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THERMAL STABILITY OF AMINO ACIDS IN MEALS AND FEEDS USED IN SHRIMP FARMING

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ABSTRACT – The Brazilian shrimp farming uses mainly commercial feed for shrimp nutrition. This choice occurs because of the advantages related to convenience and good adaptation of Litopenaeus vannanmei to feed intake. Thus, the quality of feed is a determining factor for maximum performance of the shrimp farms, making the right selection of suppliers and control of the storage conditions as ways to prevent contamination and spoilage of feed. The objective of this study was to evaluate the stability of amino acids in meals and commercial feed with different protein levels, subjected to high-temperature storage. The samples were exposed to temperature of 50 ^{O} C and evaluated every 5 days for 30 days. The analyses of the degradation of amino acids were performed using an elution gradient in HPLC system. In evaluated meals it was observed that valine and arginine were the amino acids that suffered greater loss during the experiment and histidine and alanine suffered less degradation. Significant difference was observed in the content of all amino acids analyzed after exposure of the feed to the temperature of 50 ° C; with reduce in values of its amino acid content. The results obtained in this study indicate that meals and feed exposed to elevated temperatures significantly reduced the content of its amino acids.

KEY WORDS: *LITOPENAEUS VANNAMEI, STABILITY, STORAGE*

ESTABILIDADE TÉRMICA DE AMINOÁCIDOS DE FARINHAS E RAÇÕES UTILIZADAS NA CARCINICULTURA

RESUMO – A carcinicultura brasileira utiliza principalmente ração comercial para a nutrição dos camarões. Esta escolha ocorre pelas vantagens relativas à praticidade e boa adaptação do Litopenaeus vannanmei ao consumo de ração. Desse modo, a qualidade da ração fornecida é fator determinante para o máximo desempenho da carcinicultura, tornando importante a seleção dos fornecedores e o controle das condições de armazenamento como formas de prevenir a contaminação e deterioração da ração. O objetivo do trabalho foi avaliar a estabilidade de aminoácidos em farinhas e em rações comerciais com diferentes teores proteicos, submetidas a temperaturas elevadas de armazenamento. As amostras foram expostas a temperatura de 50 ^{O}C, e avaliadas a cada cinco dias durante trinta dias. As análises da degradação de aminoácidos foram realizadas, utilizando-se um sistema de HPLC, em modo de gradiente de eluição. Em todas as farinhas avaliadas, observou-se que avalina e a arginina, foram os aminoácidos que sofreram maior perda durante o período do experimento, enquanto a histidina e alanina sofreram menor degradação. Observou-se diferença significativa no conteúdode todos os aminoácidos analisadosdepois da exposição das rações a temperatura de 50 ºC, com redução do teor de aminoácidos. Os resultados obtidos nesta pesquisa indicam que farinhas e rações expostas a temperaturas elevadas diminuem consideravelmente o teor de aminoácidos.

PALAVRAS CHAVE: *LITOPENAEUS VANNAMEI, ESTABILIDADE, ARMAZENAMENTO.*

LA ESTABILIDAD TÉRMICA DE LOS AMINOÁCIDOS EN LAS COMIDAS Y PIENSOS USADOS EN EL CULTIVO DE CAMARÓN

RESUMEN – El cultivo de camarón en Brasil utiliza el alimento comercial para la alimentación. Esta elección es las ventajas relacionadas con la conveniencia y la buena adaptación de Litopenaeus vannanmei el consumo de alimento. Por lo tanto, la calidad del pienso es un factor determinante para el máximo rendimiento del cultivo de camarón, por lo que es importante para la selección de proveedores y control de las condiciones de almacenamiento como las formas de prevenir la contaminación y el deterioro de los alimentos. El objetivo era evaluar la estabilidad de aminoácidos en harina y comerciales dietas con diferentes niveles de proteína, el almacenamiento a alta temperatura. Las muestras se expusieron a la temperatura de 50 ^{O}C y evaluados cada cinco días durante treinta días. El análisis de la degradación de aminoácidos se realizaron usando un sistema de HPLC, el modo de gradiente de elución. En todas las harinas evaluadas, se reveló que avalina y la arginina, eran los aminoácidos que han sufrido una mayor pérdida durante el período del experimento, mientras que la histidina y alanina sufrieron menos degradación. Hubo una diferencia significativa en el contenido de todos los aminoácidos analizados después de la exposición de temperatura de alimentación de 50 ° C, reduciendo el contenido de aminoácidos. Los resultados obtenidos en este estudio indican que la harina de alimentación y se expone a temperaturas elevadas reducir considerablemente el contenido de aminoácidos.

PALABRAS CLAVE: *LITOPENAEUS VANNAMEI, LA ESTABILIDAD DE ALMACENAMIENTO.*

Introduction

In 2011 the Brazilian aquaculture consumed about 489 tons of aquatic feed with 397 thousand tons for fish farming and 92 thousand tons forshrimp farming.This represented 0.7% of total animal feed consumed in the country in 2011. Although they represent a small fraction, this is the fastest growing segment, with a rate above 15% per year. This growth demonstrates the potential of this market, which is growing in Brazil. This has required investments and technological innovations in aquatic feed, which is the main input in the production of protein of high biological value of fish and shrimp (SINDIRAÇÕES, 2011).

The Brazilian shrimp farming uses mainly commercial feed for shrimp nutrition (Waldige and Homemade, 2004). This choice is made because the relative advantages and good adaptation of *Litopenaeus vannanmei* to feed intake (Aries Nephew, 2003). Thus, the quality of feed is a determining factor for maximum performance of shrimp (Barbiere Junior and Ostresky Neto, 2001), making it important the selection of suppliers and control the storage conditions as ways to prevent contamination and deterioration of the ration (Amaral et al, 2003).

The manufacture of animal feeds involves the use of a variety of raw materials for production of feed. The feeds are defined according to some criteria as regards the nutrient composition based on specific descriptions of hygiene and adequate nutritional quality formulation (Thomas and Poel, 1996).

Most farmers do not realize the importance of proper storage of feed. They often stockpile large quantities of feed that are stored for a long period. During extended and inadequate storage the feeds are subjected to adverse physical conditions (heat, humidity, light) and micro-organisms (fungi, bacteria, yeasts) which can cause deterioration, and resulting in decrease in palatability and nutritive value, with degradation of amino acids and vitamins in feed and consequent economic loss (Chow, 1980).

The study aimed to evaluate the stability of amino acids in meals and commercial feeds with different protein levels, subjected to high temperature storage.

