Apparent Dry Matter, Protein and Amino Acid Digestibility of Six Rendered Animal Products in *Litopenaeus vannamei* Juveniles

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Resumen

La digestibilidad aparente de materia seca, proteína cruda y aminoácidos individuales de 6 subproductos de rastro fue determinada in vivo al incluir los subproductos al 30% en dietas prueba para alimentar juveniles de camarón blanco del Pacifico (peso inicial 5g), el 70% restante siendo la mezcla de referencia, constituida de una dieta comercial molida suplementada con 1% de alginato de sodio como aglutinante, y 1% de oxido de cromo como marcador inerte. El estudio se llevo a cabo con dos harinas de subproductos de pollo grado mascota (72.3 y 68.6% PC = proteína cruda en base seca), dos harinas de pluma (85.5 y 86.7% PC), una harina de sangre de pollo (94.5%PC) y una harina de subproductos de cerdo (58.5% PC), procedentes de diferentes procesadoras de EUA.

La digestibilidad de materia seca fue significativamente mayor en las harinas de pollo o de cerdo (69-73%) que en harinas de sangre o pluma (57-62%), pero fue menor en todos los productos que en la dieta de referencia (78%), formulada a base de harinas de pescado, pasta de soya y trigo. La misma tendencia se observó para digestibilidad de proteína cruda (ref 84% > pollo o cerdo 75-80% > pluma o sangre 57-62%) y para la suma de aminoácidos (ref 88% > pollo o cerdo 74-80% > pluma o sangre 65-67%).

La digestibilidad de aminoácidos individuales mostró variaciones importantes entre productos y entre aminoácidos: la cistina fue el aminoácido menos digestible, con una diferencia de -7% en sangre, -10% en pluma, -17% en pollo y -37% en cerdo con respecto a la digestibilidad de proteina cruda. Los aminoácidos de mayor digestibilidad fueron histidina y glicina en general. Arginina, metionina y lisina, así como la suma de aminoácidos totales o esenciales, mostraron digestibilidades cercanas a la de proteína cruda.

Las concentraciones de aminoácidos digestibles, tomados individualmente, fueron mayores en harinas de sangre y de pollo que en la dieta de referencia; pero en harinas de pluma, los niveles de histidina, metionina y lisina digestibles fueron muy bajos, así como en harina de cerdo los niveles de cistina, metionina, isoleucina y leucina digestibles.

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Editores: L. Elizabeth Cruz Suárez, Denis Ricque Marie, Mireya Tapia Salazar, Martha G. Nieto López, David A. Villarreal Cavazos, Juan Pablo Lazo y Ma. Teresa Viana.
Avances en Nutrición Acuícola IX. IX Simposio Internacional de Nutrición Acuícola. 24-27 Noviembre. Universidad Autónoma de Nuevo León, Monterrey, Nuevo León, México.

1. Introduction

Rendered terrestrial animal products are of growing quality through better controlled processes. They are *a priori* free of sanitary restriction for their use in aquatic animals,
and relatively cheap *versus* marine and vegetable protein sources.

But their amino acid profile is very different from the recommended profile in shrimp feeds, presenting very low levels for certain essential AAs; and this may be worse or better in terms of digestible AA contents.

Therefore, knowledge on digestibility of these potentially growth limiting Aas will be of crucial importance to preview the nutritional value of rendered products.

2. Material and methods

2.1 Ingredients proximal composition (Table 1)

For this study, we have chosen six rendered products, which are classified in Fig 1 on their crude protein content: a poultry blood meal, two hydrolyzed feather meals, two poultry by-products meals pet food grade, and a swine meat & bone meal.

Let point out the high protein contents of blood and feather meals, with low mineral contents, while poultry meals had a little more than 10% ash (a condition to get the pet food grade), and swine meat and bone meal contained up to 25% ash.

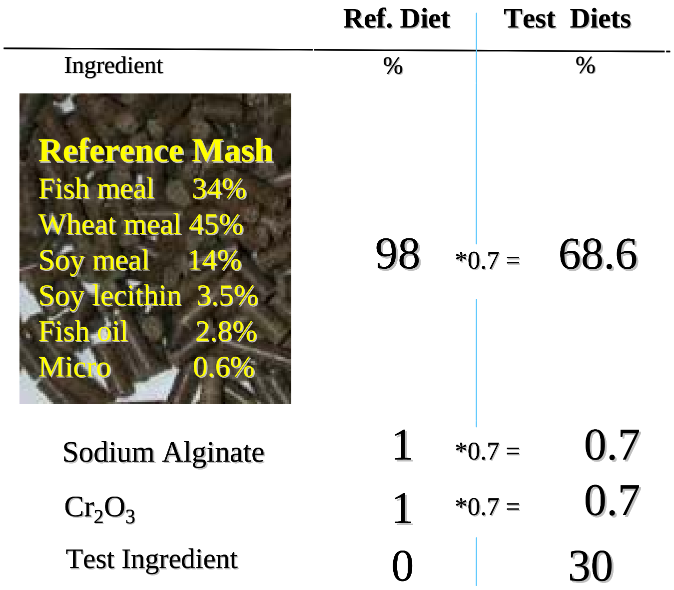
The reference ingredient, at the bottom, contained 35% crude protein and 10% lipids, and was formulated as a traditional fish-meal based shrimp feed, according to the recommendations proposed by Akiyama *et al.* (1991).

