THE INFLUENCE OF VARIATIONS IN SEED SIZE AND HULL CONTENT ON COMPOSITION AND DIGESTIBILITY OF RAPESEED

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ABSTRACT

Rapeseed samples with a variation in seed weight from 2.9 mg to 8.8 mg per seed have been investigated according to chemical composition *in vitro* digestibility and digestibility in feeding experiments with rats and chickens.

In whole seeds lipid content ranged between 434-504 g kg^{-1}, and the hull proportion ranged between 105-172 g kg^{-1} corresponding to 209-304 g kg^{-1} in oil free dry matter (DM). In oil free DM protein content varied between 395-549 g kg^{-1}. Pure hulls contained 150-180 g protein kg^{-1} and 130-200 g lipid kg^{-1}.

Total dietary fibres (TDF) and lignin content in the seeds correlated positively with their hull content ($P<0.05$ and $P<0.01$, respectively). Seed weight correlated negatively to lignin content ($P<0.01$) and tended to correlate negatively to hull content ($P=0.1$).

Digestibilities of oil free meals fed to rats ranged from 67-84% for energy and 82-90% for protein; both were negatively correlated to the hull and lignin content ($P<0.05$). *In vitro* digestibilities showed the same pattern.

Two rapeseed varieties were each divided into two fractions of which one contained small seeds and the other contained large seeds. Four diets with milled full fat rapeseed (350 g rapeseed per kg diet) was then fed to 10 days old broilers for three periods in a 2x2x3 factorial design.

The diets with large seeds clearly showed higher digestibility for all measured dietary components. The surpluses as absolute percentage units respectively for dry mater was 2.8 ($P<0.001$); gross energy 3.8 ($P<0.001$); fat 7.9 ($P<0.001$) and protein 1.6 ($P<0.05$).

The observed variations in seed size and hull proportion showed that larger seeds are more digestible than small seeds. A selection towards larger seeds or a mechanical separation during processing provides thus a scope for further improvement of the content of digestible energy and protein.

INTRODUCTION

The relatively low content of digestible energy in rapeseed meal is associated with its high content of non-starch poly-saccharides (NSP) and lignin (Bell, 1993). Therefore, triple low cultivars with yellow hulls in particular have received much attention due to their lower and more digestible NSP and lignin content (Downey and Bell, 1990). On the other hand, yellow seeded rapeseed in general can not be considered to have higher digestibility than traditional brown seeded rapeseed (Agunbiade et al., 1991).

The highest proportions of NSP and lignin are present in hulls. This is in accordance with the very low digestibility coefficients of both protein and energy found in isolated hull fractions (Downey and Bell, 1990; Jensen et al., 1990). The hulls are generally reported to constitute about 28-30% of the dry matter (DM) in oil-free rapeseed meal (Jensen et al., 1990; Bell, 1993). It is thus obvious that variations in hull content might affect protein and energy digestibility (Jensen et al., 1995).

Only few studies have been reported on variations in hull content (Jensen et al., 1995; Liu et al., 1995). The objectives of the present work were to determine whether there is a variation in the hull content not only between different rapeseed cultivars from different origins, but also from the same cultivar, but divided into large and small seeds. Supporting this hypothesis was the idea that the larger the seeds are, the smaller the proportion of hulls may constitute in the whole seeds. The protein, lipid, NSP, lignin and glucosinolate contents of the different seed were determined and compared to the digestibility of energy and N measured in digestibility trials with rats and broilers.

EXPERIMENTAL

The rapeseed investigated in this experiment was obtained from Danish rapeseed breeders, Maribo Seed A/S, DK-4960 Holeby and DLF-Trifolium, DK-4660 St. Heddinge. Details of the analytical and experimental procedure has previous been described (Jensen et al., 1995; Liu et al., 1995).

Digestibility trial with rats

The chemical composition of the thirteen defatted rapeseed samples and results from digestibility trial with rats and *in vitro* digestibilites of the energy (enzyme digestive organic matter) are shown in Table 1. Thus seed size varied from 2.9-8.8 mg $seed^{-1}$, protein content varied from 395-549 g kg^{-1} and the hull content ranged 196-304 g kg^{-1}. In concordance with the variations in hull content the lignin, IDF (insoluble dietary fibre) and TDF content also variated.

Analyses of the amino acid content in the hull fraction showed that 6.7-9.6% of total seed protein, but 6.9-12.4% of total lysine and 7.9-14.2% of total threonine occurred in the hulls.

Table 1 Chemical composition of rapeseed samples on an oil-free dry matter basis, in g kg^{-1} (mean of two samples) and digestibility in rats and *in vitro* digestibility.

