AMINO ACID AVAILABILITY OF SOME POULTRY FEEDSTUFFS AS AFFECTED BY HEAT STRESS AND ENZYME SUPPLEMENTATION

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SUMMARY

Four similar experiments were conducted with four feed ingredients, mung beans, sorghum, rice bran and wheat bran. Each experiment was carried out to evaluate the bioavailability of amino acids of each feed ingredients understudy. Apparent amino acid availability (AAAA) and true amino acid availability (TAAA) were evaluated either under thermoneutral (24 ºC) or cyclic heat stress (8 hrs at 38 ºC and 16 hrs at 24 ºC) without or with enzyme supplementation (optizyme at level of 300 mg/kg or phytase at level of 1500 FTU/kg feed). Forty sixteen month old mature Dandarawi roosters divided into eight groups of five birds each were used in these experiments. Force feeding was applied for determining AAAA and TAAA. The results showed that:

1- *The effect of heat stress at 38 ºC on apparent and true availability of amino acids differed according to the feedstuff under study and to the amino acid itself.*
2- *The impact of enzyme supplementation on amino acids availability tended to be positive in general.*
3- *The interaction between thermoneutral conditions and optizyme supplementation significantly ($P<0.05$) increased both AAAA and TAAA values in sorghum, rice bran and wheat bran. Also, phytase supplementation had a similar effect in case of mung beans. Moreover, enzyme supplementation (optizyme or phytase) under heat stress significantly increased the values of the overall mean of AAAA and TAAA of all amino acids of the four feedstuffs under study. The effect of optizyme was more pronounced than that of phytase.*

Keywords: Amino acid availability, Dandarawi chickens, mung beans, heat stress

INTRODUCTION

Several studies revealed that heat stress has negative effects on poultry performance. In experiments with laying hens, high constant or cyclic temperature led to a reduction in egg production and egg quality (Marsden *et al.,* 1987 and Peguri and Coon, 1991). In broilers, high environmental temperature decreased growth rate (Howlider and Rose, 1987); weight gain (Cahaner *et al.,* 1993) and feed intake (Cooper and Washburn, 1998 and Veldkampal *et al*., 2000).

Zuprizal *et al.* (1993) found that true digestibility of amino acids of raw rapeseed and soybean meal was decreased as the ambient temperature increased from 21 ºC to

32 ºC. A 12% reduction in true digestibility of protein value was observed with the rapeseed meal whereas the reduction was only 5 % with the soybean meal.

Makled *et al*. (2000) found that cyclic and consistant heat stress depressed digestibility of amino acids and the depression was higher in wheat bran compared to corn, soybean meal and sorghum.

On the other hand, Koelkebeck *et al.* (1998) found that heat stress generally had no significant effect on amino acid digestibility except for histidine and lysine digestibility which was higher during heat stress period compared to the initial thermoneutral period. So in their study, heat stress showed no adverse effect on dietary amino acid digestibility in laying hens.

Phytase supplementation improved nitrogen retention in laying hens (Van der Kils and Versteegh, 1991) and in broiler chickens (Farrell *et al*., 1993). The addition of phytase at level of 900 FTU/kg feed exerted a positive effect on the apparent ileal digestibility of crude protein as well as lysine, tryptophan, isoleucine and threonine (Kemme *et al*., 1995). Attia *et al.* (2001) reported that amino acids availability were improved when phytase was added at 1000 FTU /kg feed. The magnitude of improvement is the highest in corn followed in a descending order by rice polishing and soybean meal. Wu *et al.* (2003) found that the use of phytase was beneficial in increasing nutrient digestibility of wheat for broilers. Ravindran *et al*. (1999) reported that improvements in ileal amino acid digestibility generated by phytase were markedly greater in wheat than maize. Wu *et al.* (2004) reported that the addition of microbial phytase was effective in improving the performance of broiler chickens fed on wheat-based diets. Also, they found that improved performance with enzyme supplementation was associated with reduced digesta and reduced relative weight and length of small intestine.

On the other hand, Peter and Baker (2001) concluded that dietary addition of phytase didn't improve sulfur amino acid utilization in soybean meal.

Veldkamp *et al.* (2000) studied the effects of interaction between ambient temperature and supplementation of synthetic amino acid on performance of commercial male turkeys. They found that the production performance did not respond positively to extra supplementation of lysine, methionine and threonine when subjected to heat stress.

The aim of the present study was to determine the impact of enzyme supplementation in a single form (phytase) or a mixture form (optizyme) under thermoneutral or heat stress conditions on amino acids bioavalability of mung beans, sorghum, rice bran and wheat bran.

MATERIALS AND METHODS

1. Birds and management

This study was carried out at the Poultry Research Farm, Faculty of Agriculture, Assiut University, Assiut, Egypt. Four similar experiments were conducted with four feed ingredients: mung beans, sorghum, rice bran and wheat bran. Each experiment was carried out to evaluate the bioavailablity of amino acids (apparent amino acid availability, **AAAA** and true amino acids availability, **TAAA**) of each one of the feed ingredients under study either under thermoneutral or cyclic heat stress; with or without enzymes supplementation either in a single form (phytase) or in a blend form (optizyme).

In each experiment, forty, Dandarawi roosters 16-month old were randomly assigned into eight groups of five birds each. Group 1 (general control) in which birds were kept under thermoneutral conditions (24 ºC) and received the feed under study without enzymes supplementation. Group 2 (Control for group 5) was kept under thermoneutral conditions (24 ºC) and received the feed understudy beside optizyme supplement at 300 mg/kg feed. Group 3 (control for group 6) was kept under thermoneutral conditions (24 ºC) and received the feed understudy beside phytase supplement at 1500 FTU/kg feed. Group 4 (birds were kept under cyclic heat stress (8 hrs at 38 ºC and 16 hrs at 24 ºC) and received the feed understudy without any enzyme supplementation. Group 5: As group 4, however, birds received the feed under study beside optizyme supplement at 300 mg/kg feed. Group 6: As group 4, however, birds received the feed under study beside phytase supplement at 1500 FTU/kg feed. Group 7 was kept fasted for the whole experimental period under thermoneutral conditions (i.e. fasted control birds). Group 8 was kept fasted for the whole experimental period under cyclic heat stress (i.e. fasted heat stressed control birds).

The experiments were conducted using force feeding methodology of Sibbald (1976). Therefore, the birds were kept individually in cages with plastic trays under cages to collect the excreta. Each experiment lasted for 18 days according to the following time table: Day 1, roosters were moved to the experimental chamber in the afternoon. Day 2 to day 14: adjustment period (feed and water *ad lib*.). Days 15 and 16: fasting period (feed off for 30 hrs). Day 16: Funnel force feeding (at the end of fasting period, birds were fed using funnel and forced with 30 g for mung beans or sorghum or with 20 g for rice bran or wheat bran). Day 16 to 18: excreta collection (for 48 hrs, starts just after funnel feeding). All tested materials were forced fed as alone (100%) or mixed with enzymes under study.

