IN PIGS THE TRUE ILEAL DIGESTIBILITY OF ESSENTIAL AMINO ACIDS OF LUPIN AND WHEAT ARE EQUAL BUT THE INDUCED ILEAL BASAL ENDOGENOUS LOSSES ARE DIFFERENT

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ABSTRACT

In pigs, the true ileal digestibility (TD), a synonym for standardised ileal digestibility (SID) of crude protein (CP) and amino acids (AA) of lupin and wheat, was determined to characterise their nutritional value as protein feed. Using the regression analysis technique, the basal ileal endogenous losses of AA (EL_bAA) induced by feeding lupin and wheat were determined. Furthermore because lupin is used as food, mixtures of both grains and two animal proteins were designed to achieve the AA requirement profile as recommended by (FAO/WHO/UNU, 1985) for preschool-aged children.

The TD of CP and AA of lupin and wheat were with few exceptions mostly equal. Lupin induced higher EL_b of various AA than wheat. Lupin protein was higher in true digestible Leu, Lys and Thr than wheat but contained less sulfur AA and Trp. A mixture of 17% lupin and 83% wheat resulted in a TD AA pattern close to the recommendation for preschool-aged children (Schaafsma, 2000) except for Lys, Thr, and Trp. A combination of 17% lupin, 75% wheat and 8% milk (dried skim) reduced the discrepancy when compared to the FAO recommendation. Another combination of 17% lupin, 62% wheat and 21% fish protein (dried fishmeal) provided profiles of all indispensable AA including the limited AA Lys, Thr and Trp close to this recommendation.

KEYWORDS

lupin, wheat, amino acids, true ileal digestibility, methodology, diet design, pig

Introduction

Usually, the true ileal digestibility of protein and AA are determined to characterise the nutritional value of feed for animals, but this could be applied for human food, too. Hence, pigs could serve as a human model, because the ileal protein digestion in pigs is similar to that in human (Rowan *et al*. 1994). We aimed to determine both the ileal TD of AA using the regression analysis technique according to (Furuya *et al.* 1986) and the basal ileal endogenous losses of AA (EL_bAA) induced by feeding of lupin and wheat diets (Fan *et al*. 1995). Furthermore, mixtures of both grains and two different animal proteins were designed to achieve the AA requirement profile as recommended by the FAO/WHO/UNU (1985) for preschool-aged children.

MATERIAL AND METHODS

Five assay diets containing five graded levels of lupin (cultivar 'Borweta', low in alkaloids) or of wheat each blended with N-free mixture (starch, minerals, vitamins) were fed to 5 Goettingen minipig barrows (62 ± 7 kg BW) in three consecutive repetitions (finally three pigs per diet) in a Latin rectangle design. The animals were fitted with an ileo-rectal anastomosis conserving the ileo-ceco-colic valve and housed individually. Feed supply (35 g DM/kg $BW^{0.75}$), sampling and analyses of ileal effluents and feeds as well as calculations were done according to Hennig *et al.* (2008). The TD of AA was calculated by means of the equation TD (%) = (1 – b) × 100. Whereby (b) is the slope of the linear regression y = a + b × x (where y = amount of digested AA; x = intake of AA). The EL_bAA were derived from the intercept (a) of regression. For both feeds, the REG procedure was used. Intercepts and slopes of the two regression functions were compared using the GLM procedure of SAS software.

RESULTS AND DISCUSSION

TRUE AND STANDARDISED DIGESTIBILITY OF BOTH SEEDS

The TD of CP and AA in both seeds were almost equal with few exceptions being Arg, Glu and Pro (Table 1). Lupin induced significantly higher EL_b of Arg, His, Leu, Met, Phe, Trp, Cys, Glu, and Ser than wheat (all $P < 0.05$; Table 1). In addition, EL_b of Ile and Lys tended to be higher ($P = 0.06$ to 0.07) when lupin was fed. The TD of both lupin and wheat was remarkably higher than the corresponding apparent digestibility (AD) values. The specific EL_bAA could explain these differences. The SID levels were very

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close to the TD levels when calculated from AD using the food specific EL_bAA. The TD of AA should be calculated from the AD at the so-called threshold levels for AA intakes (Fan *et al*. 1995). However, there are some weaknesses in these calculations when 'constant means' for EL_bAA were used, as recommended by the German Society of Nutrition (GfE, 2005), which were adapted from Jansman *et al*. (2002). After transforming AD to SID using tabulated (constant) EL_bAA, in both lupin and wheat the SID of some AA were over- or underestimated depending on whether the tabulated EL_bAA are too high, or too low (Table 2). Consequently, we suggest that the direct determination of TD using the regression analysis technique should replace the recommended calculation of SID to avoid inaccuracy (Hennig *et al.* 2008).