Sample	Type	Seed Wt,mg	Protein	Hulls	Lignin	IDF	TDF	GS	Digestibilities		
									TD	ED	Enz
Tarok small	D.L.[2]	2.9	437	304	114	319	351	11.6	81.6	66.9	80.6
Tarok large	D.L.	4.6	453	259	105	311	347	15.2	86.0	77.2	85.6
Star	D.L.	5.4	549	270	86	236	321	23.3	89.0	79.6	84.9
916 small	D.L.	5.3	440	293	105	391	517	18.1	84.7	74.4	85.8
916 medium	D.L.	6.8	428	266	96	333	458	22.0	85.2	75.5	83.6
916 large	D.L.	8.8	395	257	107	322	415	25.3	86.0	81.0	87.7
240-0871	D.L.	4.0	530	199	47	225	262	23.9	87.4	78.7	88.9
238-0451	D.L.	4.4	535	196	53	264	284	20.6	89.9	84.2	87.4
1-9075	D.L.	4.9	507	238	96	321	401	9.4	86.7	74.0	82.6
1-9076	D.L.	5.3	495	247	63	306	429	27.6	85.9	80.6	86.4
1-9074	D.L.	5.4	453	280	115	354	448	13.1	84.7	68.3	81.1
1-9077	T.L.[2]	3.3	573	212	53	216	245	22.4	87.9	74.2	87.8
DP-271223	T.L.	3.9	460	209	61	319	434	14.4	83.0	69.4	86.2

[1] Abbreviation: IDF, insoluble dietary fibre. TDF, total dietary fibre, GS = glucosinolates in μmol g^{-1}, TD, true protein digestibility in rats. ED, energy digesibility in rats. Enz, *in vitro* digestibility of energy.
[2] D.L., double low (low erucic acid and glucosinolates) and T.L., triple low (plus low crude fibre).

The digestibility trial showed rather big differences in digestibility of the individual samples. Linear regression analyses showed increasing digestibility of both protein and energy as well as *in vitro* digestibility with decreasing hull content ($P<0.01$, $P<0.05$ and $P<0.01$, respectively), decreasing lignin content ($P<0.05$), decreasing IDF content ($P<0.01$, $P=0.1$ and $P<0.05$, respectively). In agreement with earlier findings (Bjergegaard et al., 1991; Danielsen et al., 1994), the IDF content showed better correlations to the digestibility coefficients than the TDF content.

Digestibility trial with broilers

The purpose with the broiler trial was to determine wether the results from the rat trial could be verified with broilers. Thus two rapeseed varieties was each divided into a fraction with small seeds and a fraction with large seeds by screening at 1.75 mm pore size. The resulting average seed size and chemical composition of the four samples are presented in Table 2.

Table 2 Description and chemical composition of the seed samples feed to broilers.

Variety	Sample	Seed size mm	Seed weight mg	g kg^{-1} DM					Glucosinolates μmol g^{-1}
				Protein	Fat	Lignin	IDF	TDF	
Jaguar	small	<1.75	3.6	234	478	52	148	178	6.3
	large	>1.75	4.9	250	480	45	145	179	7.1
Impala	small	<1.75	4.1	206	495	61	157	187	4.8
	large	>1.75	5.3	196	513	57	147	170	5.6

In concordance with the chemical composition of the rapeseed used in the rat experiment the larger seed contained less lignin and other dietary fibre components, especially IDF, but had a higher protein + fat content protein (1-2%, absolute units).

Each sample was fed to 10 days old broilers (Ross 208) for three weeks in a 2x2x3 factorial design. The diets consisted of 350 g milled full fat rapeseed and 650 g feed mixture per kg which was

identical for all four diets (see Liu et al., 1995 for details).

No difference between varieties was observed so in Table 3 only the differences between small and large seed are summarized.

The diets with large seeds were consistently superior to the small seeds in all three periods of the digestibility trial. For DM and GE, the differences were 2.8 and 3.8 percentage units higher, protein and fat were 1.6 and 7.9 percentage units higher, respectively ($P<0.01$ or $P<0.05$). Apparent fat digestibility displayed the most pronounced difference between the two seed sizes ($P<0.001$), and contributed largely to the difference in energy digestibility owing to the high proportion of dietary fat from rapeseed. The birds receiving the large seeds grew thus faster than those fed the small seeds, the difference was $P=0.071$ and the average feed conversion for the entire growth period were 2.06 and 1.90, respectively for small and large seeds.

Table 3 Apparent digestibility and growth performance of the broilers fed two varieties of big and small full-fat rapeseeds [1].

	Observ.	Apparent digestibility, %						Growth performance	
		DM	GE	Protein	Fat	α-Tocoph.	γ-Tocoph.	Growth, g	F/G
Seed size									
Small	18	74.3[a]	75.8[a]	67.9[a]	70.7[a]	54.9	50.2[a]	613	2.06[a]
Big	18	77.1[b]	79.6[b]	69.5[b]	78.6[b]	56.4	60.2[b]	655	1.90[b]
	SD	2.29	2.35	2.29	4.04	5.08	5.73	67.5	0.13

[1] *Different letters in column indicates a significant difference between means ($P<0.05$).*
DM, dry matter; GE, gross energy; F/G, feed/gain.

CONCLUSION

In conclusion, this study clearly showed that there is an appreciable variation in the hull proportion, which is largely depending on the seed size. Compared to the small seeds, the large seeds contained lower levels of hulls, lignin and DF that are the main factors depressing the digestibility. The larger seed tended also to contain a higher level of protein + oil, but also glucosinolates. A selection towards large seed or a mechanical separation of small and large seed during seed processing will thus be nutritionally beneficial on the condition that the glucosinolate content are kept at an acceptable level.

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