Protein and amino acid digestibility of meals derived from two types of winter rapeseed differ in colour of seeds

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Introduction

Production of rapeseed is increasing recently in Poland, exceeding the amount of 2000 thousand tonnes in the year 2009. This tendency can be related to the growing interest in alternative renewable energy sources as well as higher requirements for the plant protein-rich components for feed purposes. Rapeseed meal contains 35-40% of crude protein with a ***well-balanced*** pattern of ***amino acids.*** High content of dietary fibre is considered being the major factor of poor utilization of protein and amino acids from rapeseed meals by simple-stomached animals as compared to soybean meal. Seed colour in rapeseed is associated with coat thickness together with the level of dietary fibre in the meal, thus developing yellow-seeded genotypes with reduced seed-***coat thickness*** is believed to be one of the main goals of the qualitative breeding program of rapeseed in Poland.

The aim of this study was to determine nutritive value of the meals derived from the most advanced lines of yellow-seeded winter types of rapeseed and indicate possibility of its utilization as feed ingredients for monogastrics.

Materials and Methods

Meals derived from three lines of yellow-seeded rapeseed (YRSM) and black-seeded rapeseed cultivar Bojan were used in this study. They represented winter type of rapeseed. Commercially available soybean meal (SBM) was also included as a control. All rapeseed meals were laboratory prepared by hot extraction of seeds with hexane. Meals were analysed for contents of protein, amino acids, ash, lipids, sucrose and dietary fibre (TDF) with detailed characteristics of its components, nonstarch polysaccharides (NSP), oligosaccharides, uronic acids and Klason lignin. The monosaccharide composition of NSP polymers was analysed as alditol acetates by gas chromatography, as described by Englyst and Cummings (1984). The amino acids content was determined using ion-exchange chromatography in accordance to the procedure of Moore and Stein (1963), in which proteins were hydrolysed with 6N HCl for 24 h at 100˚C, after earlier oxidation of cysteine and methionine with performic acid (Mason et al., 1980). Basing on amino acid content chemical score (CS) and essential amino acid index (EAA) were calculated as the protein quality indices. The rest of analyses were performed with approved standard procedures (AACC, 2000) and theresults were recalculated on fat-free dry matter. Two balance experiments were carried out on growing Wistar rats (Eggum, 1973) to determine digestibility of dry matter (DMD), protein (TPD) and amino acids, biological value (BV) and net protein utilization (NPU). One-way analysis of variance was carried out with the GLM Procedure of SAS® and means were compared using Duncan's multiple range test.

Results

The contents of basic nutrients and total dietary fibre of yellow-seeded meals was comparable (Table 1 and 2). As compared their chemical composition to that of the black-seeded meal the similarities were only observed in the content of sucrose and energy. The yellow-seeded meals were characterized,on average,bythehigher amountofprotein (7%),ash (17%) andparticularlylower content of dietary fibre (20%). The differences between the content of TDF in meals of yellow or black colour of seeds were *mainlydue* to the differences in the content of Klason lignin, about 4.5-fold lower in YRSM than in the black counterpart (2.3 vs. 10.8%). In respect to the other dietary fibre components meals prepared from yellow-seeded rapeseed showed, on average, higher levels of NSP and uronic acids, by 9 and 11%, respectively and the same amount of oligosaccharides (1.5 vs. 1.6%). Content of TDF and its constituents in yellow-seeded meals was similar to that of SBM with the exception of 2.5-fold

lower amount of oligosaccharides (1.5 vs. 3.6%), and 1.5-fold higher amount of uronic acids (6 vs. 4%), (Table 2).

Table 1. ***Comparison of chemical composition of rapeseed and soybean meals [% fat-free DM]***

Line	Lipid residues	Gross energy [kcal/kg]	Protein	Ash	Sucrose
YRSM 1	3.7	4233	47.7	8.3	9.4
YRSM 2	4.3	4141	47.9	9.0	10.2
YRSM 3	4.3	4091	44.8	8.7	10.2
Bojan	7.6	4160	43.5	7.4	9.6
SBM	4.4	4358	54.3	7.7	7.2
Average for YRSM	**4.1**	**4155**	**46.8**	**8.7**	**10.0**

Table 2. ***Comparison of content and composition of dietary fibre in rapeseed and soybean meals[% fat-free DM]***

Line	NSP	Oligo-saccharides	Uronic acids	Klason lignin	Dietary fibre
YRSM 1	16.8	1.7	5.7	3.0	27.2
YRSM 2	16.4	0.8	6.0	2.3	25.5
YRSM 3	16.4	2.0	6.2	1.5	26.1
Bojan	15.2	1.6	5.4	10.8	33.0
SBM	16.4	3.6	4.0	1.7	25.7
Average for YRSM	**16.5**	**1.5**	**6.0**	**2.3**	**26.2**

However, as compared to soybean, all rapeseed meals had lower content of protein, by 15%, but of much better quality, indicated mostly by 66% higher content of sulphur amino acids,cysteine and methionineand more than 40% higher indicator of limiting amino acid, CS. (Table 3).There were no differences found between yellow-seeded rapeseed meals in the content of essential amino acids (EAA), index EAA and CS. The aromatic amino acids, i.e. phenylalanine and tyrosine are the first limiting amino acids in all types of rapeseed meals.

