, Amino acid score, in vivo

INTRODUCTION

In developing areas of the world, people often have diets low in energy and protein. This condition causes malnutrition and therefore more susceptible to disease throughout life (Wardlaw, 1999).

For the world populace as a whole, there probably is no great need to improve the quality of protein. Normal adults have a relatively low demand for protein, and their intake of every day staple food probably already overcomes any serious deficiencies. However, superimposed stressed raise a person's protein needs and can push these needs above the levels of normal intake. At that point, protein becomes a main cause of malnutrition. Thus, protein quality can be the limiting factor for people of all ages.

To improve the nutritional status of the malnourished, the composition of the diet with more nutritious food are encouraged. To reach sick children, weanlings, lactating mothers, pregnant women, and others requires various approaches. Broadening the diet to incorporate a wider range of foods is one, and increasing the availability of conventional staples is another.

In many areas of Indonesia, maize is a vital staple, particularly for the rural poor. It spreads widely among poor areas because it is highly adaptable to a wide range of environment and because of its many valuable properties. Unfortunately, maize is low in protein quantity and quality, both of which are insufficient to satisfy the protein needs of the rural poor that are most vulnerable to malnutrition. The prevalence of protein-calorie malnutrition among village and slum children in African and Latin American countries demonstrated the underlying inadequacy of maize-dependent diets (Brown *et al.*, 1988)

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Concerning poor nutritional value of maize have been expressed in various national and international organization (Vasal, 2001). Centro Internacional de Mejoramiento de maizy Trigo (CIMMYT) has produced a new class of maize that combines the nutritional excellence of opque-2 maize with the kernel structure of conventional maize varieties that labeled quality-protein maize (QPM) (Brown et. al., 1988). Some genotypes of the QPM have been planted in Makasar (south Sulawesi) in order to find out the most susceptible type with the local condition.

Although QPM has about the same amount of protein as common maize, but QPM's benefits are higher lysine and tryptophane content than common maize (Brown et. al., 1988). In this research, protein quality (in vivo) of two types of QPM planted in Makasar (Srikandi Putih and Srikandi kuning) and two types of Indonesia common maize (Bisi-2 and Lamuru) was evaluated.

MATERIALS AND METHODS

Materials

QPM (Srikandi Putih and Srikandi kuning) and Lamuru maize were obtained from Agricultural Cerealia Research Center, Maros South Sulawesi, and Bisi 2 maize was obtained from farmer in Kalirejo Lampung.

Experimental design and composition of the diets

Diets were based on maize flours 80 mesh and formulated according to National Research Council (1988) with modification on protein content (6%). The proximate composition and amino acids content of flours were assessed using techniques described by the AOAC (1990). During adaptation period (1 week), 50 three weeks-old (weaning) Sprague-Dawley male rats were fed with casein based diet containing 10 % protein (AOAC, 1990). Table 1 shows the composition of the diets. After adaptation period, rats were grouped based on their body weight, into randomly assigned to four groups (treated rats) as follow: rats fed Lamuru maize based diet (L), rats fed Bisi-2 maize based diet (B), rats fed Srikandi Putih maize based diet (S), rats fed Srikandi kuning maize based diet (K) and rats fed protein deficient diet (metabolic group) for 13 days. During this period, starting on the third day, the body weights of the rats were recorded every 2 days and food intakes were recorded daily. Feces were collected daily and separated from spilt food. The feces were dried, weighed, ground and analyzed protein according to the same methodology used for the diets. Protein efficiency ratio (PER), protein true digestibility (TD) and protein digestibility corrected amino acid score (PDCAAS) were calculated.

Table 1. Composition of the diets (1 Kg)

Ingredient	Srikandi putih	Srikandi kuning	Bisi 2	Lamuru	standard	Metabolic group
Maize flour (g)	783.41	739.13	607.14	739.13	-	
Maize oil (g)	50.00	50.00	50.00	50.00	77.70	50
Mineral mix (g)	40.00	40.00	40.00	40.00	44.80	40
Vitamin mix (g)	10.00	10.00	10.00	10.00	10.00	10
Maize starch (g)	116.59	160.87	292.86	160.67	699.40	900
Casein (g)	-		-	-	114.90	
Cellulose (g)	-		-	-	10.00	
Water (g)	-		-	-	43.20	

Body weight, protein content of feed consumed and dried feces were used to estimate the following variables:

1) Protein efficiency ratio (PER) (Matthews, 1999):

$$PER = \text{g weight gain/g protein intake}$$

2) Protein true digestibility (PTD) (Schaafsma, 2000)

$$PTD = \frac{[\text{g protein intake} - \text{g protein dried feces of treated rats} - \text{g protein dried feces of metabolic rats}]}{\text{g protein intake}} \times 100\%$$

3) Protein digestibility corrected amino acid score (PDCAAS) (Schaafsma, 2000)

$$PDCAAS\ (\%) = \frac{\text{mg of limiting amino acid in 1 g of maize protein}}{\text{mg of same amino acid in 1 g of reference protein}} \times PTD \times 10$$

Statistical analysis

The data was calculated using one-way ANOVA. The means of the treatment were compared using Least Significant Different (LSD) test with confident limit 95% ($P \leq 0.05$.

RESULTS AND DISCUSSIONS

Chemical compositions and amino acid scores

Table 2 shows chemical composition and amino acid scores of the maizes. Bisi 2 maize had protein content higher than Srikandi putih, Srikandi kuning or Lamuru. Between the maizes, Srikandi putih had relatively more lipid content, but relatively there were not significant difference in water, ash, crude fiber, and carbohydrate contents.

