

EFFECT OF HEAT TREATMENT ON NUTRITIONAL VALUE OF WINGED BEAN (*Psophocarpus tetragonolobus*) AS COMPARED TO SOYBEAN II. AMINO ACIDS DIGESTIBILITY

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Summary

The effect of heat treatment (autoclave) on amino acid digestibility of winged bean determined using intact cockerels had been investigated. The winged beans were autoclaved at 120°C for 45 or 90 min, respectively, and the soybean were autoclaved for 45 min. The treated winged bean and soybean were fed to 3 intact cockerels, which had been previously starved for 24 h. Excreta were collected individually for 48 h. The amino acids contained in the diets and excreta were determined to measure the digestibility values. Apparent and true digestibilities of all amino acids except histidine of unheated winged bean were significantly ($p < 0.05$) lower than those of heated winged bean and soybean. Heat treatment significantly ($p < 0.05$) improved amino acid digestibility of winged bean. However, over heating (90 min of autoclaving) destroyed lysine, cystine and arginine of winged bean. The true digestibility values of all amino acids of winged bean heated for 90 min were the same as those values of treated soybean. However, true digestibilities of glycine, alanine, phenylalanine and lysine of treated soybean were significantly ($p < 0.05$) higher than those of winged bean heated for 45 min.

(Key Words: Winged Bean, Soybean, Heat Treatment, Amino Acid Digestibility)

Introduction

Winged bean (*Psophocarpus tetragonolobus*) is a tropical legume that is grown almost exclusively in Southeast Asia and Papua New Guinea (NAS, 1981). The winged bean seed has a high protein content (32-37%) and amino acid composition of this bean is similar to that of soybean with methionine and cystine being limiting amino acids (Okezie and Martin, 1980; Wyckoff et al., 1983). However, lack of information about amino acid digestibilities of this bean, it may be due to techniques which are cumbersome and which are limited to the examination of a single amino acid at a time. The little work that has been done on this subject has generally been concentrated on *in vitro* protein digesti-

bilities (Tan et al., 1984; Ekpenyong and Borchers, 1980). Knowledge about this amino acid digestibility will be useful to evaluate a substitution of soybean by winged bean in animal feeds especially in poultry diets.

In previous study, the authors carried out experiments concerning the chemical characteristics of heat-treated winged bean (Mutia and Uchida, 1993), the purpose of the present study was to evaluate the effect of heat treatment (autoclave) on amino acid digestibilities of winged bean as compared to soybean using intact cockerels. The procedure employed in this experiment was based on the "rapid bioassay" technique, developed by Likuski and Dorrel (1978) and Sibbald (1979). Compared with growth assays which are widely accepted as the standard for determining availability of amino acids, the precision fed cockerels assay is rapid and inexpensive, and it provides digestibility estimates of several or all amino acids in feed ingredients. Furthermore, Nordheim and Coon (1984) and Parson (1986) have demonstrated that the result of such digestibility studies show good agreement with those of availability trials in which chick growth was the response measured.

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Materials and Methods

Materials

The winged bean and soybean seeds were obtained from local cultivars grown in Indonesia. The beans were cracked to pass a 0.5 cm screen and then were autoclaved at 120°C for 45 and 90 min, respectively except for soybeans that were autoclaved for 45 min. These beans were allowed to cool at room temperature before being grounded to pass a 1 mm screen.

Digestibility assays

Three adult Single Comb White Leghorn cockerels for each treatment were used in digestibility assays. The birds were housed in individual wire cages placed in an environmentally controlled room and they received 24 h of light daily. Feed and water were supplied *ad libitum* before the experiment was started. The assay procedure was described by Sibbald (1979). Following a 24 h fast, each cockerel was fed about 23-30 g of the test feedstuff. A similar number of cockerels were fasted throughout the experimental period to measure endogenous amino acid excretion. A plastic tray was placed under each cage and excreta were collected quantitatively for 48 h. The excreta were dried, weighed and ground to pass through a 1 mm screen.

Chemical analysis

Moisture and total nitrogen were determined according to the standard procedure of AOAC (1980). The amino acids were determined by a JEOL, JLC-300 amino acid analyser after acid hydrolysis of samples in 6 N HCl in evacuated sealed tubes at 110°C for 22 h. The trypsin inhibitors were determined according to the method described by Hamerstrand et al. (1981).

Calculation and statistical analysis

Digestibility of amino acids was calculated as the method of Sibbald (1979) as the following:

$$\text{Apparent digestibility (\%)} = \frac{\text{AA input} - \text{AA output}}{\text{AA input}} \times 100$$

$$\text{True digestibility (\%)} = \frac{\text{AA input} - (\text{AAf} - \text{AAc})}{\text{AA input}} \times 100$$

AA = Amino acids

AAf = Amino acids excreted by fed bird

AAc = Amino acids excreted by negative control bird

Experimental data were analyzed by analysis of variance procedure (SAS, 1987). Significant differences between means were calculated according to Duncan's multiple range test.