Table 1. Pigs True Ileal Digestibility (TD %), basal endogenous losses (EL_b, g/kg DMI) and concentration of digestible crude protein and indispensable amino acids (AA) in lupin and wheat (LSM).

Items	TD of AA, %			EL_b g/kg DMI			True digestible AA, g/kg DM	
	Lupin	Wheat	*P*-value	Lupin	Wheat	*P*-value	Lupin	Wheat
Crude protein	90.7	93.2	0.180	9.758	8.325	0.346	336	148
Arginine	97.5	93.7	0.003	0.391	0.249	0.008	35.5	5.8
Histidine	96.0	94.9	0.456	0.211	0.129	0.034	10.3	4.0
Isoleucine	92.4	92.9	0.767	0.371	0.258	0.068	13.8	5.2
Leucine	93.7	93.6	0.933	0.605	0.404	0.047	23.5	9.3
Lysine	93.1	92.0	0.618	0.370	0.247	0.059	16.2	4.1
Methionine	83.4	89.4	0.217	0.195	0.111	0.036	1.6	1.8
Phenylalanine	92.6	94.2	0.202	0.352	0.244	0.042	12.9	6.9
Threonine	89.6	90.6	0.642	0.405	0.314	0.113	10.8	4.1
Tryptophan	91.6	93.5	0.385	0.089	0.034	0.010	2.4	1.5
Valine	91.3	93.0	0.325	0.429	0.318	0.116	14.2	6.7

Table 2. Standardised Ileal Digestibility (SID) of crude protein and amino acids of lupin and wheat calculated by using own determined or published (GfE, 2005) basal endogenous losses (EL_b) according to (Furuya and Kaji, 1989) and (Rademacher *et al*. 2000)[a].

P	Lupin		Wheat	
EL_b	Own [b]	Published	Own [b]	Published
Items	SID %		SID %	
Crude protein [c]	88.2	89.0	92.2	94.8
Arginine	96.8	96.8	92.5	95.6
Histidine	91.4	90.9	92.8	94.5
Isoleucine	87.1	87.1	90.7	93.4
Leucine	90.2	89.2	92.7	93.6
Lysine	89.3	89.5	87.5	91.9
Methionine	79.9	71.9	91.3	91.2
Phenylalanine	90.0	89.6	94.2	95.6
Threonine	85.4	88.2	90.7	99.0
Tryptophan	88.6	92.0	89.9	98.8
Valine	84.0	85.1	90.0	94.1
Cysteine	92.4	92.8	94.8	97.7
Tyrosine	92.3	97.2	94.1	108.6

a Using following equation:
TD, % = AD + [(Endogenous AA, g/kg DMI / Dietary AA content, g/kg DM) × 100].
b Determined by regression analyses.
c Nitrogen × 6.25.

DESIGN OF DIETS WITH RECOMMENDED AMINO ACID PROFILES

High concentrations of Lys and Thr but low levels of sulfur AA characterise lupin. In contrast, wheat protein contained less Lys and Thr but more Met + Cys. Both grains are well suitable as food because of their high digestible CP and AA. Related to the AA requirement pattern in humans (Schaafsma, 2000), a mixture of both reduced the disadvantages of the single foods. However, lupin protein is higher in true digestible Leu, Lys and Thr than wheat but poorer in sulfur AA and Trp (g/100 g CP) as shown in Figure 1. A mixture of 17% lupin and 83% wheat resulted in a true digestible AA pattern close to the recommendation for preschool-aged children (Schaafsma, 2000) with the exception of Lys, Thr and Trp. A combination of 17% lupin, 75% wheat and 8% milk (dried skim) reduced this discrepancy when compared to the FAO recommendation (Figure 2). Another combination of 17% lupin, 62% wheat and 21% fish protein (e.g. fishmeal) provided profiles of limited AA Lys, Thr and Trp close to this recommendation as shown in Figure 3. Alternatively, and in contrast to human diets, an addition of crystalline AA overcomes the mentioned deficiency problem in feed mixtures for pigs. Simultaneously, protein intake and nitrogen excretion were minimised.