Material and methods

The study was performed at the Laboratory of Fishery Product Development and Flavor Laboratory of the Department of Food Engineering, Campus I Universidade Federal da Paraíba (UFPB), João Pessoa, Paraíba.

Material

The samples used for this experiment were commercial feed with protein contents of 35 and 40% and fish meal and soya meal used in the formulation of feed with the following characteristics: Extruded feed and later transformed into the form of pellets with 1.0 to 1.8 mm in diameter with 40% protein used for feeding marine shrimp with an average weight between 1 and 3g, populated in nurseries systems, pre-creates or fattening nurseries (feed 40A); extruded feed and subsequently converted into the form of pellets with a diameter of 2.38 mm, with 35% protein used for feeding marine shrimp from the juvenile stage (with an average weight of 3g)

to reach market weight, populated in fattening systems under densities above 30 shrimps/m2 (feed 35A);extruded feed and subsequently converted into the form of pellets of 1 to 1.7 mm in diameter, with 40% protein used for feeding marine shrimp with an average weight between 1 and 3 g, populated in nurseries systems, pre-creates or fattening nurseries (feed 40B)and extruded feed subsequently converted into the form of pellets with 2.0 to 2.5 mm in diameter, with 35% protein used for feeding marine shrimp from the juvenile stage (with an average weight of 3g) until reaching market weight, populated in fattening systems under densities above 30 shrimps/ m2 (feed 35 B); fish meal used in feed formulation A (FPA), fish meal used in feed formulation B (FPB); soya meal used in the formulation of the feed A (FSA); soya meal used in the formulation of the feed B (FSB).

Subsequently the samples with bigger particle size were ground with the utilization of a cutting mill and smaller particle size samples were ground by hand using grade and pistil, after grinding, the samples were sieved on 200 mesh sieves. Then the samples were separated for analyzes.

Thermal stability

For the evaluation of thermal degradation of the samples It was weighed 5 g of each feed and meal, after weighing the samples were placed in glass jars in an oven stabilized at 50^{O} C for evaluation in periods of 05, 10, 15, 20, 25 and 30 days. The removal of each of the samples after each time period waspromoted to evaluate the stability of amino acids.

Amino acids analyses

Analyses for obtaining amino acid profile were performed using the methodology used by White, Hart and Fry (1986). It was used an elution gradient in HPLC system for determination of amino acids. The mobile phases employed consisted of mobile phase A: sodium acetate buffer (0.014 M) and mobile phase B: Acetonitrile: Water 60/40. The sample injection (20µL) was performed manually and the detection was at 245nm. The chromatographic separation was performed with an elution gradient at a temperature of 35 C^{O} Samples equivalent to approximately 400µg of protein were weighed into Pyrex tubes with teflon screw cap, previously washed with 6N HCl solution with deionized water and dried. Adding to the pyrex tube with a teflon cap 300µL of a solution of 6N HCl containing 1% phenol, the contents of the tubes were thoroughly rapidly inflated with N2 and sealed with a screw cap.

The sealed tubes were placed in an oven at 110 C for $24h^{O}$ for hydrolysis. After hydrolysis and cooling of the tubes it was added 20µLof a mixture methanol: water: triethylamine (2:2:1), the mixture was homogenized and drying of the material was promoted for 20 minutes. Derivatization of the hydrolyzate was made by mixing methanol: water: triethylamine: PITC (7:1:1:1), the mixture was homogenized; waiting for 20 minutes and subsequently the material was dried for 20 minutes. Then the samples were resuspended in mobile phase and then injected into the HPLC-Varian model 1690 with drag detector diode, C18-Waters 3.9 x150mm, 5µm reading at 245nm.

For identification of the chromatographic peaks, the comparisonof the retention times obtained with standards of amino acids (Sigma-AAS-18) under the same chromatographic conditions and the absorption spectra obtained in drag diode detector (DAD) was used. The quantification was performed by external standard.

Statistical Analysis

The results of the analysis, in triplicate, were statistically analyzed by analysis of variance (ANOVA) andTukey's test applied between the means at 5% probability using the SPSS version 14.0 (SPSS Inc., 2001) according with Marocco (2007).

Results

Profile and degradation of amino acids in fish meal and soya meal

The mean values and the percentage of degradation of amino acids of fish meal and soya meal used for manufacturing of feed during zero (control) and after 5, 10, 15, 20, 25 and 30 days exposed to a temperature of 50 ± 2 ° C are presented tables 1, 2, 3 and 4. With respect to fishmeal, it was observed that the one used for the preparation of commercial feed A deteriorated 5% less than that the one used for manufacturing of feed B. There wasn't significant difference in the soya mealsevaluated regarding the percentage of degradation. Prominently in all flours evaluated it was observed that valine and arginine were the amino acids that suffered greater loss during the experimentwhile histidine and alanine suffered less degradation.

Table 1 - Mean values and amino acid degradation percentage of fishmeal used in the manufacture of commercial feed exposed to the temperature of 50 ± 2 ° C.

Amino acids (mg/100g)	T0	T5	T10	T15	T20	T25	T30	%
Isoleucine	$4,21^{a}\pm0,03$	$2,55^{b}\pm0,09$	$2,14^{c}\pm0,01$	$1,58^{d}\pm0,01$	$1,34^{e}\pm0,05$	$1,16^{f}\pm0,02$	$0,91^{g}\pm0,05$	78
Leucine	$6,69^{a}\pm0,04$	$3,94^{b}\pm0,07$	$3,64^{c}\pm0,00$	$3,23^{d}\pm0,06$	$2,46^{e}\pm0,09$	$2,01^{f}\pm0,06$	$1,75^{g}\pm0,02$	74