Results and Discussion

The crude protein, amino acid and trypsin inhibitors content of winged bean and soybean are shown in table 1. Some amino acids contained in winged bean (valine, leucine, tyrosine, histidine, lysine and proline) were higher than those in soybean. However, the other amino acids of winged bean were lower than that of soybean. Change in the composition of amino acid by heat treatment was quite small, however cystine, lysine and arginine content of winged bean decreased as heating time increased from 0 to 90 min.

The apparent digestibility of amino acids of winged bean and soybean is presented in table 2. The apparent digestibility values of all amino acids except histidine of unheated winged bean were significantly ($p < 0.05$) lower than those of heated winged bean or soybean. Heat treatment had significant ($p < 0.05$) effect to improve apparent digestibility of amino acids of winged bean. The apparent digestibility values for all amino acids of soybean were greater than those values of heated winged bean, but these values were not differ significantly.

The true digestibility of amino acids of winged bean and soybean is presented in table 3. True digestibilities of all amino acids except histidine of unheated winged bean were significantly ($p < 0.05$) lower than those of heated winged bean or soybean. Heat treatment significantly ($p < 0.05$) increased true digestibility of all amino acids of winged bean except histidine. Compared to soybean, there is no significant difference in true digestibility of amino acids of winged bean heated for 90 min. However, the true digestibilities of glycine, alanine, phenylalanine and lysine of soybean were significantly ($p < 0.05$) higher than those of winged bean heated for 45 min.

The results of this experiment showed that heat treatment improved amino acid digestibility of winged bean as well as soybean. This im-

NUTRITIONAL VALUE OF WINGED BEAN

TABLE 1. AMINO ACID COMPOSITION, CRUDE PROTEIN AND TRYPSIN INHIBITORS OF WINGED BEAN AND SOYBEAN

Item	Treatments			
	WB-0 ¹	WB-45	WB-90	SB-45 ²
Amino acids:	(AA g/10 g N)			
ASP	9.85	9.86	9.88	10.28
THR	3.55	3.53	3.54	3.37
SER	4.67	4.62	4.65	4.67
GLU	12.39	12.30	12.18	16.13
GLY	3.65	3.66	3.64	3.81
ALA	3.60	3.61	3.60	3.85
CYS	0.85	0.79	0.69	0.92
VAL	4.50	4.58	4.56	4.21
MET	0.62	0.63	0.64	0.75
ILEU	4.00	4.04	4.02	4.07
LEU	7.42	7.41	7.45	6.85
TYR	3.80	3.74	3.86	2.87
PHE	4.51	4.62	4.75	4.90
HIS	2.83	3.13	3.07	2.55
LYS	6.03	5.65	5.19	5.17
ARG	5.12	4.87	4.61	5.79
PRO	5.19	5.22	5.22	4.45
CP (% DM) ³	38.25	38.75	38.43	42.17
TI (mg/g) ⁴	16.92	2.22	2.08	1.61

¹ WB - Winged bean heated for 0, 45 or 90 min

² SB = Soybean heated for 45 min.

³ CP = Crude protein.

⁴ TI = Trypsin inhibitors.

provement may partially be due to reduction in trypsin inhibitor. In this experiment trypsin inhibitor content of winged bean reduced from 16.92 to 2.08 mg/g as heating time increased from 0 to 90 min (table 1). As pointed out by other workers, winged bean has trypsin inhibitor which is heat labile and can be destroyed by heat processing (de Lumen and Salamat, 1980). Ekpenyong and Borchert (1980) and Tan et al. (1984) reported a significant improvement in *in vitro* protein digestibility with concomitant decrease in trypsin inhibitor and tannin levels in winged bean meal as a result of moist heat treatment. Heat treatment not only inactivates protease inhibitors but also permits the opening of protein structure through denaturation thus the proteolytic enzyme attacked easily.

The biological activity of most protein is destroyed by exposure to strong heat. Lysine is one of the most heat labile amino acid, so the

decrease in the digestibility of lysine is a useful indicator of the effects of heat treatment and 'quality' of the heated protein source (Johns et al., 1986). In this experiment lysine content of winged bean decreased as heat treatment increased from 0 to 90 min. However, lysine digestibility increased significantly ($p < 0.05$) in heated winged bean. The same pattern was also found in arginine and cystine. The improvement of digestibility in heated winged bean might be due to reduction of protease inhibitors.