The mentioned above steps were done for groups 1, 2, 3 and 7 under thermoneutral conditions and for groups 4, 5, 6 and 8 under cyclic heat stress.

The birds were kept for recovery period (14 days) between each two following experiments.

2. Enzyme preparations

The enzyme preparations used in this study were 1. Microbial phytase which produced from *Aspergillus neiger* in a powder produced by Gistbrocades, The Netherlands and BASF, Germany, at two levels (0 and 1500 FTU/kg. FTU is the quantity of enzyme required to produce 1 micromol of inorganic phosphorus/min from 5.1 mmol/L of Na phytate at a pH of 5.5 and a water-bath temperature of 37 ºC (Boling *et al.,* 2000). The 1500 FTU used in the present study equal to 0.3 g phytase/kg tested material. 2. Optizyme produced by Optivite International LTD, Main street, Laneham, Retford, Nottinghamshire, DN 22 OVA, England, at two levels (0 and 0.3 g/kg tested material). Optizyme is a blend of enzymes which contains proteases, hemicellulases, cellulases, xylanase, β-glucanase and amyloglucosidases.

3. Preparation of excreta samples for analysis

Excreta collected at the end of each experiment, was dried in electric oven at 70ºC for 24 hrs. Samples of dried excreta were weighed and ground to pass through a 20-

mesh sieve, left for 24 hrs in Lab. for moisture equilibrium and stored in glass containers till analysis.

4. Amino acids determination

Feed and excreta samples were prepared for amino acids determination using technique of Smith *et al.* (1965) then amino acid determination were carried out using Amino Acid Analyzer Model 119 CL. The results obtained were expressed as percentage (g amino acid/100 g feed).

5. Calculation of bioavailability of amino acid (AAAA and TAAA)

Apparent amino acid availability (AAAA %) and true amino acid availability (TAAA %) were calculated according to Sibbald (1986) and Mohamed *et al.* (1991) as follows:

$$AAAA\ \% = [(AA_i - AA_{ef}) / AA_i] \times 100$$

Where AA_i is the total amount (g) of amino acid of tested material which fed to the bird and was calculated as follows: $AA_{I} = F_i \times AAP_f$

Where: F_i is feed intake (g).

AAP_f is the amino acid (%) of fed-tested material.

AA_{ef} is the total amount (g) of amino acid excreted by the fed tested material birds and was calculated as follows:

$AA_{ef} = E_{fw} \times AAP_{ef}$

Where: E_{fw} is excreta weight (g) voided by test material-fed birds, and

AAP_{ef} is the amino acid % of excreta voided by test material-fed birds.

$$TAAA\ \% = [(AA_i - (AA_{ef} - AA_{ec})/ AA_i] \times 100$$

Where : AA_{ec} is the mean amount (g) of amino acid excreted by the fasted control birds and was calculated as follows:

$AA_{ec} = E_c \times AAP_{ec}$

Where: E_c is the mean excreta weight (g) voided by fasted control birds.

AAP_{ec} is the mean amino acid % of excreta voided by fasted control birds.

6. Statistical analysis

Statistical analysis for amino acids bioavailability were conducted using the General Linear Model (GLM) procedure of SAS (SAS Institute 1987). The factors tested were enzymes and temperature beside the interaction between enzymes and temperature. The following model was used:

$$Y_{ijk} = \mu + T_i + P_j + (TP)_{ij} + e_{ijk} .$$

Where Y = the observation.

μ = General mean.

T_i = effect due to temperature.

P_j = effect due to enzymes supplementation.

TP_{ij} = effect of interaction between enzymes and temperature.

e_{ijk} = the error related to individual observation.

The significant differences between treatment means were tested by Duncan multiple range test (Duncan, 1955). While, the significant differences between interactions were tested by least square differences.

RESULTS AND DISCUSSION

The values of apparent and true amino acid availability of the tested materials understudy as affected by heat stress, enzymes and their interactions are presented in Tables 1 to 8.

1. Effect of heat stress on amino acid availability

In regard to the availability of amino acids in mung beans, the results showed that heat stress didn't show any significant effect on both AAAA and TAAA values. This result is in agreement with the results reported by Koelkebeck *et al.* (1998); however, it is in a disagreement with the results reported by Makled *et al.* (2000) who used different feedstuffs rather from mung beans. Also, heat stress had adverse effects on apparent availability of some amino acids of mung bean. It significantly ($P<0.05$) decreased AAAA of threonine, glutamic acid, proline and glycine while significantly ($P<0.05$) increased AAAA of cystine. In regard to TAAA, it significantly increased the values of cystine, methionine and cystine + methionine.

AAAA values for sorghum were significantly decreased by heat stress, while it significantly increased TAAA values.

For rice bran, heat stress didn't affect AAAA, while it significantly increased TAAA value.

Heat stress significantly ($P<0.05$) decreased AAAA, while it significantly increased TAAA values.

Wallis and Blanave (1984) showed that increasing temperature from 21 to 31 C caused a significant decrease in threonine, alanine, methionine, isoleucine and leucine digestibility for broilers. Zuprizal *et al.* (1993) showed that the digestibility of most amino acids were significantly depressed for broilers exposed to 32 C than 21 C. They also noticed that the effect of heat stress was more pronounced in female than males when fed either a whole rapeseed meal, dehulled rapeseed meal or soybean meal diet.

The present results of amino acids availability are in partial agreement with the results reported by Koelkbeck *et al.* (1998). They found no adverse effect of heat stress on dietary amino acid digestibility in laying hens, however, they are in disagreement with the results reported by Makled *et al.* (2000).

Heat stress significantly ($P<0.05$) decreased some apparent availability of amino acids of rice bran, but it significantly increased most of true amino acid availability in rice bran except true availability of lysine. The increase in AAAA and TAAA of some amino acids may be attributed heat stress decreasing the feed passage rate (Wilson *et al*. 1980) and that might enhance nutrient absorption.

Similar results were found for AAAA and TAAA of some amino acids in sorghum. It may be noticed that the true availability of cystine and lysine was very high compared to their apparent availability. This was because the endogenous output of the fasted birds under heat stress (control) contained high concentration of amino acids.