Arginine	4,56^{a}±0,07	2,87^{b}±0,06	2,64^{bc}±0,01	2,46^{c}±0,00	1,73^{d}±0,04	1,04^{e}±0,08	0,16^{f}±0,02	96
Valine	5,24^{a}±0,08	3,36^{b}±0,01	3,04^{c}±0,02	2,06^{d}±0,00	1,84^{d}±0,03	1,14^{e}±0,00	0,21^{f}±0,02	96
Methionine	1,39^{a}±0,07	1,44^{a}±0,04	1,33^{b}±0,04	0,97^{c}±0,03	0,76^{d}±0,04	0,46^{e}±0,05	0,48^{e}±0,03	65
Lysine	8,83^{a}±0,06	6,95^{b}±0,02	5,15^{c}±0,03	4,31^{d}±0,01	3,65^{e}±0,09	3,35^{f}±0,08	2,25^{g}±0,03	75
Phenylalanine	4,79^{a}±0,04	2,45^{b}±0,00	2,45^{b}±0,02	2,25^{c}±0,04	1,46^{d}±0,04	1,26^{e}±0,07	1,02^{f}±0,02	79
Aspartic Acid	3,53^{a}±0,07	3,26^{b}±0,06	2,90^{c}±0,00	2,04^{d}±0,05	1,54^{e}±0,02	0,77^{f}±0,05	0,65^{f}±0,07	82
Glutamic Acid	5,97^{a}±0,01	5,56^{b}±0,05	5,27^{c}±0,06	2,62^{d}±0,09	2,65^{d}±0,05	1,53^{e}±0,02	1,12^{f}±0,06	81
Proline	0,29^{a}±0,00	0,15^{b}±0,00	0,09^{c}±0,00	0,08^{d}±0,00	0,08^{d}±0,00	0,05^{e}±0,00	0,04^{f}±0,00	86
Serine	3,06^{a}±0,06	2,93^{b}±0,05	1,54^{c}±0,09	1,32^{d}±0,00	0,64^{e}±0,04	0,56^{f}±0,03	0,44^{g}±0,05	86
Glycina	5,82^{a}±0,05	4,33^{b}±0,09	3,96^{c}±0,00	3,05^{d}±0,03	2,53^{e}±0,09	2,01^{f}±0,00	1,95^{f}±0,08	66
Threonine	8,45^{a}±0,02	2,23^{b}±0,07	2,06^{b}±0,07	1,45^{c}±0,00	1,24^{c}±0,02	0,77^{d}±0,04	0,76^{d}±0,04	91
Tyrosine	2,20^{a}±0,00	1,68^{b}±0,08	1,63^{b}±0,04	1,62^{b}±0,02	1,46^{c}±0,06	1,03^{d}±0,06	0,84^{e}±0,06	62
Histidine	1,84^{a}±0,09	1,63^{b}±0,06	1,22^{b}±0,08	0,95^{d}±0,06	0,96^{d}±0,02	0,86^{d}±0,08	0,63^{e}±0,06	66
Alanine	0,35^{a}±0,01	0,30^{b}±0,02	0,27^{b}±0,03	0,25^{b}±0,02	0,23^{b}±0,02	0,20^{b}±0,02	0,18^{b}±0,03	49
%Total degradation								77

Different letters in the same row indicate significant differences by Tukey test (α = 95%).

Table 2 - Mean values and amino acid degradation percentage of fishmeal used in the manufacture of commercial feed B exposed to a temperature of 50 ± 2 ° C.

Amino acids(mg/100g)	T0	T5	T10	T15	T20	T25	T30	%
Isoleucine	2,86^{a}±0,04	1,95^{b}±0,09	1,64^{c}±0,02	1,21^{d}±0,08	1,03^{e}±0,09	0,92^{e}±0,06	0,44^{f}±0,00	85
Leucine	4,53^{a}±0,09	3,42^{b}±0,05	2,49^{c}±0,03	2,35^{d}±0,05	2,14^{e}±0,04	1,57^{f}±0,04	0,95^{g}±0,01	79
Arginine	2,73^{a}±0,05	2,25^{b}±0,02	1,96^{c}±0,02	1,54^{d}±0,07	0,56^{e}±0,09	0,21^{f}±0,01	0,10^{g}±0,00	96
Valine	3,34^{a}±0,05	2,27^{b}±0,03	1,98^{c}±0,03	1,37^{d}±0,03	1,13^{e}±0,02	0,54^{f}±0,01	0,33^{g}±0,09	90
Methionine	2,14^{a}±0,03	1,43^{b}±0,04	0,95^{c}±0,01	0,87^{d}±0,04	0,55^{e}±0,09	0,43^{e}±0,05	0,32^{e}±0,08	85
Lysine	9,53^{a}±0,01	7,45^{b}±0,07	4,97^{c}±0,05	4,83^{d}±0,04	4,07^{e}±0,09	3,74^{f}±0,00	2,16^{g}±0,08	77
Phenylalanine	2,97^{a}±0,04	2,14^{b}±0,08	1,55^{c}±0,04	1,42^{c}±0,09	1,26^{d}±0,01	0,83^{e}±0,05	0,45^{f}±0,02	85
Aspartic Acid	3,53^{a}±0,03	3,31^{b}±0,03	1,39^{c}±0,05	1,35^{c}±0,06	0,94^{d}±0,03	0,61^{e}±0,03	0,33^{f}±0,04	91
Glutamic Acid	7,34^{a}±0,06	5,65^{b}±0,00	2,54^{c}±0,03	2,03^{d}±0,06	1,83^{e}±0,06	1,63^{f}±0,05	0,64^{g}±0,08	91
Proline	0,18^{a}±0,00	0,17^{b}±0,00	0,13^{c}±0,00	0,09^{d}±0,01	0,09^{d}±0,00	0,05^{e}±0,00	0,03^{f}±0,00	83
Serine	2,32^{a}±0,02	1,84^{b}±0,05	0,86^{c}±0,03	0,64^{d}±0,08	0,56^{d}±0,02	0,27^{e}±0,08	0,28^{e}±0,06	88
Glycina	4,56^{a}±0,09	3,14^{b}±0,04	2,17^{c}±0,08	1,82^{d}±0,05	1,85^{d}±0,01	1,44^{e}±0,01	0,93^{f}±0,08	80
Threonine	3,73^{a}±0,01	2,73^{b}±0,04	1,92^{c}±0,07	1,17^{d}±0,07	0,95^{e}±0,09	0,78^{f}±0,07	0,43^{g}±0,09	88
Tyrosine	2,04^{a}±0,04	1,38^{b}±0,01	1,13^{c}±0,08	1,04^{d}±0,00	0,93^{e}±0,03	0,83^{f}±0,00	0,44^{g}±0,09	78

Histidine	2,16^{a}±0,04	1,62^{b}±0,00	1,05^{c}±0,01	1,05^{c}±0,09	0,96^{c}±0,06	0,97^{c}±0,00	0,44^{d}±0,09	80
Alanine	0,31^{a}±0,00	0,24^{b}±0,01	0,19^{c}±0,03	0,18^{c}±0,01	0,18^{c}±0,02	0,11^{d}±0,01	0,08^{e}±0,00	74
%Total degradation								84

Different letters in the same row indicate significant differences by Tukey test (α = 95%).