Green et al. (1987) reported that apparent and true digestibilities of amino acids in soybean were 77.9 and 88.1%, respectively (mean values of intact and caecotomised cockerels). In present experiment, mean values of apparent and true digestibility in soybean are slightly lower (73.9 and 85.7%, respectively). There is a lack of published data on the digestibility of amino acids from winged bean as measured by the technique

MUTIA AND UCHIDA

TABLE 2. EFFECT OF HEAT TREATMENT ON APPARENT DIGESTIBILITY (%) OF AMINO ACIDS IN WINGED BEAN AND SOYBEAN

Amino acids	Treatments			
	WB-0 ¹	WB-45	WB-90	SB-45 ²
ASP	53.59 ^a	72.29 ^b	67.69 ^b	78.12 ^b
THR	43.71 ^a	65.35 ^b	65.89 ^b	74.06 ^b
SER	47.97 ^a	70.28 ^b	69.44 ^b	78.71 ^b
GLU	56.20 ^a	73.42 ^b	72.09 ^b	83.32 ^c
GLY	26.57 ^a	42.57 ^{ab}	45.21 ^{ab}	61.44 ^b
ALA	44.36 ^a	60.03 ^b	63.90 ^{bc}	73.87 ^c
CYS	22.56 ^a	46.06 ^b	54.04 ^{bc}	70.34 ^c
VAL	44.86 ^a	69.22 ^b	70.91 ^b	76.76 ^b
MET	44.55 ^a	62.98 ^{ab}	66.34 ^b	80.89 ^b
ILEU	48.92 ^a	73.13 ^b	75.43 ^{bc}	80.41 ^c
LEU	53.01 ^a	75.58 ^b	77.02 ^b	81.13 ^b
TYR	49.13 ^a	67.16 ^b	68.00 ^b	70.35 ^b
PHE	44.94 ^a	68.66 ^b	71.78 ^{bc}	78.43 ^c
HIS	84.62 ^a	82.96 ^b	65.70 ^b	83.04 ^b
LYS	55.02 ^a	66.33 ^b	67.94 ^b	78.26 ^c
ARG	55.11 ^a	71.89 ^a	75.98 ^a	84.81 ^b
PRO	49.79 ^a	69.69 ^b	67.72 ^b	77.11 ^b

¹ WB = Winged bean heated for 0, 45 or 90 min.² SB = Soybean heated for 45 min.^{a,b,c} Means in the same row with different superscripts differ significantly ($p < 0.05$).

TABLE 3. EFFECT OF HEAT TREATMENT ON TRUE DIGESTIBILITY (%) OF AMINO ACIDS IN WINGED BEAN AND SOYBEAN

Amino acids	Treatments			
	WB-0 ¹	WB-45	WB-90	SB-45 ²
ASP	63.39 ^a	81.00 ^b	77.37 ^b	84.72 ^b
THR	60.73 ^a	80.70 ^b	82.96 ^b	86.74 ^b
SER	64.44 ^a	85.54 ^b	86.34 ^b	90.64 ^b
GLU	68.12 ^a	84.30 ^a	84.32 ^a	89.89 ^a
GLY	55.01 ^a	72.76 ^{ab}	78.13 ^b	84.71 ^b
ALA	61.62 ^a	75.77 ^b	81.41 ^{bc}	85.57 ^c
CYS	61.55 ^a	85.98 ^b	91.32 ^b	97.58 ^b
VAL	59.07 ^a	82.05 ^b	85.20 ^b	87.83 ^b
MET	67.83 ^a	84.18 ^{ab}	89.42 ^b	95.00 ^b
ILEU	60.07 ^a	83.22 ^b	86.65 ^b	88.34 ^b
LEU	63.97 ^a	85.64 ^b	88.12 ^b	89.74 ^b
TYR	67.18 ^a	83.56 ^b	85.81 ^b	87.21 ^b
PHE	60.08 ^a	81.87 ^b	86.13 ^{bc}	88.28 ^c
HIS	97.59 ^a	89.26 ^a	78.09 ^a	94.46 ^a
LYS	65.19 ^a	77.42 ^b	81.09 ^{bc}	87.97 ^c
ARG	67.11 ^a	85.76 ^b	91.80 ^b	94.20 ^b
PRO	66.39 ^a	84.74 ^b	84.54 ^b	91.06 ^b

¹ WB = Winged bean heated for 0, 45 or 90 min.² SB = Soybean heated for 45 min.^{a,b,c} Means in the same row with different superscripts differ significantly ($p < 0.05$).

NUTRITIONAL VALUE OF WINGED BEAN

employed in this experiment. The true digestibility values of amino acids of winged bean were higher and less variable compared to apparent digestibility values. It is due to correction of endogenous amino acids.

The true digestibility values of amino acids of heated winged bean were similar to those of soybean. This means that winged bean protein not only had similar amino acid composition but it also had similar digestibility of each amino acid. It seems to be concluded that winged bean can be fed to the animal including poultry instead of soybean.

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