Table 1. Apparent amino acid availability of mung beans

Amino acids	Temperature			Enzymes				Temperature x Enzymes						
	Thermon-eutral (N)	Stress (S)	P*	Without (W)	Optizyme (OP)	Phytase (PH)	P*	N x W	N x OP	N x PH	H x W	H x OP	H x PH	P*
Threonine	69.3^{a}	61.6^{b}	*	56.5^{b}	67.6^{a}	72.3^{a}	*	61.7^{bc}	65.0^{b}	81.2^{a}	51.4^{c}	70.1^{ab}	63.4^{bc}	*
Serine	75.4	69.5	NS	68.4	76.4	72.6	NS	72.8^{ab}	74.3^{ab}	79.2^{a}	64.0^{b}	78.5^{a}	66.1^{b}	*
Glutamic	86.8^{a}	81.9^{b}	*	83.0	86.3	83.8	NS	86.7^{a}	86.5^{ab}	87.3^{a}	79.3^{c}	86.1^{a}	80.3^{bc}	*
Proline	70.3^{a}	56.6^{b}	*	59.7	66.4	64.3	NS	68.0^{a}	69.7^{a}	73.2^{a}	51.5^{bc}	63.0^{ab}	55.4^{b}	*
Glycine	73.5^{a}	64.5^{b}	*	64.3^{b}	76.2^{a}	66.4^{b}	*	71.7^{a}	76.3^{a}	72.5^{a}	56.8^{c}	76.2^{a}	60.4^{bc}	*
Cystine	37.6^{b}	62.0^{a}	*	28.0^{b}	60.2^{a}	61.2^{a}	*	30.8^{c}	39.4^{b}	42.5^{b}	25.2^{c}	81.0^{a}	79.8^{a}	*
Valine	77.8	70.9	NS	69.0	79.6	74.4	NS	77.0^{a}	78.2a	78.1^{a}	61.1^{b}	80.9^{a}	70.7^{ab}	*
Methionine	68.8	68.9	NS	61.6^{b}	75.5^{a}	69.4^{a}	*	64.1^{ab}	72.7^{a}	69.6^{a}	59.2^{b}	78.3^{a}	69.2^{a}	*
Isoleucine	76.6	73.4	NS	72.9^{ab}	79.9^{a}	72.2^{b}	*	75.4^{abc}	76.3^{ab}	78.0^{ab}	70.5^{bc}	83.4^{a}	66.3^{c}	*
Leucine	78.1	79.2	NS	75.1	82.0	78.8	NS	76.9	80.0	77.3	73.4	84.0	80.2	NS
Tyrosine	77.5	72.5	NS	69.3^{b}	82.1^{a}	73.6^{b}	*	74.9^{ab}	80.3^{ab}	77.2^{ab}	63.7^{c}	84.0^{a}	69.9^{bc}	*
Phenylala.	80.9	77.7	NS	75.4	83.3	79.1	NS	79.4^{ab}	80.3^{ab}	82.9^{ab}	71.3^{b}	86.3^{a}	75.4^{ab}	*
Histidine	50.6	53.6	NS	43.1^{b}	45.6^{b}	67.6^{a}	*	40.6^{b}	41.8^{b}	69.5^{a}	45.7^{b}	49.4^{b}	65.9^{a}	*
Lysine	82.3	74.9	NS	76.1	83.7	75.9	NS	80.5^{ab}	83.9^{a}	82.4^{ab}	71.7^{ab}	83.5^{a}	69.4^{b}	*
Arginine	77.8	72.2	NS	72.8	80.9	71.3	NS	77.4	81.9	74.0	68.2	79.4	68.5	NS
Cys + Met.	53.2^{b}	65.4^{a}	*	44.8^{b}	67.8^{a}	65.3^{a}	*	47.5^{c}	56.0^{b}	56.0^{b}	42.2^{c}	79.6^{a}	74.5^{a}	*
Average	72.2	69.3	NS	65.0^{b}	75.0^{a}	72.2^{a}	*	69.2^{b}	72.4^{ab}	75.0^{a}	60.9^{c}	77.6^{a}	69.2^{b}	*

a,b,… Means within a row within each effect with no common superscript are significantly different ($P < 0.05$)

Table 2. True amino acid availability of mung beans

	Temperature			Enzymes				Temperature X Enzymes						
Amino acids	**Thermon-eutral (N)**	**Stress (S)**	**P**	**Without (W)**	**Optizyme (OP)**	**Phytase (PH)**	**P**	**N x W**	**N x OP**	**N x PH**	**H x W**	**H x OP**	**H x PH**	**P**
Threonine	73.9	71.7	NS	62.2^{b}	76.6^{a}	79.6^{a}	*	66.3^{bc}	69.7^{bc}	85.8^{a}	58.0^{c}	83.6^{ab}	73.3^{b}	*
Serine	78.6	76.5	NS	72.4^{b}	82.6^{a}	77.7^{ab}	*	76.0^{abc}	77.5^{abc}	82.4^{ab}	68.7^{c}	87.7^{a}	73.1^{bc}	*
Glutamic	88.3	86.3	NS	85.6	89.1	87.3	NS	88.1^{ab}	88.0^{ab}	88.8^{ab}	83.0^{b}	90.2^{a}	85.8^{ab}	*
Proline	73.4	74.1	NS	69.1	78.1	77.0	NS	73.1^{ab}	74.8^{ab}	78.3^{ab}	65.1^{b}	81.4^{a}	75.8^{ab}	*
Glycine	77.0	74.4	NS	70.3^{b}	82.3^{a}	74.6^{ab}	*	75.3^{abc}	79.8^{ab}	76.0^{abc}	65.3^{c}	84.8^{a}	73.1^{bc}	*
Cystine	62.9^{b}	87.3^{a}	*	51.9^{c}	83.0^{b}	90.5^{a}	*	56.1^{d}	64.7^{c}	67.8^{c}	47.6^{d}	101.2^{b}	113.1^{a}	*
Valine	79.7	79.4	NS	73.2^{b}	85.3^{a}	80.2^{ab}	*	78.9^{ab}	80.2^{ab}	80.1^{ab}	67.5^{b}	90.4^{a}	50.3^{ab}	*
Methionine	73.8^{b}	83.7^{a}	*	69.5^{b}	86.8^{a}	79.7^{a}	*	69.1^{c}	77.7^{bc}	74.6^{c}	69.9^{c}	95.9^{a}	85.3^{b}	*
Isoleucine	78.6	82.5	NS	77.5^{b}	85.7^{a}	78.5^{ab}	*	77.4^{b}	78.4^{b}	80.1^{b}	77.6^{b}	93.0^{a}	77.0^{b}	*
Leucine	80.1^{b}	88.5^{a}	*	80.1	87.2	85.7	NS	78.9^{a}	82.0^{a}	79.3^{a}	81.3^{a}	92.3^{a}	92.0^{a}	NS
Tyrosine	79.3	80.6	NS	73.0^{b}	88.1^{a}	78.7^{b}	*	76.7^{bc}	82.0^{b}	79.0^{bc}	69.3^{a}	94.0^{a}	78.4^{bc}	*
Phenylala.	82.4	82.7	NS	78.3	86.3	83.1	NS	81.0^{ab}	81.8^{ab}	84.4^{ab}	75.6^{b}	90.8^{a}	81.8^{ab}	*
Histidine	58.4	63.3	NS	50.6^{b}	54.9^{b}	77.0^{a}	*	48.3^{c}	49.5^{c}	77.2^{a}	53.0^{c}	60.2^{bc}	76.8^{ab}	*
Lysine	83.4	79.5	NS	78.2	87.3	78.7	NS	81.6^{ab}	85.2^{ab}	83.5^{ab}	74.8^{b}	89.6^{a}	74.0^{ab}	*
Arginine	79.6	78.4	NS	75.5	85.6	74.9	NS	79.2^{a}	83.7^{a}	75.8^{a}	72.6^{a}	87.5^{a}	75.1^{a}	NS
Cys + Met.	68.3^{b}	85.5^{a}	*	69.9^{c}	84.6^{a}	77.3^{b}	*	72.2^{bc}	78.7^{b}	75.3^{bc}	76.6^{c}	90.4^{a}	79.2^{b}	*
Average	79.3	76.8	NS	71.2^{c}	82.3^{a}	80.3^{b}	*	73.7^{c}	77.0^{bc}	79.5^{b}	68.6^{d}	88.2^{a}	81.0^{b}	*

a,b,… Means within a row within each effect with no common superscript are significantly different ($P < 0.05$)