Table. 1. Ingredients proximal composition

	Protein	Fat	Ash	Fiber
Poultry blood meal				
Blood	94.5	2.2	3.6	---
Hydrolyzed feather meals				
Feath A	86.7	10.4	3.6	---
Feath B	85.9	12.2	1.9	---
Poultry byproduct meals				
Poult A	72.3	15.4	10.8	---
Poult B	68.6	16.2	13.3	---
Swine meat & bone meals				
Swine	58.5	12.4	25.3	---
Shrimp commercial feed				
Reef	34.6	9.7	10.2	4.1

2.2 Diets formulation (Fig. 1) **and preparation**

Protein sources in the reference formula were fish meal, soybean meal and wheat meal; lipids sources, apart from fish meal, were soy lecithin and fish oil. The reference ingredient mixture was first pelleted in a commercial plant, then ground to obtain a particle size of less than 500 microns, and mixed with 1% chromic oxide as an inert marker, and 1% alginate as a binder, and finally reprocessed at laboratory.



Ingredient	Ref. Diet %		Test Diets %
Reference Mash Fish meal 34% Wheat meal 45% Soy meal 14% Soy lecithin 3.5% Fish oil 2.8% Micro 0.6%	98	*0.7 =	68.6
Sodium Alginate	1	*0.7 =	0.7
Cr_2O_3	1	*0.7 =	0.7
Test Ingredient	0		30

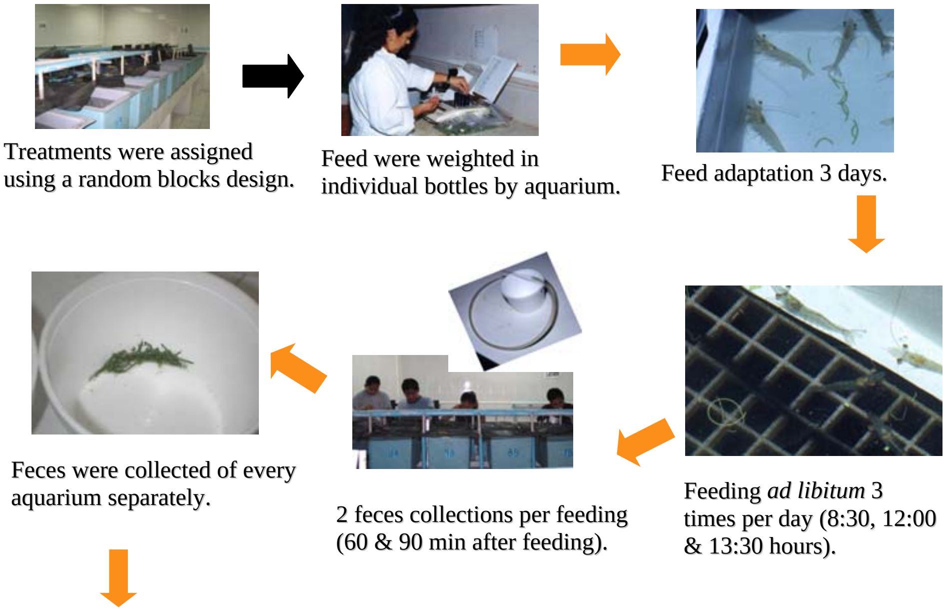
Fig. 1. Diets formulation

The test diets were formulated as containing 70 % of the reference diet mash and 30% of the test ingredient; there chromic oxide was thus 0.7 %. As for the reference diet, they were processed at laboratory by wet extrusion in a meet grinder, in the form of spaghetti-like strands (1.6mm diameter) (Cruz-Suárez *et al.*, 2001, 2007).

2.3 Digestibility Trial (Fig. 2)

The 6 test diets and the ref diet were fed each to four replicated groups of 24 shrimp (5 g average initial weight), three times a day for a total daily ration of about 10% of biomass, and feces were collected 60 and 90 minutes after each feeding.

With 24 shrimp per tank, it took 5 days to collect at least 8g fresh feces from each tank. Figures 3 and 4 show our bioassay hall, how we weight the feed, collect the feces by siphoning, clean them, freeze-dry and store them.



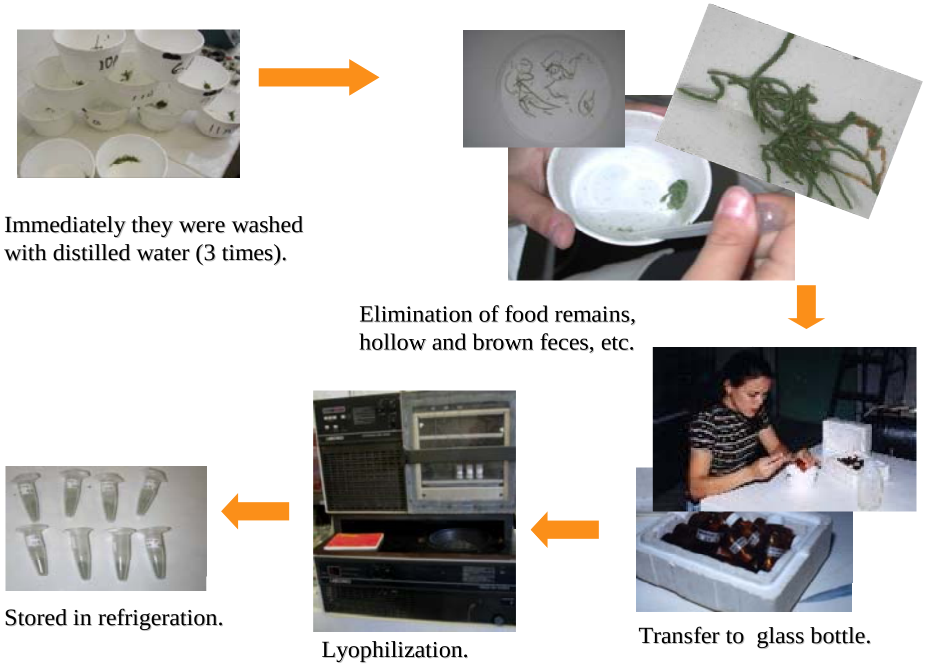


Fig. 2 Feces collection

Feces samples were sent to Hanau, Germany, for their AA analysis at Evonik-Degussa laboratory, as well as samples of the diets and test ingredients.