Observing the total degradation meansof each meal it can be seen that all feeds evaluated also showed high percentages of degradation. Therefore, the nature of the raw material (animal or vegetable), lack of stability and the amino acid composition cannot be attributed because all the flour had an average total of degradation on the amino acid content above 75%.Comparing the fishmeal it can be seen that there was a significant difference in the amino acid content and this didn't occur between soya meals of different manufacturers.

Table 3 - Mean values and percentage of amino acid degradation of the soya meal used in the commercial manufacture of feed A exposed to a temperature of 50 ± 2 ° C.

Amino acids (mg/100g)	**T0**	**T5**	**T10**	**T15**	**T20**	**T25**	**T30**	**%**
Isoleucine	3,72^{a}±0,37	2,44^{b}±0,24	1,62^{c}±0,16	1,43^{c}±0,14	1,18^{c}±0,11	0,95^{d}±0,09	0,57^{e}±0,05	85
Leucine	4,84^{a}±0,48	3,75^{b}±0,37	3,15^{b}±0,31	2,67^{b}±0,26	2,13^{c}±0,21	1,86^{c}±0,18	1,13^{d}±0,11	77
Arginine	3,32^{a}±0,33	2,63^{b}±0,26	1,91^{c}±0,19	1,46^{d}±0,14	1,16^{e}±0,11	0,67^{f}±0,06	0,33^{g}±0,03	90
Valine	3,24^{a}±0,32	2,52^{b}±0,25	1,63^{c}±0,16	1,16^{d}±0,11	0,96^{d}±0,09	0,58^{e}±0,05	0,24^{f}±0,02	93
Methionine	1,05^{a}±0,10	0,76^{b}±0,07	0,75^{b}±0,07	0,45^{c}±0,04	0,33^{d}±0,03	0,27^{e}±0,02	0,26^{e}±0,02	75
Lysine	7,45^{a}±0,74	6,53^{a}±0,65	6,27^{a}±0,62	5,06^{b}±0,50	4,71^{b}±0,47	3,35^{c}±0,33	2,54^{d}±0,25	66
Phenylalanine	3,60^{a}±0,36	2,73^{b}±0,27	2,02^{c}±0,20	1,64^{d}±0,16	1,27^{e}±0,12	1,24^{e}±0,12	0,47^{f}±0,04	87

Aspartic Acid	5,45^{a}±0,54	3,37^{b}±0,33	3,23^{b}±0,32	2,64^{c}±0,26	2,33^{c}±0,23	1,94^{c}±0,19	1,04^{d}±0,10	81
Glutamic Acid	7,92^{a}±0,79	4,85^{b}±0,48	4,65^{b}±0,46	4,01^{b}±0,40	3,85^{b}±0,38	3,46^{b}±0,34	1,26^{c}±0,12	84
Proline	0,26^{a}±0,02	0,13^{b}±0,01	0,08^{c}±0,00	0,07^{d}±0,00	0,06^{e}±0,00	0,04^{f}±0,00	0,03^{g}±0,00	88
Serine	2,13^{a}±0,21	1,34^{a}±0,13	1,07^{b}±0,10	0,87^{c}±0,08	0,86^{c}±0,08	0,44^{d}±0,04	0,36^{e}±0,03	83
Glycina	3,63^{a}±0,36	2,23^{b}±0,22	2,07^{b}±0,20	1,64^{c}±0,16	1,27^{c}±0,12	1,12^{d}±0,11	0,75^{e}±0,07	79
Threonine	6,24^{a}±0,62	1,95^{b}±0,19	1,36^{c}±0,13	1,14^{c}±0,11	1,08^{c}±0,10	0,84^{d}±0,08	0,43^{e}±0,04	93
Tyrosine	1,40^{a}±0,14	1,25^{a}±0,12	1,22^{a}±0,12	1,13^{a}±0,11	0,66^{b}±0,06	0,55^{b}±0,05	0,46^{b}±0,04	67
Histidine	1,73^{a}±0,17	1,57^{a}±0,15	1,54^{a}±0,15	1,25^{b}±0,12	1,02^{c}±0,10	0,74^{d}±0,07	0,63^{d}±0,06	64
Alanine	0,58^{a}±0,05	0,26^{b}±0,02	0,25^{b}±0,02	0,19^{c}±0,01	0,19^{c}±0,01	0,15^{d}±0,01	0,13^{d}±0,01	78
%Total degradation								81

Different letters in the same row indicate significant differences by Tukey test (α = 95%).

Table 4 - Mean values and percentage of amino acid degradation of the soya meal used in the manufacture of commercial feed B exposed to a temperature of 50 ± 2 ° C.

Amino acids (mg/100g)	**T0**	**T5**	**T10**	**T15**	**T20**	**T25**	**T30**	**%**
Isoleucine	3,11^{a}±0,31	2,30^{b}±0,23	1,56^{c}±0,15	1,46^{c}±0,14	1,03^{d}±0,10	0,95^{d}±0,09	0,47^{e}±0,04	85
Leucine	4,87^{a}±0,48	3,36^{b}±0,33	2,83^{b}±0,28	2,67^{b}±0,26	2,05^{c}±0,20	1,63^{d}±0,16	0,93^{e}±0,09	81
Arginine	2,73^{a}±0,27	1,88^{b}±0,18	1,74^{b}±0,17	1,73^{b}±0,17	1,66^{b}±0,16	0,53^{c}±0,05	0,18^{d}±0,01	93