Table 3. Apparent amino acid availability of sorghum grains

	Temperature			Enzymes				Temperature X enzymes						
Amino acids	**Thermon-eutral (N)**	**Stress (S)**	**P***	**Without (W)**	**Optizyme (OP)**	**Phytase (PH)**	**P***	**N x W**	**N x OP**	**N x PH**	**H x W**	**H x OP**	**H x PH**	**P***
Threonine	38.4^{a}	29.3^{b}	NS	29.1	36.3	36.2	NS	33.3^{ab}	41.4^{a}	40.5^{a}	24.9^{b}	31.2^{b}	31.8^{b}	*
Serine	49.3^{a}	35.8^{b}	*	34.4^{b}	48.5^{a}	44.8^{a}	*	43.5^{b}	50.9^{ab}	53.4^{a}	25.2^{c}	46.1^{a}	36.2^{b}	*
Glutamic	67.2^{a}	54.0^{b}	*	57.5	63.4	60.8	NS	65.9^{a}	68.5^{a}	67.2^{a}	49.1^{b}	58.2^{ab}	54.5^{b}	*
Proline	70.5	67.2	NS	60.4^{b}	76.2^{a}	69.8^{a}	*	64.7^{bc}	76.1^{ab}	70.6^{bc}	56.1^{c}	76.3^{a}	69.0^{ab}	*
Glycine	39.5	38.0	NS	35.8	40.1	40.5	NS	34.9	39.6	44.2	36.7	40.5	36.8	NS
Cystine	47.2	53.8	NS	38.3^{c}	48.9^{b}	64.2^{a}	*	32.8^{c}	55.0^{b}	53.7^{b}	43.8^{bc}	42.7^{bc}	74.7^{a}	*
Valine	68.9^{a}	55.1^{b}	*	52.6^{b}	67.8^{a}	65.7^{a}	*	64.5^{b}	86.2^{a}	66.5^{b}	42.9^{c}	85.4^{a}	70.4^{b}	*
Methionine	72.4	66.2	NS	53.7^{c}	85.8^{a}	68.4^{b}	*	66.4^{a}	76.9^{a}	72.4^{a}	38.8^{b}	67.7^{a}	58.9^{a}	*
Isoleucine	73.1^{a}	51.7^{b}	*	47.7^{b}	72.7^{a}	66.8^{a}	*	69.3^{a}	73.9^{a}	76.0^{a}	46.0^{c}	71.5^{a}	57.6^{b}	*
Leucine	76.5	71.8	NS	65.2^{b}	78.6^{a}	78.5^{a}	*	70.6^{a}	76.3^{a}	82.5^{a}	59.8^{b}	80.8^{a}	74.6^{a}	*
Tyrosine	45.8	52.8	NS	48.1^{b}	58.5^{a}	41.4^{b}	*	49.4^{a}	56.7^{a}	31.4^{b}	46.9^{a}	60.3^{a}	51.3^{a}	*
Phenylala.	70.0	62.8	NS	58.0^{b}	70.5^{a}	70.6^{a}	*	66.7^{a}	69.4^{a}	73.9^{a}	49.3^{b}	71.6^{a}	67.4^{a}	*
Histidine	41.6	44.5	NS	38.5^{b}	46.1^{a}	44.5^{b}	*	34.8^{b}	45.0^{a}	45.0^{a}	42.2^{b}	47.3^{a}	43.9^{ab}	*
Lysine	33.0^{b}	37.0^{a}	*	30.5^{b}	37.3^{a}	37.2^{a}	*	25.6^{b}	36.5^{a}	36.7^{a}	35.3^{a}	38.1^{a}	37.7^{a}	*
Arginine	61.2	54.4	NS	41.6^{b}	70.4^{a}	61.4^{a}	*	48.5^{b}	69.8^{a}	65.2^{a}	34.8^{b}	71.0^{a}	57.5^{ab}	*
Cys + Met.	59.8	60.0	NS	46.0^{b}	67.3^{a}	66.3^{a}	*	48.6^{b}	70.6^{a}	60.1^{b}	43.4^{c}	64.1^{b}	72.5^{a}	*
Average	61.2	54.4	NS	41.6^{b}	70.4^{a}	61.4^{a}	*	48.5^{b}	69.8^{a}	65.2^{a}	34.8^{b}	71.0^{a}	57.5^{ab}	*

a,b,… Means within a row within each effect with no common superscript are significantly different ($P< 0.05$)