3. Results

3.1 AA concentrations in test ingredients and reference diet

Among the test ingredients, feather meals contained a lower proportion of essential amino acids with respect to their crude protein and total amino acids contents (Fig. 3).

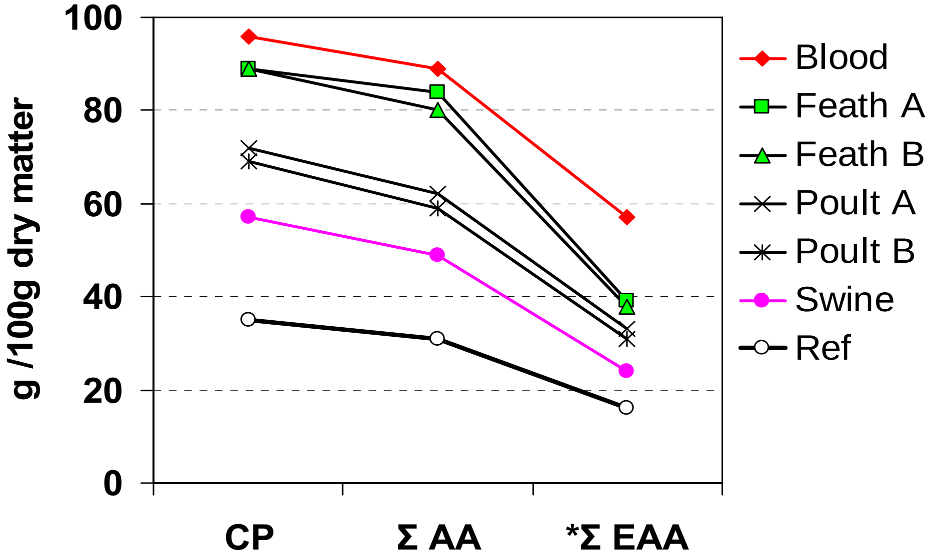


Fig. 3. Sum of AA concentrations

In the following series of figures, we will see how the analyzed amino acid composition of the test ingredients was representative of their category, and where are their deficiencies with respect to the balanced amino acid profile of the reference diet.

Upper and lower limits of the 95% confidence interval for each AA concentration, as calculated from the data given by the Degussa Aminodat program for a specific ingredient, will be shown as simple continuous lines.

3.1.1 AA concentrations – Blood meal, poultry (Fig.4)

Poultry blood meal provides very high essential amino concentrations, although it is not so good for met, but still not bad.

3.1.2 AA concentrations – Blood meal, pig & cow? (Fig. 5)

Definitely, our blood meal sample did not fit in a pig&cow blood aminoacid profile.

3.1.3 AA concentrations – Feather meals (Fig. 6)

The two feather meal samples had a typical amino acid profile, unfortunately clearly deficient in four essential aminoacids: histidine, methionine, tryptophane and Lysine.

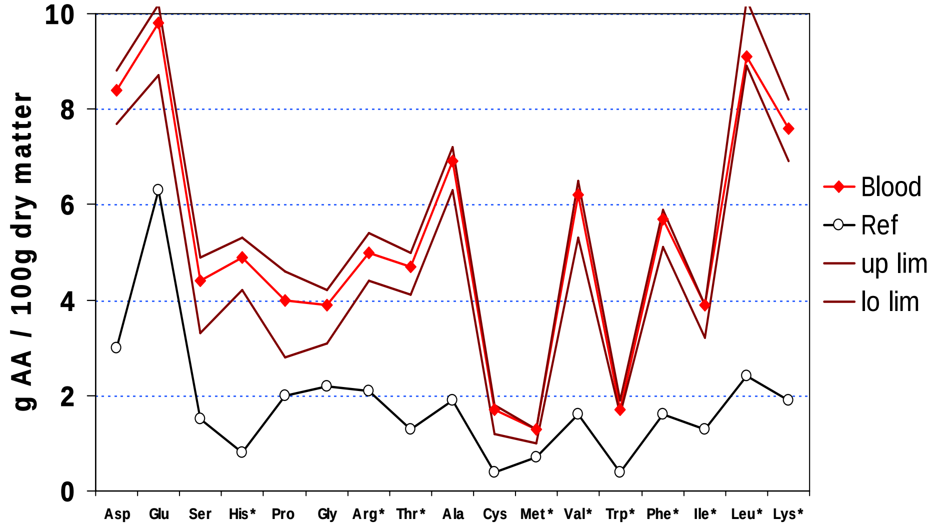


Fig. 4. AA concentrations

Blood meal, poultry

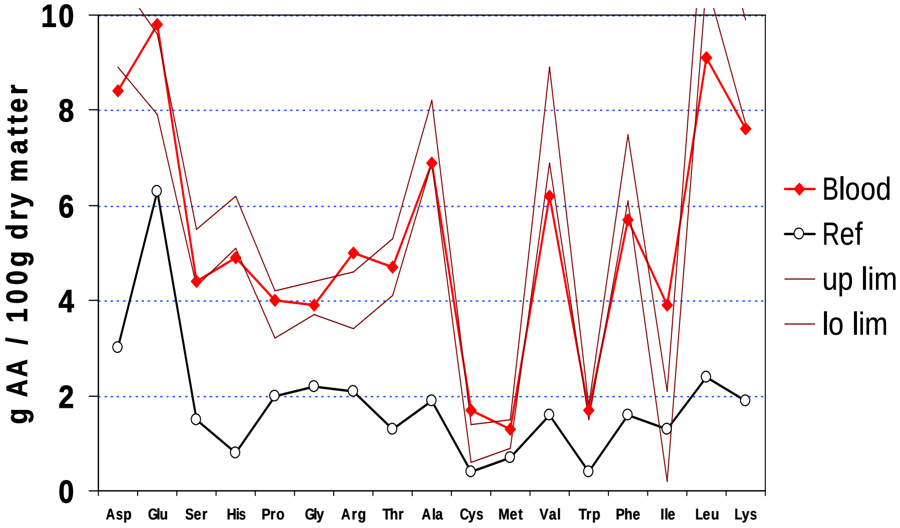


Fig. 5. AA Concentrations

Blood meal, pig & cow?