Valine	3,22^{a}±0,32	2,41^{b}±0,24	1,54^{c}±0,15	1,46^{c}±0,14	1,05^{d}±0,10	0,45^{e}±0,04	0,20^{f}±0,02	94
Methionine	0,94^{a}±0,09	0,63^{b}±0,06	0,57^{b}±0,05	0,39^{c}±0,03	0,33^{c}±0,03	0,33^{c}±0,00	0,17^{d}±0,01	82
Lysine	8,45^{a}±0,84	5,55^{b}±0,55	5,32^{b}±0,53	4,48^{b}±0,44	3,55^{c}±0,35	3,36^{c}±0,33	1,73^{d}±0,17	80
Phenylalanine	3,52^{a}±0,35	2,18^{b}±0,21	1,94^{b}±0,19	1,84^{c}±0,18	1,44^{d}±0,14	1,14^{e}±0,11	0,48^{f}±0,04	86
Aspartic Acid	6,87^{a}±0,68	4,21^{b}±0,42	3,95^{c}±0,39	3,16^{d}±0,31	2,25^{e}±0,22	2,11^{e}±0,21	0,73^{f}±0,07	89
Glutamic Acid	10,44^{a}±1,04	5,83^{b}±0,58	5,37^{b}±0,53	4,39^{b}±0,43	3,37^{b}±0,33	2,76^{c}±0,27	1,03^{d}±0,10	90
Proline	0,15^{a}±0,01	0,13^{b}±0,01	0,07^{c}±0,00	0,06^{d}±0,00	0,06^{d}±0,00	0,05^{e}±0,00	0,05^{e}±0,00	67
Serine	2,75^{a}±0,27	1,64^{b}±0,16	1,35^{c}±0,13	0,65^{d}±0,06	0,64^{d}±0,06	0,43^{e}±0,04	0,24^{f}±0,02	91
Glycina	2,43^{a}±0,24	1,77^{b}±0,17	1,56^{b}±0,15	1,45^{b}±0,14	1,09^{c}±0,10	1,05^{c}±0,10	0,58^{d}±0,05	76
Threonine	4,78^{a}±0,47	2,37^{b}±0,23	1,35^{c}±0,13	1,32^{c}±0,13	0,75^{d}±0,07	0,71^{d}±0,07	0,33^{e}±0,03	86
Tyrosine	1,55^{a}±0,15	0,97^{b}±0,09	0,92^{b}±0,09	0,83^{b}±0,08	0,67^{c}±0,06	0,65^{c}±0,06	0,26^{d}±0,02	83
Histidine	2,05^{a}±0,20	1,34^{b}±0,13	1,28^{b}±0,12	1,19^{b}±0,11	0,82^{c}±0,08	0,72^{c}±0,07	0,44^{d}±0,04	79
Alanine	0,25^{a}±0,02	0,20^{b}±0,02	0,17^{c}±0,01	0,17^{c}±0,01	0,16^{d}±0,01	0,16^{d}±0,01	0,07^{e}±0,00	72
%Total degradation								83

Different letters in the same row indicate significant differences by Tukey test ($\alpha = 95\%$).

Profile and degradation of amino acids in feeds with different protein levels

The average values and the percentages of degradation of amino acids of the feeds RA35, RB35, RA40 and RB40 during zero (control) and after 5, 10, 15, 20, 25 and 30 days exposed to a temperature of 50 ± 2 ° C are presented in tables 5, 6, 7 and 8. It can be observed a significant

difference in the content of all amino acids investigated after exposure of the feeds to the temperature of 50 ° C, with considerable reduction in the amino acid content of the feeds.

Table 5 - Mean values and percentage of amino acid degradation of the commercial feed A with 35% protein (RA35) exposed to a temperature of 50 ± 2 ° C**.**

Amino acids(mg/100g)	T0	T5	T10	T15	T20	T25	T30	%
Isoleucine	1,96^{a}±0,19	1,93^{a}±0,19	1,23^{b}±0,12	0,94^{c}±0,09	0,93^{c}±0,09	0,89^{c}±0,08	0,35^{d}±0,03	82
Leucine	3,23^{a}±0,32	3,14^{a}±0,31	2,27^{b}±0,22	1,91^{b}±0,19	1,91^{b}±0,19	1,88^{b}±0,18	0,84^{c}±0,08	74
Arginine	2,92^{a}±0,29	2,16^{b}±0,21	1,96^{b}±0,19	1,56^{c}±0,15	1,34^{c}±0,13	0,85^{d}±0,08	0,55^{e}±0,05	81
Valine	2,34^{a}±0,23	2,16^{a}±0,21	1,17^{b}±0,11	1,08^{b}±0,10	0,90^{b}±0,09	0,84^{b}±0,08	0,46^{c}±0,04	80
Methionine	1,13^{a}±0,11	0,64^{b}±0,06	0,54^{b}±0,05	0,53^{b}±0,05	0,44^{c}±0,04	0,33^{d}±0,03	0,12^{e}±0,01	89
Lysine	4,53^{a}±0,45	4,24^{a}±0,42	4,22^{a}±0,42	4,15^{a}±0,41	3,63^{a}±0,36	3,62^{a}±0,36	1,63^{b}±0,16	64
Phenylalanine	2,56^{a}±0,25	2,23^{a}±0,22	1,23^{b}±0,12	1,16^{b}±0,11	1,02^{b}±0,10	0,91^{b}±0,09	0,34^{c}±0,03	87
Aspartic Acid	6,94^{a}±0,69	3,32^{b}±0,33	2,38^{c}±0,23	2,38^{c}±0,23	2,14^{c}±0,21	1,78^{c}±0,17	0,56^{d}±0,05	92
Glutamic Acid	6,75^{a}±0,67	4,33^{b}±0,43	4,28^{b}±0,42	3,45^{c}±0,34	2,41^{d}±0,24	1,25^{e}±0,12	0,76^{f}±0,07	89
Proline	0,13^{a}±0,01	0,09^{b}±0,00	0,09^{b}±0,00	0,08^{c}±0,00	0,06^{d}±0,00	0,04^{e}±0,00	0,03^{f}±0,00	77
Serine	2,11^{a}±0,21	1,73^{b}±0,17	1,24^{c}±0,12	0,97^{d}±0,09	0,84^{d}±0,08	0,72^{d}±0,07	0,28^{e}±0,02	87
Glycina	3,04^{a}±0,30	2,38^{b}±0,23	2,05^{b}±0,20	1,44^{c}±0,14	1,44^{c}±0,14	1,11^{d}±0,11	0,65^{e}±0,06	79
Threonine	2,25^{a}±0,22	1,63^{b}±0,16	1,05^{c}±0,10	1,05^{c}±0,10	1,03^{d}±0,10	0,94^{d}±0,09	0,35^{e}±0,03	84

Tyrosine	1,35^{a}±0,13	0,74^{b}±0,07	0,74^{b}±0,07	0,63^{b}±0,06	0,55^{b}±0,05	0,53^{b}±0,05	0,26^{c}±0,02	81
Histidine	1,45^{a}±0,14	1,15^{b}±0,11	1,06^{b}±0,10	1,04^{b}±0,10	0,98^{b}±0,09	0,53^{c}±0,05	0,43^{d}±0,04	70
Alanine	0,32^{a}±0,03	0,23^{b}±0,02	0,22^{b}±0,02	0,20^{b}±0,02	0,15^{c}±0,01	0,15^{c}±0,01	0,08^{d}±0,00	75
%Total de degradation								81

Different letters in the same row indicate significant differences by Tukey test (α = 95%).