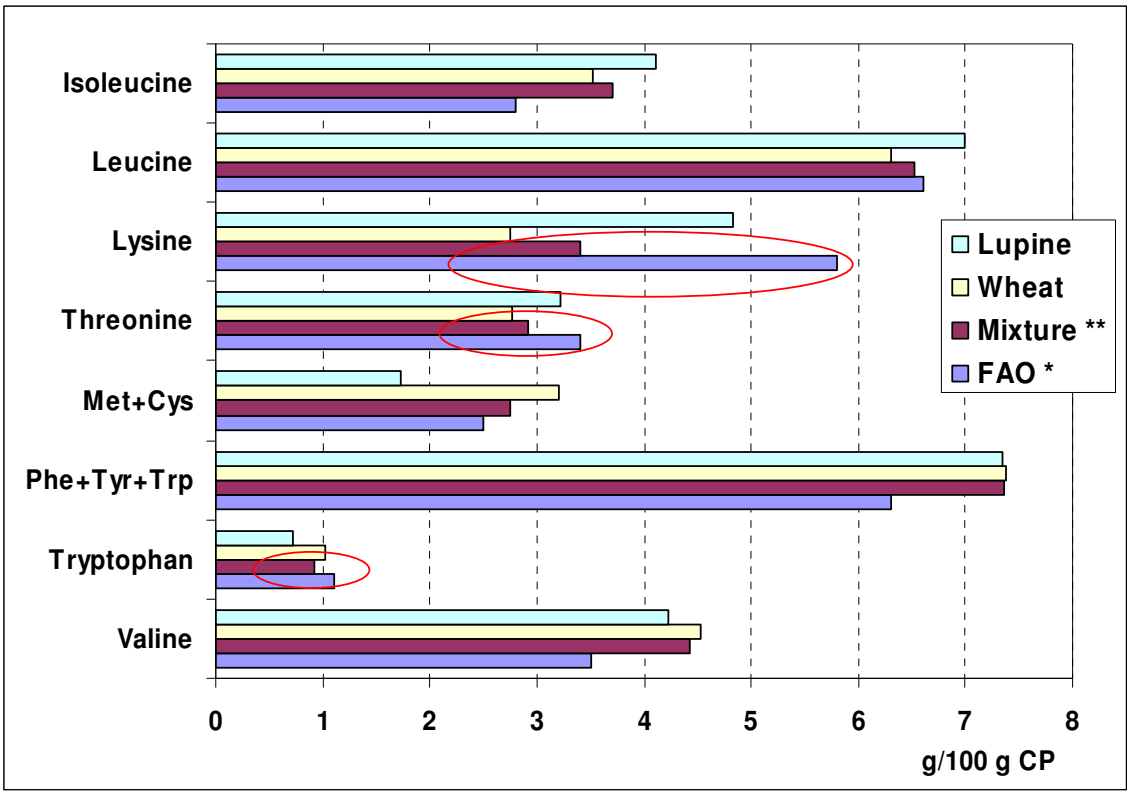

Fig. 1. Amino acid profile (g/100 g CP) in lupin, wheat and in a mixture of both **(17 and 83%, resp.) compared to the recommended AA pattern *(FAO/WHO/UNU, 1985).