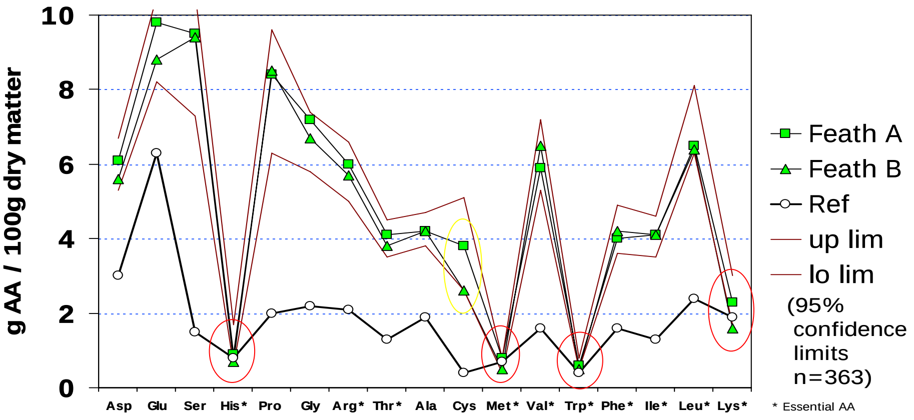


Fig. 6 AA concentrations

Feather meals

3.1.4 AA concentrations – Poultry meals (Fig. 7)

Poultry by-product meals were also typical in their composition, and much closer to the shrimp requirement profile, although low in cystine and tryptophane.

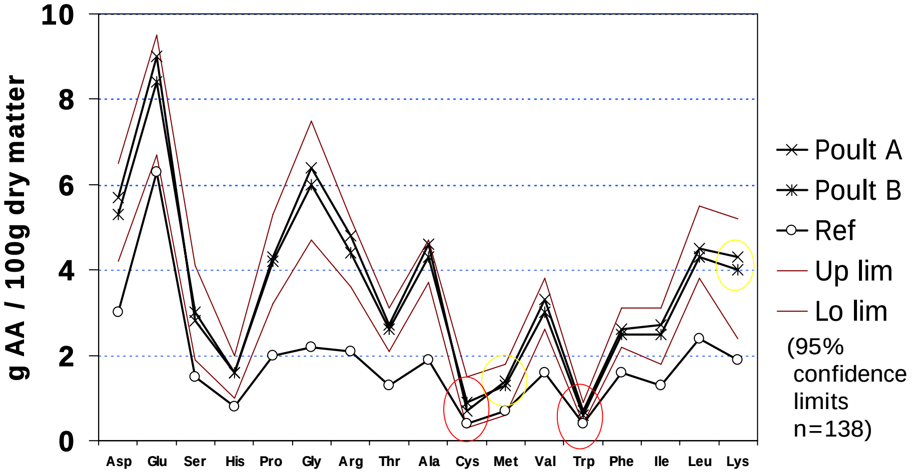


Fig. 7. AA concentrations

Poultry meals

3.1.5 AA concentrations – Meat and bone meal, pig (Fig. 8)

Swine meat & bone meal are also relatively well balanced for shrimp, but our sample was certainly in the low part of the range.

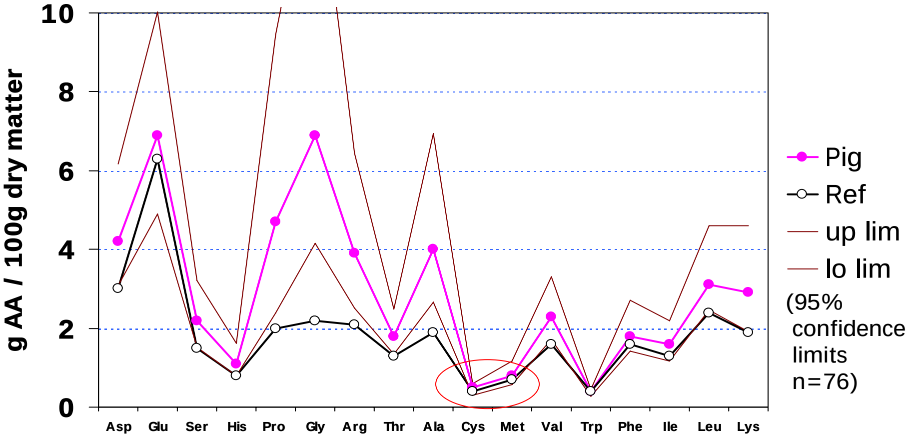


Fig. 8. AA concentrations

Meat & bone meal, pig

3.2 Apparent digestibility coefficients for DM, CP and sum of AA

These are the apparent digestibility coefficients (ADCs) for dry matter, crude protein, sum of AAs and sum of essential AAs (Fig. 9):

- on top is the reference formula

with 78% digestibility for dry matter,

84 % digestibility for crude protein and 88% for total amino acids

- then come the poultry and swine by-products meals,

    with 69-73% digestibility for dry matter

    and 75 to 80% for crude protein and total amino acids

    but a lower digestibility for essential amino acids with the swine (meat and bone) meal