Table 4. True amino acid availability of sorghum grains

	Temperature			Enzymes				Temperature X Enzymes						
Amino acids	Thermon-eutral (N)	Stress (S)	P^{*}	Without (W)	Optizyme (OP)	Phytase (PH)	P^{*}	N x W	N x OP	N x PH	H x W	H x OP	H x PH	P^{*}
Threonine	54.6^{b}	68.1^{a}	*	54.5^{b}	68.0^{a}	61.6^{ab}	*	49.5^{c}	57.7^{bc}	56.7^{bc}	59.5^{bc}	78.4^{c}	66.4^{ab}	*
Serine	71.5^{a}	64.1^{b}	*	58.0^{c}	77.0^{a}	68.4^{b}	*	58.3^{c}	65.7^{bc}	68.2^{b}	57.6^{c}	88.3^{a}	68.6^{b}	*
Glutamic	74.4	78.6	NS	74.6	76.9	77.9	NS	73.2^{a}	75.7^{a}	74.7^{a}	76.1^{a}	78.1^{a}	81.5^{a}	*
Proline	74.7^{b}	83.7^{a}	*	71.1^{b}	86.1^{a}	80.5^{a}	*	68.9^{c}	80.4^{b}	74.9^{b}	73.2^{b}	91.8^{a}	86.1^{ab}	*
Glycine	52.4^{b}	79.2^{a}	*	65.3	62.0	70.0	NS	74.7^{b}	52.4^{ab}	57.0^{ab}	83.0^{a}	71.7^{a}	83.0^{a}	*
Cystine	81.9	85.1	NS	67.5^{c}	78.5^{b}	104.4^{a}	*	67.5^{c}	89.7^{b}	88.4^{b}	89.5^{b}	45.4^{d}	120.3^{a}	*
Valine	73.7	78.5	NS	66.8^{b}	81.8^{a}	79.8^{a}	*	71.2^{bc}	72.7^{bc}	77.2^{ab}	62.3^{b}	91.0^{a}	82.4^{ab}	*
Methionine	78.6	83.0	NS	66.8^{c}	94.1^{a}	81.5^{b}	*	70.7^{b}	92.5^{a}	72.7^{b}	62.9^{b}	95.7^{a}	90.4^{a}	*
Isoleucine	80.3	84.2	*	70.2^{b}	87.2^{a}	89.3^{a}	*	76.5^{ab}	81.1^{a}	83.2^{a}	63.9^{b}	93.3^{a}	95.4^{a}	*
Leucine	81.4^{b}	78.1^{a}	*	82.3^{b}	91.4^{a}	95.6^{a}	*	75.5^{b}	81.3^{ab}	87.4^{ab}	89.0^{ab}	101.5^{a}	103.8^{a}	*
Tyrosine	51.9^{b}	82.4^{a}	*	65.1^{b}	78.1^{a}	58.3^{b}	*	55.4^{c}	62.8^{b}	37.5^{d}	74.7^{b}	93.4^{a}	79.2^{b}	*
Phenylala.	75.0	81.6	NS	70.9^{b}	80.4^{b}	83.6^{a}	*	71.7^{b}	74.5^{b}	78.9^{b}	70.2^{b}	86.3^{a}	88.2^{a}	*
Histidine	60.7^{b}	71.4^{a}	*	61.5^{b}	69.1^{a}	67.5^{b}	*	53.9^{c}	64.0^{b}	64.1^{b}	69.1^{ab}	74.2^{a}	70.8^{ab}	*
Lysine	44.9^{b}	74.2^{a}	*	61.2^{b}	49.1^{c}	67.9^{a}	*	37.5^{c}	48.5^{b}	48.7^{b}	50.5^{b}	87.2^{a}	84.8^{a}	*
Arginine	67.6^{b}	79.1^{a}	*	56.6^{b}	87.1^{a}	76.4^{a}	*	54.9^{c}	76.2^{b}	71.6^{b}	58.3^{c}	98.0^{a}	81.1^{b}	*
Cys + Met.	65.5^{b}	81.1^{a}	*	66.1^{b}	78.1^{a}	75.8^{a}	*	59.2^{c}	72.4^{b}	64.8^{bc}	72.9^{b}	83.7^{a}	86.7^{a}	*
Average	67.7^{b}	54.4^{a}	*	66.9^{b}	77.1^{a}	77.5^{a}	*	62.2^{c}	71.7^{b}	69.4^{b}	71.6^{b}	82.5^{a}	85.0^{a}	*

a,b,… Means within a row within each effect with no common superscript are significantly different ($P < 0.05$)

Table 5. Apparent amino acid availability of rice bran

Amino acids	**Temperature**			**Enzymes**				**Temperature X enzymes**						
	Thermon-eutral (N)	**Stress (S)**	**P***	**Without (W)**	**Optizyme (OP)**	**Phytase (PH)**	**P***	**N x W**	**N x OP**	**N x PH**	**H x W**	**H x OP**	**H x PH**	**P***
Threonine	30.9^{a}	27.2^{b}	*	22.2^{b}	31.9^{a}	33.0^{a}	*	23.6^{b}	34.4^{a}	34.7^{a}	20.8^{b}	29.4^{a}	31.3^{a}	*
Serine	34.0	34.0	NS	30.3^{b}	35.5^{a}	36.2^{c}	*	29.1^{b}	36.4^{a}	36.4^{a}	31.5^{b}	34.7^{a}	35.9^{a}	*
Glutamic	48.7	50.6	NS	37.8^{b}	54.8^{a}	56.6^{a}	*	36.4^{b}	52.4^{b}	57.4^{b}	39.2^{b}	52.1^{a}	55.7^{a}	*
Proline	57.3^{a}	44.0^{b}	*	38.1^{c}	63.2^{a}	50.8^{b}	*	55.7^{b}	60.0^{ab}	56.2^{b}	20.4^{d}	66.3^{a}	45.4^{c}	*
Glycine	39.8	39.4	NS	27.4^{c}	40.4^{b}	51.0^{a}	*	28.8^{d}	37.5^{c}	53.1^{a}	26.0^{d}	43.3^{b}	49.0^{b}	*
Cystine	67.9^{b}	75.8^{a}	*	62.5^{c}	70.2^{b}	82.9^{a}	*	57.6^{a}	72.0^{bc}	74.1^{b}	67.3^{c}	68.5^{bc}	91.8^{a}	*
Valine	36.4^{b}	49.9^{a}	*	29.9^{b}	49.0^{a}	50.5^{a}	*	28.8^{c}	37.4^{bc}	42.9^{b}	31.0^{bc}	60.6^{a}	58.2^{a}	*
Methionine	58.7^{a}	42.3^{b}	*	42.7^{b}	50.2^{a}	58.7^{a}	*	54.0^{a}	59.0^{a}	63.1^{a}	31.3^{c}	41.4^{b}	54.3^{a}	*
Isoleucine	64.0^{a}	58.1^{b}	*	53.6^{c}	69.8^{a}	58.8^{b}	*	62.6^{b}	68.2^{ab}	61.3^{b}	44.6^{c}	71.3^{a}	58.3^{b}	*
Leucine	70.0^{a}	59.5^{b}	*	55.3^{b}	71.3^{a}	67.6^{a}	*	64.0^{a}	71.7^{a}	74.3^{a}	46.6^{b}	70.9^{a}	60.9^{ab}	*
Tyrosine	53.8	56.8	NS	39.1^{c}	69.8^{a}	56.9^{b}	*	38.3^{c}	72.7^{a}	50.4^{b}	39.8^{bc}	67.0^{a}	63.5^{a}	*
Phenylala.	60.6^{a}	48.6^{b}	*	39.9^{b}	64.1^{a}	58.8^{a}	*	51.4^{b}	66.4^{a}	62.0^{ab}	28.3^{c}	61.8^{ab}	55.7^{ab}	*
Histidine	39.2^{b}	47.0^{a}	*	39.3^{b}	44.9^{c}	45.1^{a}	*	37.3^{b}	39.8^{b}	40.3^{b}	41.3^{b}	49.9^{a}	49.9^{a}	*
Lysine	43.6^{b}	51.2^{a}	*	26.2^{b}	58.1^{a}	57.9^{a}	*	25.0^{b}	53.1^{a}	52.6^{a}	27.3^{b}	63.0^{a}	63.2^{a}	*
Arginine	54.9	57.8	NS	39.1^{b}	67.9^{a}	62.0^{a}	*	44.1^{ab}	62.0^{a}	58.6^{a}	34.2^{b}	73.3^{a}	65.5^{a}	*
Cys + Met.	63.3	59.1	NS	52.5^{c}	60.2^{b}	70.8^{a}	*	55.8^{c}	65.5^{ab}	68.6^{a}	49.3^{c}	54.9^{c}	73.0^{a}	*
Average	50.5	49.5	NS	38.7^{b}	55.9^{a}	55.1^{a}	*	42.3^{b}	54.7^{c}	55.9^{a}	35.2^{c}	58.4^{a}	57.1^{a}	*

a,b,… Means within a row within each effect with no common superscript are significantly different ($P < 0.05$)