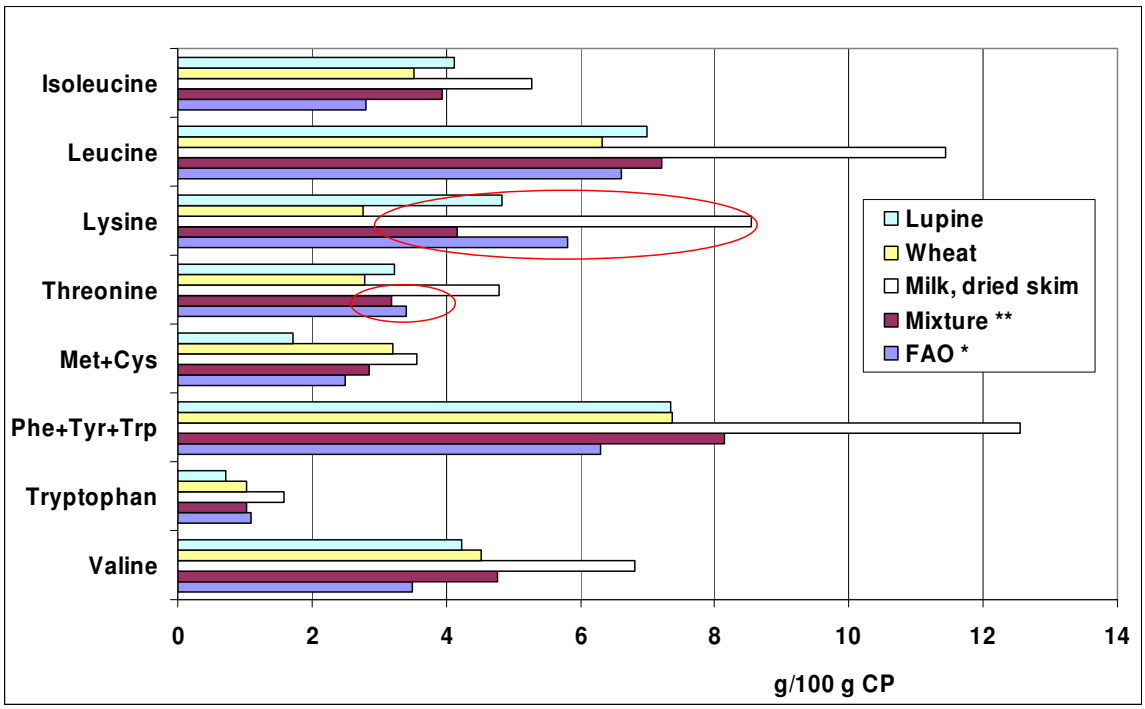

Fig. 2. Amino acid profile (g/100 g CP) in lupin, wheat (own results), milk powder (NRC, 1998) and in a mixture of those **(17, 75 and 8%, resp.) compared to the recommended AA pattern *(FAO/WHO/UNU, 1985).

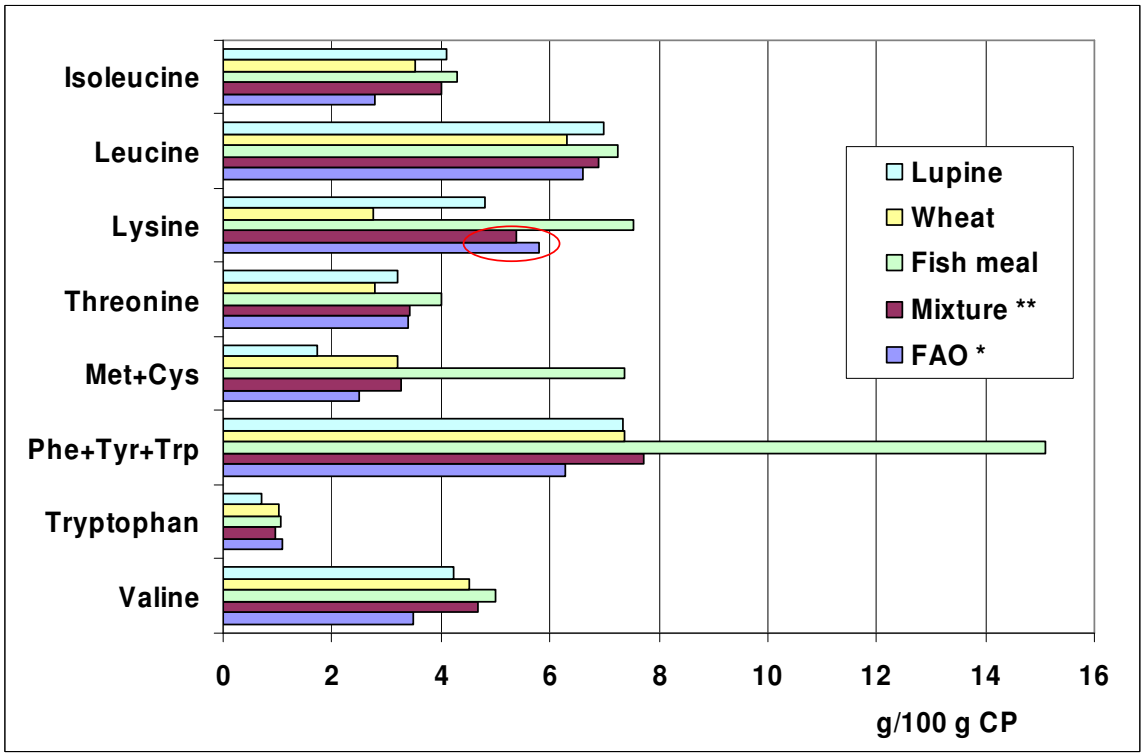

Fig. 3. Amino acid profile (g/100 g CP) in lupin, wheat (own results), fish meal (NRC, 1998) and in a mixture of those **(17, 62 and 21%, resp.) compared to the recommended AA pattern *(FAO/WHO/UNU, 1985).

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