- at bottom, are the blood and feather meals

with 57-62% digestibility for dry matter

and 65 to 67% for crude protein and total amino acids but lower value for essential AA with one of the feather meals

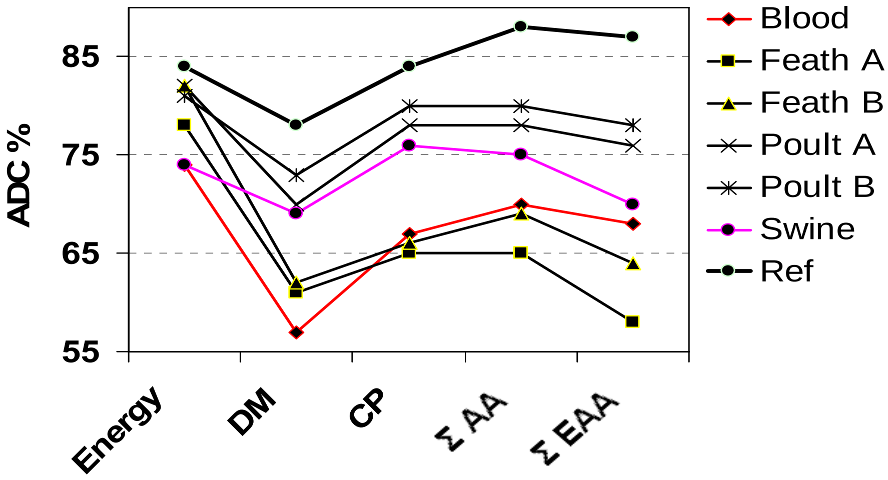


Fig. 9. Apparent digestibility coefficients

Rendered products

3.2.1 AA Apparent digestibility coefficients – All rendered products (Fig. 10)

Coming to the individual amino acid digestibility profiles, we can see important variations between amino acids and ingredients samples.

Cystine was less digested in all rendered products, in contrast with the reference formula, which had more uniform values.

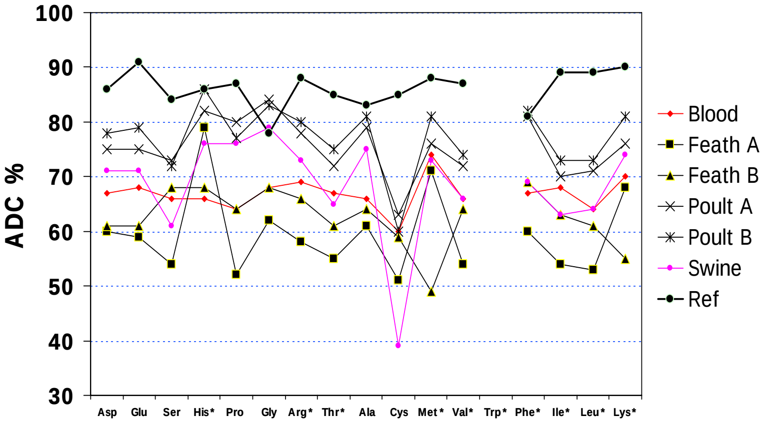


Fig. 10. AA app. Digestibility coefficients

Rendered products

3.2.2 AA ADCs variation among species – Blood meal (Fig. 11)

In the following series of slides, we will compare the figures in shrimp with ileal digestibility in swine and poultry, which have been often used by shrimp feed formulators in absence of digestibility figures in shrimp.

In the present case, shrimp did not digest the blood meal as well as swine and poultry do.

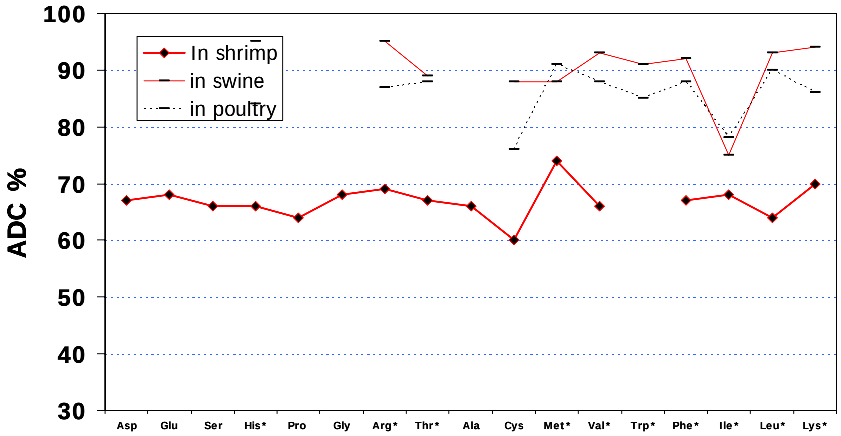


Fig. 11. AA ADCs variation among species

Blood meal

3.2.3 AA ADCs variation among species – Feather meals A *vs* B (Fig. 12)

Shrimp digest feather meal amino acids as bad as swine and poultry do.

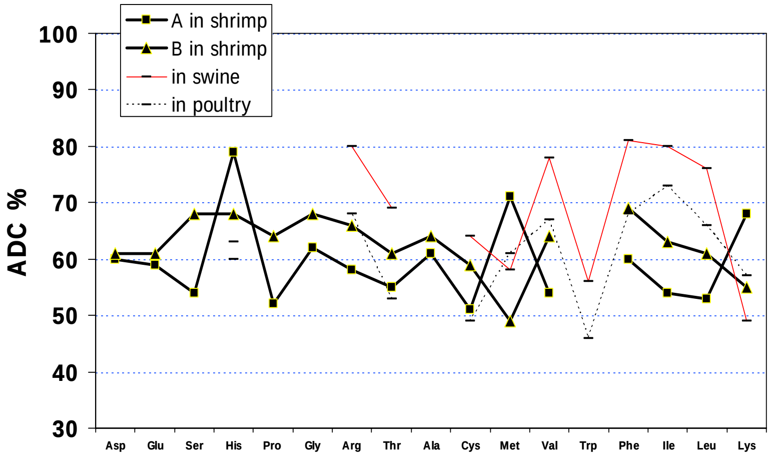


Fig. 12. AA ADCs variation among species

Feather meals A & B

3.2.4 AA ADCs variation among species – Poultry meals A *vs* B (Fig 13)

AA digestibility of poultry meals in shrimp was lower than in swine and poultry, with a low value for cystine.