Table 6. True amino acid availability of rice bran

	Temperature			Enzymes				Temperature X enzymes						
Amino acids	**Thermon-eutral (N)**	**Stress (S)**	**P***	**Without (W)**	**Optizyme (OP)**	**Phytase (PH)**	**P***	**N x W**	**N x OP**	**N x PH**	**H x W**	**H x OP**	**H x PH**	**P***
Threonine	44.0^{b}	58.5^{a}	*	42.7^{b}	57.5^{a}	53.6^{a}	*	36.7^{d}	47.5^{c}	47.8^{c}	48.7^{c}	76.6^{a}	59.3^{b}	*
Serine	45.4^{b}	61.7^{a}	*	48.6^{b}	57.6^{a}	54.5^{a}	*	40.5^{c}	47.9^{d}	47.9^{d}	56.6^{c}	67.4^{a}	61.0^{b}	*
Glutamic	55.5^{b}	73.7^{a}	*	53.8^{b}	67.5^{a}	72.6^{a}	*	43.2^{c}	59.2^{b}	64.2^{b}	64.5^{b}	75.7^{a}	81.0^{a}	*
Proline	63.0	66.0	NS	52.3^{c}	76.3^{a}	65.0^{b}	*	61.4^{b}	65.7^{b}	61.9^{b}	43.1^{c}	86.9^{a}	68.1^{b}	*
Glycine	47.7^{b}	64.8^{a}	*	45.6^{c}	54.0^{b}	69.2^{a}	*	36.7^{c}	45.4^{d}	61.0^{b}	54.4^{c}	62.5^{b}	77.4^{a}	*
Cystine	72.4^{b}	84.7^{a}	*	67.6^{c}	79.9^{b}	88.1^{a}	*	62.1^{d}	76.4^{c}	78.6^{bc}	73.1^{c}	83.4^{b}	97.6^{a}	*
Valine	41.9^{b}	76.8^{a}	*	46.1^{b}	65.1^{a}	66.7^{a}	*	34.3^{d}	42.9^{cd}	48.3^{bc}	57.9^{b}	87.4^{a}	85.1^{a}	*
Methionine	70.3^{b}	84.9^{a}	*	73.4^{b}	76.4^{a}	83.1^{a}	*	65.6^{c}	70.6^{bc}	74.7^{bc}	81.2^{ab}	82.2^{ab}	91.5^{a}	*
Isoleucine	69.0^{b}	83.4^{a}	*	69.2^{c}	84.0^{a}	75.4^{b}	*	67.6^{d}	73.2^{c}	66.3^{d}	70.9^{d}	94.8^{a}	84.6^{b}	*
Leucine	74.4	83.1	NS	70.6	82.8	82.9	NS	68.4^{c}	76.2^{ab}	78.7^{ab}	72.8^{bc}	89.4^{a}	87.1^{a}	*
Tyrosine	58.7^{b}	80.8^{a}	*	52.8^{c}	85.7^{a}	70.7^{b}	*	43.3^{d}	77.6^{b}	55.3^{c}	62.4^{c}	93.8^{a}	86.1^{ab}	*
Phenylala.	65.3	68.7	NS	53.7^{b}	74.6^{a}	72.7^{a}	*	56.8^{bc}	71.8^{a}	67.4^{ab}	50.6^{c}	77.4^{a}	78.0^{a}	*
Histidine	52.5^{b}	69.9^{a}	*	57.5^{b}	62.9^{a}	63.3^{a}	*	50.7^{c}	53.2^{c}	53.7^{c}	64.2^{b}	72.6^{a}	72.9^{a}	*
Lysine	48.3^{a}	73.1^{b}	*	38.3^{b}	73.7^{a}	70.0^{a}	*	29.8^{c}	57.9^{b}	57.3^{b}	46.9^{b}	89.6^{a}	82.8^{a}	*
Arginine	59.8^{b}	76.8^{a}	*	50.7^{b}	80.7^{a}	73.6^{a}	*	49.0^{c}	66.9^{bc}	63.5^{c}	52.3^{c}	94.5^{a}	83.6^{ab}	*
Cys + Met.	59.0^{b}	74.9^{a}	*	59.5^{c}	65.2^{b}	76.1^{a}	*	51.1^{c}	58.0^{c}	67.8^{b}	67.8^{b}	72.4^{ab}	84.4^{a}	*
Average	57.7^{b}	73.1^{a}	*	54.8^{b}	71.9^{a}	70.7^{a}		49.7^{c}	62.1^{b}	61.7^{b}	59.9^{b}	81.6^{a}	79.1^{a}	*

a,b,… Means within a row within each effect with no common superscript are significantly different ($P < 0.05$)