Observing the total degradation means of each feed it can be verified that all feeds evaluated showed high percentages of degradation. Moreover, the amino acid composition stability cannot be attributed to the physical structure of the feed if crushed orpelletized. The feeds with 35% protein (pelletized) showed similar degradation of the samples with 40% protein (crushed), so there wasn'tthe physical structure of the feed which provided greater stability amino acids, considering that the crushed feed showed the same degradation as the pelletized ones. It's important to remember thatfeeds with 35% protein are crushed to then be pelletized while 40% ones are just crushed.

Table 6 - Mean values and percentage of amino acid degradation in commercial feed B with 35% protein (RB35) exposed to a temperature of 50 ± 2 ° C.

Amino acids (mg/100g)	**T0**	**T5**	**T10**	**T15**	**T20**	**T25**	**T30**	**%**
Isoleucine	1,93^{a}±0,19	1,45^{b}±0,14	1,45^{b}±0,14	1,13^{c}±0,11	0,83^{d}±0,08	0,54^{e}±0,05	0,46^{e}±0,04	76
Leucine	3,26^{a}±0,32	2,65^{b}±0,26	2,64^{b}±0,26	2,46^{b}±0,24	1,74^{c}±0,17	0,98^{d}±0,09	0,96^{d}±0,09	71
Arginine	3,15^{a}±0,31	1,75^{b}±0,17	1,31^{c}±0,13	1,16^{c}±0,11	0,76^{d}±0,07	0,57^{e}±0,05	0,24^{f}±0,02	92
Valine	1,82^{a}±0,18	1,76^{a}±0,17	1,44^{b}±0,14	1,03^{c}±0,10	0,65^{d}±0,06	0,57^{d}±0,05	0,35^{e}±0,03	81
Methionine	0,85^{a}±0,08	0,84^{b}±0,08	0,78^{b}±0,07	0,54^{b}±0,05	0,54^{c}±0,05	0,33^{d}±0,03	0,32^{e}±0,03	62
Lysine	6,66^{a}±0,66	5,11^{b}±0,51	5,04^{b}±0,50	4,64^{b}±0,46	3,75^{c}±0,37	2,53^{d}±0,25	2,15^{d}±0,21	68

Phenylalanine	2,14[a]±0,21	1,87[a]±0,18	1,56[b]±0,15	1,51[b]±0,15	0,95[b]±0,09	0,51[b]±0,05	0,46[c]±0,04	79
Aspartic Acid	4,85[a]±0,48	2,86[b]±0,28	2,83[b]±0,28	2,26[c]±0,22	2,14[c]±0,21	1,45[d]±0,14	0,54[e]±0,05	89
Glutamic Acid	7,15[a]±0,71	5,35[b]±0,53	5,11[b]±0,51	3,03[c]±0,30	2,96[c]±0,29	2,34[d]±0,23	0,76[e]±0,07	89
Proline	0,15[a]±0,01	0,09[b]±0,00	0,07[c]±0,00	0,06[d]±0,00	0,04[e]±0,00	0,03[f]±0,00	0,03[g]±0,00	80
Serine	1,63[a]±0,16	1,45[a]±0,14	1,37[a]±0,13	0,94[b]±0,09	0,87[b]±0,08	0,75[b]±0,07	0,34[c]±0,03	79
Glycina	2,48[a]±0,24	2,15[a]±0,21	2,12[a]±0,21	2,02[a]±0,20	1,85[a]±0,18	0,94[b]±0,09	0,85[b]±0,08	66
Threonine	1,45[a]±0,14	1,36[a]±0,13	1,35[a]±0,13	1,33[a]±0,13	0,95[b]±0,09	0,76[c]±0,07	0,43[d]±0,04	70
Tyrosine	1,16[a]±0,11	0,75[b]±0,07	0,71[b]±0,07	0,63[b]±0,06	0,54[b]±0,05	0,43[c]±0,04	0,36[d]±0,03	69
Histidine	1,53[a]±0,15	1,27[a]±0,12	1,24[a]±0,12	1,16[a]±0,11	0,92[b]±0,09	0,72[c]±0,07	0,24[d]±0,02	84
Alanine	0,26[a]±0,02	0,25[a]±0,02	0,20[b]±0,02	0,18[b]±0,01	0,17[b]±0,01	0,10[c]±0,01	0,05[d]±0,00	81
%Total degradation								77

Different letters in the same row indicate significant differences by Tukey test (α = 95%).

In referring to the manufacturers,feed A and B have experienced similar degradation in the range of 35% protein, while in the 40% range the feed A degraded about 5% higher than the feed B.

Table 7 - Mean values and percentage of amino acid degradation of the commercial feed A with 40% protein (RA40) exposed to a temperature of 50 ± 2 ° C.

Amino acids (mg/100g)	**T0**	**T5**	**T10**	**T15**	**T20**	**T25**	**T30**	**%**
Isoleucine	1,95[a]±0,19	1,82[a]±0,18	1,44[b]±0,14	0,94[c]±0,09	0,73[d]±0,07	0,65[d]±0,06	0,47[e]±0,04	76