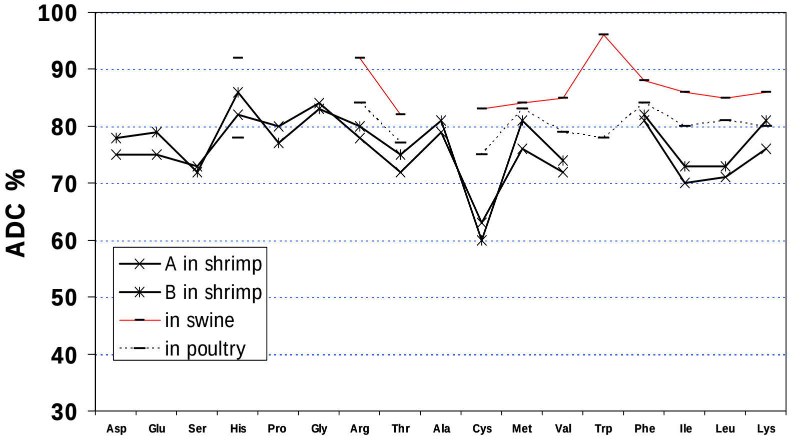


Fig. 13. AA ADCs variation among species

Poultry meals A & B

3.2.5 AA ADCs variation among species – Pig meat and bone meal (Fig. 14)

For swine meal either, AA digestibility in shrimp was lower in shrimp than in poultry and swine; cystine digestibility in shrimp was fairly low, down to 40%.

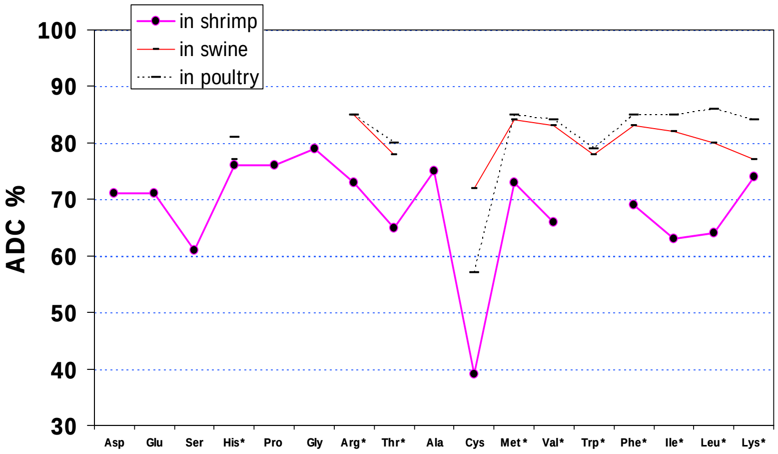


Fig. 14. AA ADCs variation among species

Pig meat & Bone meal

3.3 Digestible AA concentrations

Concentrations of digestible nutrients were calculated by multiplying the total concentration of a nutrient by its digestibility coefficient.

3.3.1 Digestible AA concentrations - Reference formula (Fig. 15)

For the reference formula, the drop from total to digestible amino acid concentrations is small because the digestibility was high, and digestible AA concentrations are still close to the AA levels recommended for shrimp diets by Akiyama, Dominy and Lawrence (1991).

3.3.2 Digestible AA concentrations – Blood meal (Fig. 16)

For blood meal, the drop to digestible concentrations was important, but they are still over those of the reference formula.