Table 7. Apparent amino acid availability of wheat bran

Amino acids	Temperature			Enzymes				Temperature X Enzymes						
	Thermon-eutral (N)	Stress (S)	P[*]	Without (W)	Optizyme (OP)	Phytase (PH)	P[*]	N x W	N x OP	N x PH	H x W	H x OP	H x PH	P[*]
Threonine	55.7[a]	45.6[b]	*	40.7[b]	64.4[a]	46.9[b]	*	47.0[b]	65.5[a]	54.6[b]	34.3[c]	63.3[ab]	39.2[a]	*
Serine	54.7	52.0	NS	44.9[b]	65.0[a]	50.1[b]	*	45.0[b]	64.3[a]	54.6[ab]	44.8[b]	65.6[a]	45.7[b]	*
Glutamic	76.9	74.6	NS	73.5[a]	77.6[a]	76.3[b]	*	74.1	77.9	78.9	72.9 68.5[a]	77.2	73.7	NS
Proline	65.8	70.0	NS	65.2	68.6	69.8	NS	62.0[b]	65.9[ab]	69.5[a]	33.8[c]	71.3[a]	70.3[a]	*
Glycine	55.5	49.5	NS	41.3[c]	63.8[a]	52.3[b]	*	48.9[b]	62.8[ab]	54.8[ab]	29.6[b]	64.9[a]	49.9[b]	*
Cystine	47.7	42.8	NS	32.8[b]	53.7[a]	48.7[a]	*	36.0[b]	56.4[a]	49.7[a]	31.4[b]	50.9[a]	47.8[a]	*
Valine	66.4[a]	55.3[b]	*	47.9[c]	73.7[a]	61.1[b]	*	64.5[a]	67.2[a]	67.5[a]	49.7[c]	79.6[a]	54.5[a]	*
Methionine	59.2[a]	55.7[b]	*	44.1[c]	68.9[a]	59.3[b]	*	58.4[b]	59.1[b]	60.1[b]	43.5[c]	78.8[b]	58.5[b]	*
Isoleucine	79.4[a]	59.9[b]	*	61.2[b]	78.5[a]	69.2[ab]	*	79.0[a]	79.8[a]	79.4[a]	39.1[d]	77.6[a]	58.7[b]	*
Leucine	74.6[a]	58.8[b]	*	55.2[c]	78.0[a]	67.0[b]	*	71.2[b]	76.1[ab]	76.6[ab]	37.3[c]	79.8[a]	57.4[c]	*
Tyrosine	59.7[a]	54.2[b]	*	44.4[c]	72.5[a]	53.9[b]	*	51.5[c]	64.1[b]	63.3[b]	45.1[d]	80.9[a]	44.4[d]	*
Phenylala.	70.7[a]	59.9[b]	*	55.9[c]	75.5[a]	64.4[b]	*	66.6[b]	71.6[ab]	73.8[ab]	48.3[ab]	79.4[a]	55.0[c]	*
Histidine	50.0	52.6	NS	42.7[b]	56.4[a]	40.5[b]	*	42.1[c]	64.6[a]	43.3[c]	35.0[b]	51.8[ab]	57.6[a]	*
Lysine	55.6	48.6	NS	36.4[b]	60.3[a]	59.6[a]	*	37.7[b]	63.3[a]	65.7[a]	68.0[b]	57.3[ab]	53.5[ab]	*
Arginine	65.6[b]	74.0[a]	*	64.0[b]	79.6[a]	65.8[b]	*	60.1[b]	73.0[b]	63.7[b]	93.6[c]	86.2[a]	67.9[b]	*
Cys + Met.	53.3	49.2	NS	38.4[c]	61.3[a]	54.0[b]	*	47.2[b]	57.7[a]	54.9[a]		54.9[a]	53.1[a]	*
Average	62.4[a]	56.9[b]	*	49.9[c]	69.1[a]	59.0[b]	*	56.1[c]	67.4[a]	62.4[b]	45.5[d]	70.7[a]	55.6[c]	*

a,b,… Means within a row within each effect with no common superscript are significantly different ($P< 0.05$)

Table 8. True amino acid availability of wheat bran

	Temperature			Enzymes				Temperature X enzymes						
Amino acids	**Thermon-eutral (N)**	**Stress (S)**	**P***	**Without (W)**	**Optizyme (OP)**	**Phytase (PH)**	**P***	**N x W**	**N x OP**	**N x PH**	**H x W**	**H x OP**	**H x PH**	**P***
Threonine	65.7	69.5	NS	56.3^{b}	84.2^{a}	62.5^{b}	*	57.0^{c}	75.5^{b}	64.6^{c}	55.6^{c}	92.4^{a}	60.5^{c}	*
Serine	63.4^{b}	73.2^{a}	*	58.9^{b}	81.9^{a}	64.2^{b}	*	53.8^{c}	73.1^{b}	63.4^{bc}	64.1^{b}	90.6^{a}	64.9^{b}	*
Glutamic	80.7^{b}	87.5^{a}	*	82.4	84.6	85.2	NS	72.4^{b}	81.7^{ab}	82.6^{ab}	87.0^{a}	87.6^{a}	87.8^{a}	*
Proline	70.4^{b}	87.6^{a}	*	76.6	79.1	81.2	NS	66.6^{c}	70.5^{bc}	74.1^{b}	86.6^{a}	87.7^{a}	88.4^{a}	*
Glycine	63.5^{b}	75.2^{a}	*	59.8^{b}	77.5^{a}	70.7^{a}	*	56.9^{b}	70.8^{ab}	62.8^{b}	62.6^{b}	84.3^{a}	78.8^{a}	*
Cystine	67.6^{b}	70.3^{a}	*	56.3^{b}	78.4^{a}	72.2^{a}	*	56.3^{d}	76.7^{bc}	69.9^{c}	56.2^{d}	74.4^{b}	80.2^{a}	*
Valine	71.1	78.1	NS	61.7^{c}	87.3^{a}	74.8^{b}	*	69.1^{b}	72.3^{b}	71.9^{b}	54.2^{c}	102.3^{a}	77.7^{b}	*
Methionine	74.1^{b}	96.4^{a}	*	75.4^{b}	89.7^{a}	90.6^{a}	*	73.3^{b}	73.9^{b}	75.0^{b}	77.4^{b}	106.2^{a}	105.4^{c}	*
Isoleucine	84.4	85.4	NS	76.9^{b}	92.8^{a}	84.9^{ab}	*	84.0^{b}	84.8^{b}	84.8^{b}	69.9^{c}	101.2^{a}	85.1^{b}	*
Leucine	80.3^{b}	89.1^{a}	*	74.8^{c}	92.7^{a}	86.6^{b}	*	76.9^{d}	81.8^{c}	82.2^{c}	72.7^{d}	103.6^{a}	91.0^{b}	*
Tyrosine	64.4^{b}	77.2^{a}	*	57.6^{c}	87.7^{a}	67.0^{b}	*	56.2^{c}	68.6^{b}	68.1^{b}	58.9^{c}	106.6^{a}	66.0^{b}	*
Phenylala.	76.4	81.3	NS	70.7^{c}	86.7^{a}	79.2^{b}	*	72.4^{bc}	77.4^{b}	79.6^{b}	69.0^{c}	96.1^{a}	78.9^{b}	*
Histidine	76.0^{b}	89.8^{a}	*	68.8^{b}	88.2^{a}	72.3^{b}	*	68.5^{b}	90.9^{a}	69.7^{b}	85.5^{a}	89.0^{a}	94.8^{a}	*
Lysine	60.6	72.0	NS	49.3^{b}	77.0^{a}	72.6^{a}	*	42.7^{c}	68.4^{ab}	70.7^{ab}	55.9^{bc}	85.6^{a}	74.4^{ab}	*
Arginine	69.5^{b}	88.9^{a}	*	73.0^{b}	89.6^{a}	74.8^{b}	*	64.0^{d}	76.9^{bc}	67.6^{cd}	82.1^{b}	102.4^{a}	82.1^{b}	*
Cys + Met.	71.3	71.1	NS	67.6^{b}	79.6^{a}	75.5^{a}	*	65.1^{b}	80.0^{a}	68.9^{b}	60.9^{c}	79.3^{a}	73.1^{a}	*
Average	71.1^{b}	81.4^{a}	*	66.6^{c}	85.1^{a}	75.9^{b}	*	64.9^{d}	76.2^{b}	72.3^{c}	69.4^{c}	94.1^{a}	80.0^{b}	*

a,b,… Means within a row within each effect with no common superscript are significantly different (P< 0.05)

Moreover, heat stress decreased the overall mean of the apparent amino acid availability in wheat bran except ariginine which significantly increased. On the opposite, heat stress increased significantly ($P<0.05$) the overall mean of true amino acid availability of wheat bran. This was due to high correction of amino acids output from the fasted birds. The result of wheat bran is in disagreement with the result reported by Koelkbeck *et al.* (1998) and Makled *et al.* (2000).