Leucine	3,31^{a}±0,33	2,98^{b}±0,29	2,66^{b}±0,26	1,67^{c}±0,16	1,53^{c}±0,15	1,26^{d}±0,12	0,94^{e}±0,09	72
Arginine	4,06^{a}±0,40	2,14^{b}±0,21	1,85^{c}±0,18	1,55^{c}±0,15	1,04^{d}±0,10	0,86^{e}±0,08	0,55^{f}±0,05	86
Valine	2,03^{a}±0,20	1,63^{b}±0,16	1,14^{c}±0,11	0,76^{d}±0,07	0,54^{e}±0,05	0,45^{f}±0,04	0,35^{g}±0,03	83
Methionine	0,76^{a}±0,07	0,76^{a}±0,07	0,44^{b}±0,04	0,42^{b}±0,04	0,33^{c}±0,03	0,32^{c}±0,03	0,16^{d}±0,01	79
Lysine	7,05^{a}±0,70	5,04^{b}±0,50	5,03^{b}±0,50	2,95^{c}±0,29	2,65^{c}±0,26	2,54^{c}±0,25	2,01^{d}±0,20	71
Phenylalanine	2,04^{a}±0,20	2,02^{a}±0,20	1,64^{b}±0,16	1,16^{c}±0,11	0,93^{d}±0,09	0,67^{e}±0,06	0,38^{f}±0,03	81
Aspartic Acid	2,94^{a}±0,29	2,87^{a}±0,28	2,24^{b}±0,22	2,12^{b}±0,21	1,62^{c}±0,16	1,14^{d}±0,11	0,54^{e}±0,05	82
Glutamic Acid	6,42^{a}±0,64	5,74^{a}±0,57	5,17^{a}±0,51	4,12^{b}±0,41	2,27^{c}±0,22	1,95^{c}±0,19	0,76^{d}±0,07	89
Proline	0,13^{a}±0,01	0,09^{b}±0,00	0,08^{c}±0,00	0,06^{d}±0,00	0,04^{e}±0,00	0,04^{e}±0,00	0,03^{f}±0,00	67
Serine	1,75^{a}±0,17	1,64^{a}±0,16	1,16^{b}±0,11	1,13^{b}±0,11	0,64^{c}±0,06	0,57^{c}±0,05	0,32^{d}±0,03	82
Glycina	2,74^{a}±0,27	2,51^{a}±0,25	2,35^{a}±0,23	1,46^{b}±0,14	1,13^{c}±0,11	0,97^{c}±0,09	0,77^{d}±0,07	72
Threonine	1,57^{a}±0,15	1,46^{a}±0,14	1,31^{a}±0,13	1,04^{b}±0,10	0,64^{c}±0,06	0,61^{c}±0,06	0,35^{d}±0,03	78
Tyrosine	2,57^{a}±0,25	0,72^{b}±0,07	0,72^{b}±0,07	0,45^{c}±0,04	0,43^{c}±0,04	0,36^{d}±0,03	0,26^{e}±0,02	90
Histidine	1,43^{a}±0,14	1,37^{a}±0,13	1,34^{a}±0,13	0,83^{a}±0,08	0,64^{b}±0,06	0,62^{c}±0,06	0,55^{d}±0,05	62
Alanine	0,25^{a}±0,02	0,24^{a}±0,02	0,19^{b}±0,01	0,19^{b}±0,01	0,18^{b}±0,01	0,13^{c}±0,01	0,01^{d}±0,00	96
%Total degradation								79

Different letters in the same row indicate significant differences by Tukey test (α = 95%).

Table 8 - Mean values and percentage of amino acid degradation commercial feed B with 40% protein (RB40) exposed to a temperature of 50 ± 2 ° C.

Amino acids (mg/100g)	T0	T5	T10	T15	T20	T25	T30	%
Isoleucine	2,18^{a}±0,21	1,31^{b}±0,13	1,05^{c}±0,10	0,77^{d}±0,07	0,76^{d}±0,07	0,57^{e}±0,05	0,55^{e}±0,05	75
Leucine	4,25^{a}±0,42	2,57^{b}±0,25	1,95^{b}±0,19	1,72^{c}±0,17	1,63^{c}±0,16	1,26^{d}±0,12	1,24^{e}±0,12	71
Arginine	2,44^{a}±0,24	1,63^{b}±0,16	1,55^{b}±0,15	0,97^{c}±0,09	0,84^{c}±0,08	0,72^{c}±0,07	0,25^{d}±0,02	90
Valine	1,73^{a}±0,17	1,36^{b}±0,13	0,96^{c}±0,09	0,94^{c}±0,09	0,75^{d}±0,07	0,61^{e}±0,06	0,25^{f}±0,02	86
Methionine	0,76^{a}±0,07	0,61^{b}±0,06	0,54^{b}±0,05	0,45^{c}±0,04	0,44^{c}±0,04	0,37^{d}±0,03	0,28^{e}±0,02	63
Lysine	6,74^{a}±0,67	4,77^{b}±0,47	3,66^{c}±0,36	3,53^{c}±0,35	3,36^{c}±0,33	3,02^{c}±0,30	2,87^{c}±0,28	57
Phenylalanine	2,45^{a}±0,24	1,54^{b}±0,15	1,23^{c}±0,12	0,88^{d}±0,08	0,85^{d}±0,08	0,66^{e}±0,06	0,36^{f}±0,03	85
Aspartic Acid	2,95^{a}±0,29	2,83^{a}±0,28	1,94^{b}±0,19	1,82^{b}±0,18	1,53^{b}±0,15	1,42^{b}±0,14	0,96^{c}±0,09	67
Glutamic Acid	6,25^{a}±0,62	5,54^{a}±0,55	3,85^{b}±0,38	3,43^{b}±0,34	2,53^{c}±0,25	2,06^{d}±0,20	1,11^{e}±0,11	82
Proline	0,18^{a}±0,01	0,09^{b}±0,00	0,08^{c}±0,00	0,06^{d}±0,00	0,05^{e}±0,00	0,03^{f}±0,00	0,03^{g}±0,00	83
Serine	1,66^{a}±0,16	1,23^{b}±0,12	1,15^{b}±0,11	1,06^{b}±0,10	0,73^{c}±0,07	0,65^{c}±0,06	0,45^{d}±0,04	73
Glycina	3,57^{a}±0,35	2,22^{b}±0,22	1,62^{c}±0,16	1,55^{c}±0,15	1,45^{c}±0,14	1,44^{c}±0,14	0,96^{d}±0,09	73
Threonine	2,08^{a}±0,20	1,65^{b}±0,16	1,04^{c}±0,10	0,92^{c}±0,09	0,84^{c}±0,08	0,81^{c}±0,08	0,64^{d}±0,06	69
Tyrosine	2,65^{a}±0,26	0,65^{b}±0,06	0,56^{b}±0,05	0,46^{c}±0,04	0,43^{c}±0,04	0,43^{d}±0,04	0,43^{e}±0,04	84
Histidine	1,77^{a}±0,17	1,24^{b}±0,12	0,95^{c}±0,09	0,87^{c}±0,08	0,84^{c}±0,08	0,84^{c}±0,08	0,83^{c}±0,08	53
Alanine	0,32^{a}±0,03	0,16^{b}±0,01	0,16^{b}±0,01	0,16^{b}±0,01	0,15^{b}±0,01	0,13^{c}±0,01	0,12^{c}±0,01	62
%Total degradation								73

Different letters in the same row indicate significant differences by Tukey test (α = 95%).