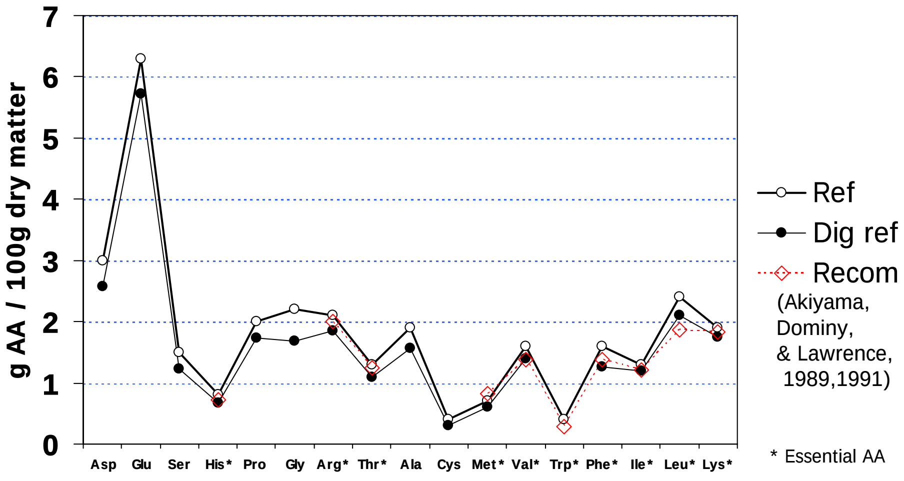


Fig. 15. Digestible AA concentrations

Referente diet

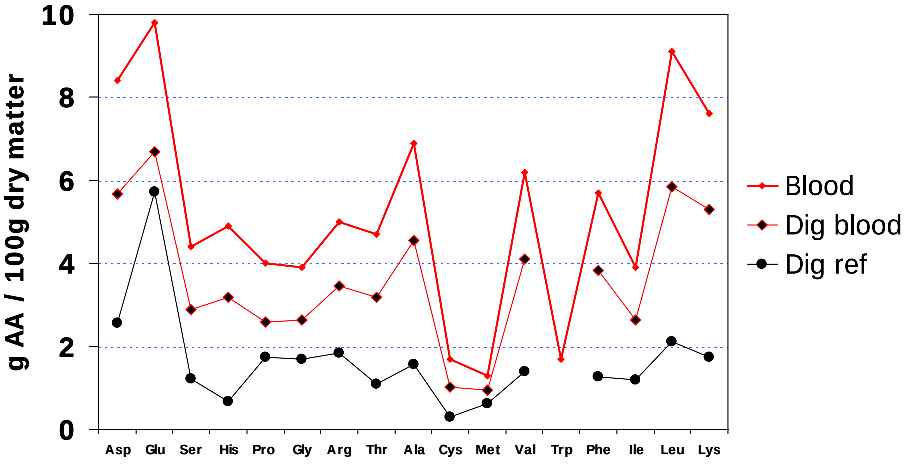


Fig. 16. Digestibile AA concentrations

Blood meal

3.3.3 Digestible AA concentrations – Feather meals (Fig. 17)

For the feather meals, concentrations of digestible amino acids passed under those of the reference formula in the case of histidine, methionine, lysine and probably tryptophane.

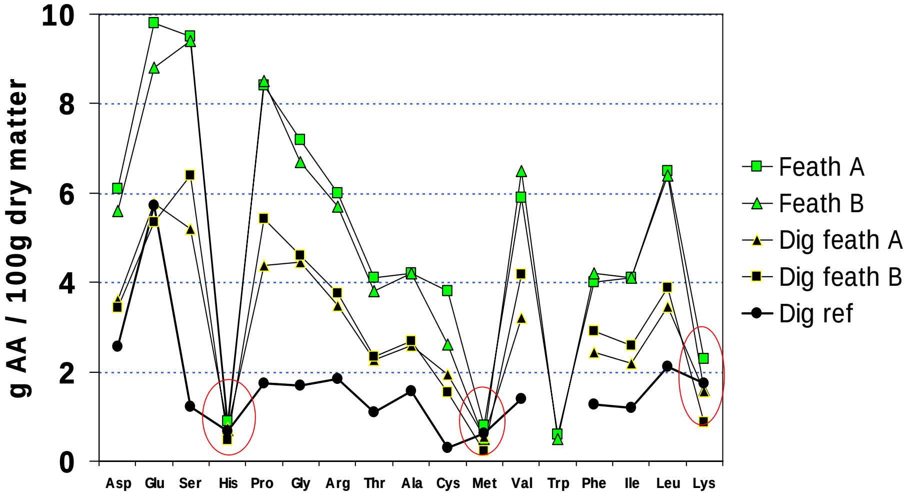


Fig. 17. Digestible AA concentrations

Feather meals

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3.3.4 Digestible AA concentrations – Poultry meals (Fig. 18)

For the poultry meals, concentration of digestible cystine dropped down to the reference level.

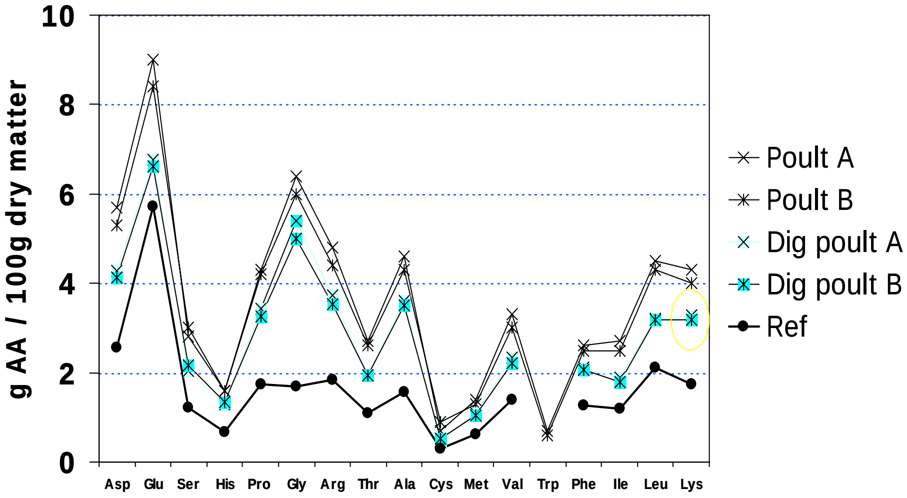

Fig. 18. Digestible AA concentrations

Poultry meals

3.3.5 Digestible AA concentrations – Pig meat and bone meal (Fig. 19)

In the swine meal, concentrations of digestible cystine, methionine, isoleucine and leucine dropped under those of the reference.