The results for true digestibility of protein showed no significant differences (P>0.05) between meals prepared from rapeseeds of various colours of seeds. Well balanced amino acid composition of protein resulted in high biological value and net utilization of protein in meals derived from yellow-seeded rapeseeds, significantly higher as compared to that of black counterpart (97.1 and 77.3% vs. 92.9 and 75.1%, respectively) despite of similar amino acid profile. The differences were more evident in absorption and net utilisation of protein between YRSM and SBM(on average, 97.1 and 77.3% vs. 79.2 and 69.6%, respectively), despite significantly higher digestibility of soybean protein (87.9%), (Table 4).

*Table 3.**Comparison of protein quality indices of rapeseed and soybean meals [g/100g AA]***

Amino acid	YRSM 1	YRSM 2	YRSM 3	Bojan	SBM
Sum EAA	36.0	36.3	36.4	36.2	35.2
Index EAA	80.8	81.2	81.2	81.1	76.0
Met +Cys	4.4	4.3	4.4	4.1	2.6
CS	64.4	67.1	66.2	66.9	45.9
Limiting AA	Phe+Tyr	Phe+Tyr	Phe+Tyr	Phe+Tyr	Met+Cys

*Table 4. **Digestibility of dry matter (DMD) and protein (TDP), its availability (BV) and net utilization (NPU) in rats fed diets containing yellow or black rapeseed or soybean meals [%]***

Line	DMD	TPD	BV	NPU
YRSM 1	91.0^{b}	82.2^{c}	96.8^{b}	79.5^{b}
YRSM 2	89.6^{c}	79.7^{d}	97.4^{ab}	77.6^{bc}
YRSM 3	90.1^{bc}	81.6^{cd}	97.0^{ab}	79.1^{b}
Bojan	89.1^{c}	80.8^{cd}	92.9^{c}	75.1^{c}
SBM	93.9^{a}	87.9^{b}	79.2^{d}	69.6^{d}
Casein	94.5^{a}	92.0^{a}	100.0^{a}	92.0^{a}
SEM	0.658	0.842	1.149	1.189
Average for YRSM	**90.2**	**81.2**	**97.1**	**77.3**

The apparent digestibility of particular amino acids differed significantly ($P<0.05$) among different meals(Table 5). On average digestibility of all amino acids was higher in SBM than in rapeseed meals. Threonine, isoleucine and valine were digested in the lowest degree among essential amino acids from YRSM, while among nonessential amino acids it was alanine and asparagine. The average digestibility of essential and nonessential amino acids was similar among rapeseed meals tested.

Table 5. ***Digestibility of protein and amino acid (AA) in rapeseed and soybean meals [%]***

AA	YRSM 1	YRSM 2	YRSM 3	Bojan	SBM	Casein
APD	75.8	73.3	75.0	74.3	81.2	85.5
LYS	81.2^{c}	75.5^{e}	78.1^{d}	79.2^{cd}	84.1^{b}	92.0^{a}
ARG	86.6^{b}	79.9^{d}	84.3^{c}	85.2^{bc}	89.7^{a}	85.9^{bc}
HIS	85.2^{c}	79.2^{e}	82.4^{d}	86.2^{c}	88.7^{b}	93.2^{a}
ILE	76.1^{b}	68.8^{d}	71.9^{c}	74.4^{bc}	82.8^{a}	84.2^{a}
LEU	80.1^{c}	73.6^{e}	75.9^{d}	78.5^{c}	83.8^{b}	91.8^{a}
MET	81.3^{bc}	74.2^{d}	77.3^{cd}	84.3^{b}	77.3^{cd}	90.2^{a}
PHE	83.4^{d}	78.3^{e}	81.0^{d}	85.8^{c}	91.1^{b}	100.0^{a}
THR	75.2^{b}	64.9^{d}	66.0^{cd}	69.4^{c}	75.9^{b}	85.3^{a}
VAL	77.0^{c}	70.1^{e}	74.0^{d}	77.0^{c}	83.0^{b}	88.1^{a}
EAA average	**80.7**	**73.8**	**76.8**	**80.0**	**84.0**	**90.1**
CYS	81.5^{ab}	74.9^{c}	78.9^{bc}	81.5^{ab}	83.1^{a}	66.7^{d}
TYR	83.4^{bc}	79.1^{c}	86.6^{b}	100.0^{a}	100.0^{a}	100.0^{a}
ALA	75.0^{b}	69.1^{c}	71.2^{c}	75.7^{b}	79.6^{a}	77.1^{ab}
ASP	75.7^{b}	70.6^{c}	70.9^{c}	74.7^{b}	85.5^{a}	83.8^{a}
GLU	89.0^{a}	83.3^{b}	80.8^{c}	87.8^{a}	89.2^{a}	89.8^{a}
GLY	79.5^{ab}	72.4^{d}	76.6^{c}	79.1^{b}	81.4^{a}	72.3^{d}
SER	78.1^{bc}	71.4^{d}	76.0^{c}	77.9^{bc}	86.6^{a}	78.7^{b}
NEAA average	**80.3**	**74.4**	**77.3**	**82.4**	**86.5**	**81.2**

APD – apparent protein digestibility

The findings of this study suggest that there are other causes of poor utilisation of protein and amino acids from rapeseed meals besides dietary fibre or its components. There should be more research performed to solve the problem of low feeding value of rapeseed meal for simple-stomached animals.

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