In general, the effect of heat stress was more contradictory. Whereas it decreased AAAA values, it seemed to increase the general values of TAAA.

2. Effect of enzyme supplementation on amino acid availability

Enzyme supplementation significantly ($P<0.05$) increased both AAAA and TAAA. These results are in agreement with those obtained by Kornegay *et al*. (1999); Ledoux and Firman (1999) and Attia *et al*. (2000). On the other hand, they are in disagreement with the results of Boling *et al.* (2000 and 2001); and Peter and Baker (2001).

The results showed that enzyme (optizyme or phytase) supplementation improved the overall mean of apparent amino acid availability of all amino acids in the four feedstuffs understudy.

From the results presented herein, it can be noticed that the positive effect of phytase supplementation on true availability of cystine was more pronounced than the effect of optizyme supplementation in all feedstuffs understudy except wheat bran.

The mean availability of all amino acids was improved by enzymes supplementation in all feedstuffs under study and the effect of optizyme supplementation was more pronounced in case of apparent availability of amino acids in wheat bran and true availability of amino acids in mung beans and wheat bran.

However, the apparent and true availability of lysine in mung beans; glutamic acid in mung beans, sorghum and wheat bran; glycine in sorghum; leucine in mung beans; phenylalanine in mung beans; proline in mung beans and wheat bran; and arginine in mung beans didn't improve with enzyme supplementation.

The reported improvement in amino acid availability by phytase supplementation is in agreement with the results reported by Kornegay (1996); Yi *et al*. (1996); Sebstian *et al.* (1997); Revindran *et al*. (1998 and 1999).

Generally, the obtained results showed that there is evidence concerning the capacity of phytic acid to binding protein/amino acids and the ability of enzymes to release bound nutrients by hydrolyzing phytic acid and the inhibition of reduction in enzyme activity due to the formation of phyate-enzymic protein complexes (Ravindran, *et al*. 1995). Also, hydrolyzing phytic acid by phytase supplementation may inhibit the chelation of calcium ions, which are essential for the activity of trypsin and α–amylase (Liener, 1989).

The improvements occurring in apparent availability with phytase supplementation may also reflect the reduced endogenous amino acid losses resulting from the amelioration of the anti-nutritional effects of phytic acid. Microbial phytase disrupted the cell wall, in a manner similar to that of endogenous xylenase enzymes. The cell wall disruption would cause a better diffusion or enhanced contact between digestive enzymes, substrate and digestion end-products (Petterson and Aman, 1988).

The improvement in AAAA and TAAA due to optizyme supplementation is probably due to its effect on NSPs and cell wall and protein digestion. Each enzyme in optizyme acts a role in protein digestion and xylenase as a component of optizyme acts by reducing the antinutritive effects, and by reducing the viscosity of ingesta (Bedford and Morgan, 1996).

The interaction between thermoneutral conditions and phytase supplementation significantly increased both AAAA and TAAA values. Moreover, the interaction between heat stress and enzymes supplementation (optizyme or phytase) significantly increased both AAAA and TAAA values in the feedstuffs understudy.

In general, it may be concluded that the effect of heat stress at 35 ºC on apparent and true availability of amino acids was contradictory and differed according to the feedstuff understudy and to every amino acid by itself. The impact of enzymes supplementation on amino acids availability was positive in general. This influence may be more effective at higher levels of enzymes supplementation than those used in this study (1500 FTU phytase or 0.3 g optizyme/kg feed). Therefore, more studies may be necessary to approve this hypothesis.

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التوافر الحيوي للأحماض الأمينية لبعض مواد علف الدواجن وتأثرها بالإجهاد الحراري وإضافة الإنزيمات

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أجريت أربع تجارب متشابهة على أربع مواد علف هي فول المانح، الذرة الرفيعـة، رجيع الكون و ردة القمح. أجريت هذه التجارب لتقييم التوافر الحيوي الظاهري والحقيقي للأحماض الأمينية لكل مادة علف من المواد المستخدمة في الدراسة. تم تقييم التوافر الحيوي للاحماض الأمينية تحت ظروف الحرارة المعتدلة (٢٤ درجة مئوية) أو تحت ظروف الإجهاد الحراري الدوري (٨ ساعات على درجة ٣٨ درجة مئوية و ١٦ ساعة على درجة ٢٤ درجة مئوية) بدون أو مع إضافة الانزيمات إما في صورة مخلوط إنزيمات (وبتزايم بمستوى ٣٠٠ مجم/ كجم مادة علف) أو في صورة إنزيم مفرد (الفيتيز بمستوى ١٥٠٠ وحدة FTU/ كجم مادة علف). استخدم فى هذه التجارب عدد ٤٠ ديك دندراوى ناضج عمر ١٦ شهر قسمت إلى ثمانية مجموعات بكل منها خمس ديوك. استخدم تكنيك الدفع الغذائي لتقدير كل من التوافر الحيوي الظاهري والحقيقي للاحماض الأمينية وكانت النتائج مايلى:

١- الإجهاد الحراري على درجة ٣٨ درجة مئوية له تأثير متضارب ومختلف على التوافر الحيوي الظاهري والحقيقي للاحماض الأمينية المختلفة وكذلك لمواد العلف المستخدمة فى الدراسة.

٢- إضافة الإنزيمات لها تأثير إيجابي على قيم التوافر الحيوي الظاهري والحقيقي للاحماض الأمينية المختلفة في مواد العلف المختلفة.

٣- أدى التداخل بين الظروف الحرارية المعتدلة وإضافة مخلوط الانزيمات (الاوبتزايم) الى زيادة معنوية فى كل من قيم التوافر الحيوي الظاهري والحقيقي للاحماض الأمينية فى كل من الذرة الرفيعة ورجيع الكون وردة القمح. كما ان إضافة انزيم الفيتيز له تأثير مشابه فى فول المانج. لوحظ أيضا ان إضافة الاوبتزايم أو الفيتيز تحت ظروف الإجهاد الحراري أدى الى زيادة معنوية فى قيم المتوسط العام للتوافر الحيوي الظاهري والحقيقي للاحماض الأمينية فى كل مواد العلف تحت الدراسة. وكان تأثير إضافة الاوبتزايم اكثر وضوحا عن تأثير أصافة الفيتيز.