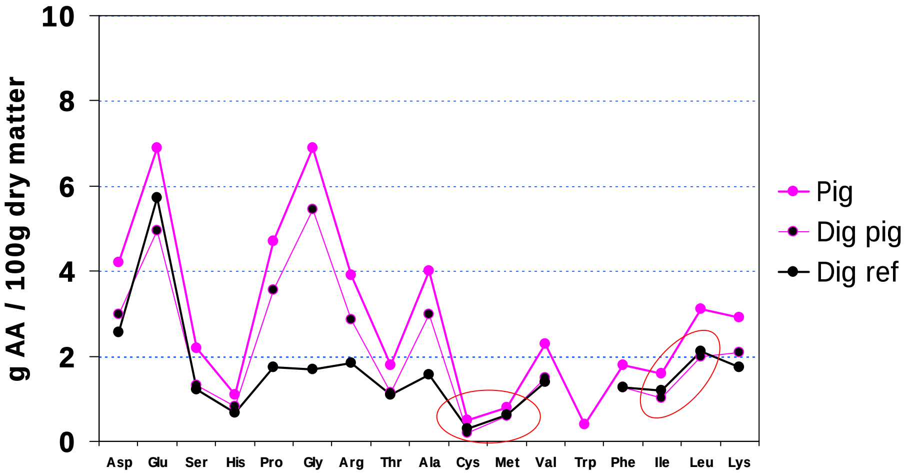

Fig. 19. Digestible AA concentrations

Pig meat & Bone meal

3.3.6 Digestible AA concentrations – Comparison with defatted soybean meal and fish meal (Fig. 20 and 21)

Digestible amino acid profile in soybean meal appears closer to the reference diets profile, with a low value for methionine (Fig. 20), while in fish meal, the low value is for cystine (Fig. 21), showing the same weakness for the soybean-fishmeal combination as for the rendered poultry blood and poultry by-products.

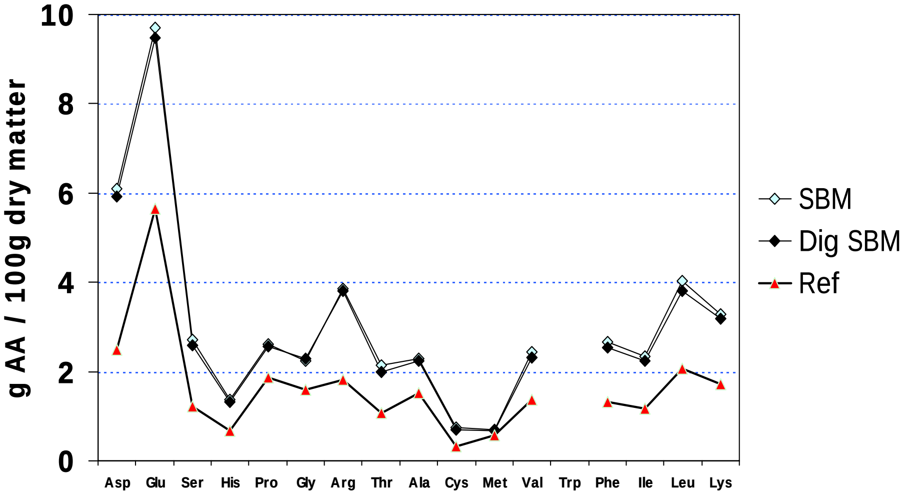

Fig. 20 Digestible AA concentrations

Soybean meal

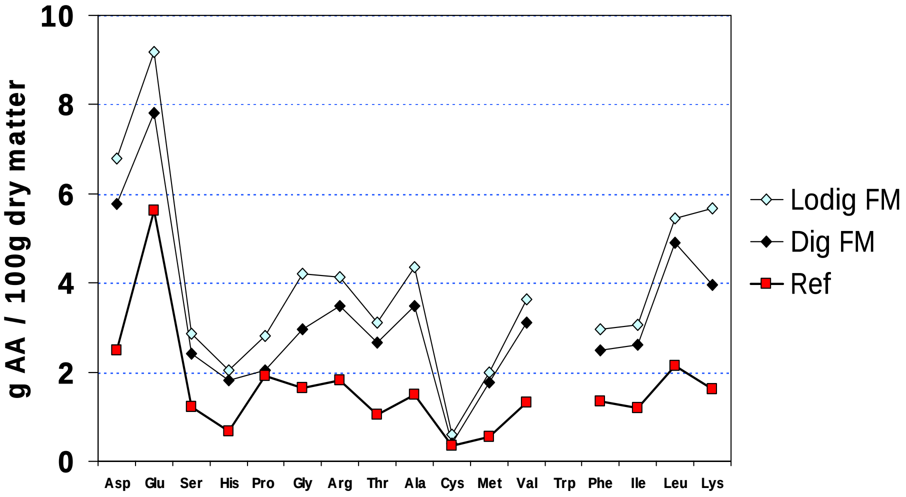

Fig. 21. Digestible AA concentrations

Low digestibility fishmeal

4. Conclusions

Apparent digestibility in shrimp was higher for poultry and swine byproduct meals than for blood and feather meals; it was lower for all these products than for the reference ingredient, a commercial-like fish meal based formula.

AA digestibility of rendered products showed important variations between AAs and products:
- Cystine was the least digested amino acid for each rendered product.
- Digestible essential AAs concentrations in poultry blood and poultry meals pet-food-grade remained higher than those in the reference formula for all AAs.
- This was not the case in feather meals where digestible histidine, methionine, lysine and triptophan dropped under the values of the reference formula, nor in swine meal where cystine, methionine, isoleucine and leucine digestible concentrations were also under those of the reference formula. A high inclusion level of these ingredients in a shrimp feed would led to growth limiting digestible amino acids concentrations.

Finally, let point out two things more:
- The use of feather meals or swine meat and bone meal in shrimp diets will be possible only if these deficiencies are compensated with other ingredients or with AA supplements.
- In contrast, poultry by-product meals - pet food grade, have already been used at commercial scale, replacing up to 60% fishmeal, without the need for methionine supplementation.

5. Acknowledgements

This research was funded by the Mexican “Fondo sectorial CONACYT-SAGARPA”, with complementary funding by the National Renderers Association Mexican office, and Evonik-Degussa laboratory in Hanau-Wolfgang, Germany (amino acid analyses). We also thanks “Maricultura del Pacifico” shrimp hatchery, Mazatlan, Sinaloa, México, for providing and sending pre-grown juveniles for the digestibility trial.

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