Table 2. Chemical composition and Amino acid scores of the maizes

Chemical composition and Amino acid score	Maizes			
	Srikandi Putih	Srikandi kuning	Bisi 2	Lamuru
Water (%)	9.59	9.90	9.70	9.80
Protein (%)	6.51	6.90	8.40	6.90
Lipid (%)	5.34	3.40	3.60	3.20
Ash (%)	1.43	1.30	1.00	1.20
Crude fiber (%)	2.07	2.40	2.20	2.60
Carbohydrate	75.06	76.10	75.10	76.30
Tryptophan (mg/gProtein)	9.52	8.69	8.09	9.56
Lysine (mg/g protein)	19.51	39.13	33.21	39.85
Amino acid score	34	67	57	69

Lisin content of Srikandi kuning, Bisi 2 and Lamuru were relatively much higher than Srikandi putih (Table 2). Tryptophan content of Bisi 2 was lower than Srikandi Putih, Srikandi kuning or Lamuru. Previous data showed that QPM had lisin content higher than common maize (Paliwal, 2000). The differences of the contents attributed to different maize growing condition..

Method to assign a quantitative value to the pattern of amino acids in a nutritional formula or to a particular dietary protein source is based on the amounts and importance of the individual amino acids (Matthews, 1999). Limiting amino acid of the four maizes was lysine, similar to the value reported by Vasal (2001) in QPM. Table 2 showed that Srikandi putih maize didn't have better amino acid score than Indonesian common maizes. However, amino acid score of Srikandi Kuning was higher than amino acid score of Bisi-2. Amino acid score of Srikandi putih obtained in this research was 34; which was much lower than amino acid score of Lamuru (67). On the other hand, Bisi 2 had amino acid score higher than Skrikandi putih, but lower than Srikandi kuning or Lamuru.

Protein quality in vivo

Protein Efficiency Ratios (PER) values were shown in Table 3. Among four maizes tested, Srikandi kuning had the highest PER. It meant that its protein caused rapid growth of the rats. Bisi 2 maize, that had the highest protein content, had the lowest PER.

Clinical human studies that measure growth and/or other metabolic indicators provided the most accurate assessment of protein quality. For reasons of both cost and ethics, such techniques could not be used. Consequently, assay techniques designed to measure the effectiveness of a protein in promoting animal growth was used.

Table 3. Protein efficiency ratio, protein true digestibility, and PDCAAS of the Maizes

Maizes	Protein evaluation methods		
	PER[1]	PTD (%)[2]	PDCAAS [3](%)
Srikandi Putih	2.59ab	63.88b	22c
Srikandi kuning	2.64a	64.07b	43ab
Bisi 2	0.97c	73.53a	42b
Lamuru	1.89b	66.69b	46a

Note: [1]$LSD_{0.05} = 0.7022$; [2]$LSD_{0.05} = 5.0499$
[3]$LSD_{0.05} = 0.2138$

It is assumed that the highest quality protein is protein that supports maximal growth of a young animal. Because rats grow quickly and have limited protein stores and a high metabolic rate, deficiencies and imbalances in amino acid patterns in young growing rats can be easily detected in short period of time. However, results from this method will be skewed in application to humans, depending upon the extent that human requirements for individual amino acids differ from those of the rats (Matthews, 1999).

It is well accepted that the nutritional value of proteins may differ substantially depending on their essential amino acid composition and digestibility. Bisi 2 maize had the highest true digestibility. True digestibility of Lamuru was similar to Srikandi putih and Srikandi kuning. These data suggested that protein of Bisi 2 was more absorbable than protein Srikandi Putih, Srikandi kuning or Lamuru.

Rats fed Bisi 2 based diet absorbed protein more than other diets. However, body weight gained of the rats was the lowest. It might be because the Bisi 2 protein absorbed was not used for growth but was metabolized as source of energy. As a consequence, body growth of rats fed Bisi 2 based diet were lower than the others.

PER method has been used in many countries because it is believed to be the best predictor of clinical tests. However, after decades of use, it is now recognized that PER overestimates the value of some animal proteins for human growth while it underestimates the value of some vegetable proteins for that purpose(Schaafsma, 2000). For that reason amino acid score has been advocated as an alternative to the PER. Although the quality of some proteins can be assessed directly by using amino acid score values, that of others cannot because of poor digestibility. Consequently, both amino acid composition and digestibility measurements are considered necessary to predict accurately the protein quality of foods for human diets (Boutrif, 2003).

The protein digestibility corrected amino acid score (PDCAAS) has been adopted by FAO/WHO as the preferred method for the measurement of the protein quality in human nutrition. The method is based on comparison of the concentration of the first limiting essential amino acid in the test protein with the concentration of that amino acid in a reference pattern. The chemical score obtained in this way is corrected for true digestibility of the test protein (Schaafsma, 2000).

Based on the PDCAAS value, protein quality of Lamuru, Srikandi kuning and Bisi-2 were higher than Srikandi Putih (Table 3). Protein quality of Srikandi kuning was higher than protein quality of Bisi-2, but not significantly different with Lamuru. Between Indonesian common maizes, Bisi 2 had the lowest PDCAAS. Low PDCAAS value of Srikandi putih could be caused by its low amino acid score value.

CONCLUSSION

Limiting amino acid of the maizes in the present study was lysine. Amino acid score of Lamuru and Srikandi kuning was superior to Srikandi Putih and Bisi-2 (69, 67, 34 and 57 respectively). Protein efficiency ratio (PER) value of QPM was higher than those in common maize. Protein true digestibility of Bisi-2 (74%) was the highest compared to Lamuru (67%), Srikandi Kuning (64%) and Srikandi Putih (64%). However, the highest value of protein digestibility corrected amino acid score was Lamuru (46). These data suggested that Lamuru maize was not less superior to Srikandi Putih or Srikandi Kuning, the quality protein maizes (QPM) based on their protein quality. Thus Lamuru maize is potential for staple food.

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