Discussions

The loss of amino acids of fish meals A and B ranged from 49% (alanine) to 96% (valine and arginine) and 74% (alanine) to 96% (arginine), respectively. Buedo et al. (2001) evaluated the storage of the pear juice for 112 days under a temperature of 37 ^{O} C and detected that the loss of alanine and arginine during a maximum period of study was 47 and 96%, respectively.

The amino acids losses found in soya meals A and B ranged from 64% (histidine) to 93% (valine and threonine) and 67% (proline) to 94% (valine), respectively. Bueno et al. (2001) evaluating the storage of the pear juice for 112 days under a temperature of 37 C ^{O} observed that loss of histidine and threonine for the maximum period of study was 64 and 93%, respectively.

The amino acids losses found in soya meals A and B ranged from 64% (histidine) to 93% (valine and threonine) and 67% (proline) to 94% (valine), respectively. Bueno et al. (2001) evaluating the storage of the pear juice for 112 days under a temperature of 37 C ^{O} observed that losses of histidine and threonine for the maximum period of study was 64 and 93%, respectively.

The amino acids degradation in the feeds (35A, 35B, 40A and 40B) were 64% (lysine) to 92% (aspartic acid), 62% (methionine) to 92% (arginine), 62% (histidine) to 96% (alanine) and 53% (histidine) to 90% (arginine), respectively. Studies relating to the storage of pear juice for 112 days under a temperature of 37 ^{O} C showed that the losses of aspartic acid and methionine for the maximum period of study was 0 and 86%, respectively (BUEDO et al. 2001).

Marty and Chavez et al. (1995) evaluating the degradation of amino acids in soy flour observed that the losses occurring amino acids from the manufacture of flours until storage for future use in making rations. In the same study, the authors observed losses of amino acids when compared to the soy flour soy flour extruded and baked, and observed for loss of amino acids histidine, threonine, valine and proline values and 16% of 6, 7 and 12% , 8 to 12%; 2 and 15%, respectively for untreated soy flour and flours extruded with subsequent baking. The authors concluded that the processes of degradation of amino acids remain in the stage of storage.

Marty and Chavez et al. (1995) evaluating amino acids degradation in soya meal observed that the amino acids losses occurred from the manufacture of the meals until storage for future use in making feeds. In the same study, the authors observed losses of amino acids when compared the untreated soya meal with the soya meal extruded and baked and observed amino acids losses of histidine, threonine, valine and proline with the values of 6 and 16%, 7 and 12%, 8 and 12%; 2 and 15%, respectively for untreated soya meal and soya meal extruded with subsequent baking. The authors concluded that the processes of degradation of amino acids remain in the stage of storage.

Marty and Chavez (1995) evaluating the digestibility of amino acids in soy based products subjected to heat treatment, observed an improvement in digestibility of these amino acids, but amino acid losses were demonstrated in products subjected to severe heat treatments. The same authors observed that the digestibility of lysine was lower in extruded and toasted soya meal than in the just extruded soya meal. The reductions observed in the apparent digestibility of lysine were primarily a result of the increased endogenous flow of lysine. For the evaluation of soybean processed under conditions of normal digestibility of amino acids appear to provide a good estimate of amino acid availability. However, if the soybean was exposed to more stringent processing conditions such as those used in the production of rumen, a larger amount of amino

acid will be absorbed and that they cannot efficiently be used and are excreted in the urine. These results suggest that diets containing extruded and toasted soya meal are not equivalent to diets containing soybean meal and fat, due to low digestibility of amino acids.

Buedo et al. (2001) demonstrated that there is a strong degradation of amino acids during the storage of pear juice, as a consequence of the reactions of non-enzymatic browning of the product which confirms the Maillard reaction. The decreases in concentration follow an exponential law with constant speed and are strongly temperature dependent. Thus, the loss of amino acids in the temperature of 37^{O} C is faster than 30° C, which in turn is faster than at 15^{O}C.

Studies evaluating the nutritional quality of processed northern shrimp (*Pandalus borealis*) and southern rough shrimp (*Trachypenaeus curvirostris*) stored at -70^{O} C found significant losses in all studied amino acids, except for proline in the northern shrimp and phenylalanine which increased its amount in the industrialized product in both shrimps (Heu et al., 2003).

The effect of pasteurization and sterilization in amino acids contained in processed cheese found that most amino acids studied suffered degradation regardless of heat treatment. The exceptions were threonine, valine and tyrosine that were stable throughout the experiment (Bunka, 2004).

Evaluating the effect of the industrial process on amino acid profile of chocolate, Adeyeye (2010) found that most amino acids are degraded except for aspartic acid, serine, glutamic acid, glycine and alanine. Cooking and sterilization affected the amino acid composition of immature seeds of three types of beans and it has been found, in general terms, that in all three kinds of beans cooking and canning were severe as regards the stability of the nutritional samples. Losses were about 7% in the fresh and cooked samples and losses of 24% between fresh samples and canned ones (Slupski, 2010).

Lysine and methionine tend to suffer changes during storage or during food processing and consequent nutritional losses. The Maillard reaction between amino groups of lysine and the reducing sugars is the most important route by which lysine present in a protein can be lost. During processing at high temperatures, especially about alkaline conditions, the lysine side chains are capable of forming bonds with other amino acids. Besides reducing the number of lysine residues available, the formation of such connections between neighboring polypeptide chains tends to prevent assimilation of much of the rest of the protein molecule, since the unwinding and access to the gut proteolytic enzymes are hampered (Coultate , 2004).

The reduction of amino acid content can be caused by various reactions, including, for example, the Strecker degradation of amino acids and Maillard reaction (Friedman, 1996; Kristensen, et al. 2001; Schar and Bosset, 2002).

The amino acids losses also occur due to deamination processes in which the results of sterilization provide an increase in ammonia concentration of over 50 mg kg-1 on average. Another important degradative process are lipid reactions (e.g., oxidation), which forms products that may affect subsequent reactions of nitrogenous substances (Kristensen and Skibsted, 1999; Kristensen et al, 2001).

Heat can also alter amino acid residues chemically. Dehydration and deamination of serine, glutamine and asparagine can lead to formation of new intra or intermolecular bonds and denaturation break disulfide covalent bonds, releasing hydrogen sulfide (Espe and Lied, 1999).

Conclusions

The results obtained in this study indicate that high temperatures reduce the amino acid content of meals and feed exposed to it significantly.

Fish meal and soya meal amino acids can be lost even before its use in the manufacturing process of feeds.

In the feed exposure to elevated temperatures the physical structure of the feed does not prevents the degradation process of amino acids.

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