Growth of Broiler Chicks Fed Diets Containing Tannin-Free and Tannin-Containing Near-Isogenic Lines of Faba Bean (*Vicia faba* L.)

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Seeds from six pairs of near-isogenic lines of *Vicia faba* L., each pair consisting of a tannin-free (TF) and a tannin-containing (TC) partner line, were used to study the effect of breeding for the absence of condensed tannins on the seed content of dry matter (DM), crude protein (CP), and starch (S), on in vitro protein digestibility (IVPD) and on growth performance of broiler chicks that were fed diets with faba beans as the main source of nitrogen. Seeds from TF partner lines showed a 10% higher IVPD, a 6% higher S content, and slightly higher levels of DM and CP than the TC partner of the same pair. Both male and female broiler chicks, which were given diets containing TF faba beans at an inclusion level of 500 g/kg of diet, showed a lower feed intake, a higher body weight gain, and, on average, a 2.5% improved feed conversion ratio as compared to birds receiving diets with corresponding inclusion levels of TC faba beans ($P < 0.01$).

Keywords: *Animal feeds; antinutritional factors; condensed tannins; growth performance; nutritional quality; poultry*

INTRODUCTION

Faba beans (*Vicia faba* L.) constitute an important source of human foods in Mediterranean countries and are used as an ingredient of diets for animals in other parts of the world. Their nutritional value is mainly based on a high protein content and the presence of starch. Besides these components with a positive nutritive effect, faba beans also contain so-called antinutritional factors (ANFs), e.g. condensed tannins, lectins, protease inhibitors, and the pyrimidine glucosides vicine and convicine (Liener, 1989). From these ANFs condensed tannins are considered to contribute most to the antinutritive activity. In *V. faba* they occur in concentrations from almost zero to more than 3.5% of the weight of seed testa (Kuhla et al., 1982), in which these polyphenols accumulate.

Tannin-free genotypes of faba beans can be obtained easily by breeding and selection since this trait is monogenetically inherited and the absence of tannins is characteristically accompanied by white flowers (Bond, 1976; Helsper et al., 1993a). However, introduction of tannin-free faba beans may have agronomic disadvantages due to their presumed lower yield (Van Norel, 1985), which may be caused by a higher susceptibility to diseases such as foot rot (Pascual Villalobos and Jellis, 1990). Recent investigations in our laboratory confirmed these findings but showed that foot rot-resistant, tannin-free faba beans may be obtained by utilizing resistance mechanisms other than condensed tannins (Helsper et al., 1994). Because of this ambivalence, which results from the putative positive nutritive but also putative negative agronomic effects of the absence of condensed tannins, careful investigation is required to provide a scientific basis for the decision whether or not to include tannin-free faba beans in livestock diets.

Although generally accepted as ANFs, the antinutritional activity of condensed tannins in animals is not unequivocally established by experimental evidence. Actually, investigations in this field have led to conflicting conclusions. In vitro studies clearly showed that condensed tannins exhibit inhibitory activity on digestive enzymes (Helsper et al., 1993a,b; Moseley and Griffiths, 1979; Van der Poel et al., 1992a). Studies with ruminants indicated that these animals actually favor the presence of tannins, particularly in diets in which protein is easily accesible for digestive proteases. A high rate of proteolysis in the absence of tannins may lead to excessive foam formation in the digestive tract and thus to feed disturbances such as bloat (Kendall, 1966). In piglets, a pair of near-isogenic lines, which differed genetically in the presence or absence of condensed tannins, have been used to show a decreased protein digestibility in the tannin-containing line (Van der Poel et al., 1992a). Wareham et al. (1993) used similar near-isogenic pairs to show a lower apparent metabolizable energy and a reduced carcass nitrogen retention in chicks due to the presence of tannins. Studies on growth performance in broiler chicks and rats showed adverse effects on body weight gain, feed intake, or feed conversion ratios when tannin-containing extracts were included in the diet (Ortiz et al., 1994) or when tannin-free, nonisogenic cultivars were compared with tannin-containing cultivars at an inclusion level of 500 g of faba beans/kg of diet (Marquardt, 1989). Jansman et al. (1989, 1993, 1995) found no detrimental effect on growth of broiler chicks at an inclusion level of 300 g of tannin-containing faba beans/kg of diet. These studies were not performed with near-isogenic lines but with tannin-free and tannin-containing faba bean cultivars that

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Table 1. Ingredients and Nutrients (Grams per Kilogram) in Experimental Diets

	faba bean genotype		
	M × H[a]	RM × HM, E × H	M × P, Ma-open pollinated, S-open pollinated
CP content in faba beans	250.0	309.0	325.0
faba beans	500.0	500.0	500.0
wheat	100.0	100.0	100.0
cane molasses	20.0	20.0	20.0
soya oil	70.0	70.0	70.0
premix[b]	10.0	10.0	10.0
NaCl	3.0	3.0	3.0
$CaCO_3$	18.0	18.0	18.0
$CaHPO_4$	12.5	12.5	12.5
$NaHCO_3$	2.0	2.0	2.0
maize	240.8	252.8	256.5
L-lysine·HCl	3.3	2.1	1.7
DL-methionine	4.0	3.8	3.7
L-threonine	1.9	1.4	1.1
L-tryptophan	0.8	0.6	0.5
L-isoleucine	1.5	0.4	0.3
L-valine	1.9	1.0	0.7
L-arginine	4.3	1.5	
L-glutamic acid	5.1	0.7	
L-glycine	0.9	0.2	
calculated			
metabolizable energy (MJ/kg)	12.8	12.8	12.8
crude protein (N × 6.25)	182.2	200.6	204.7
starch	322.9	330.3	332.6
calcium	9.8	9.8	9.8
available phosphorus[c]	3.2	3.2	3.2
digestible lysine	8.8	8.9	8.8
digestible methionine plus cystine	6.5	6.5	6.5
digestible threonine	5.9	5.8	5.9
digestible tryptophan	1.7	1.7	1.7

[a] Faba bean genotypes used as parents in the production of the near-isogenic pairs: tannin-free parents Metissa (M), Ewir (E), Rowena × Minica·M5 (RM), Mansholt's Wierboon (Ma), Staygreen (S); tannin-containing parents Herz Freya (H), Pavane (P), Hjan Mikko (HM). [b] Composition of premix (in mg/kg of feed): riboflavin, 4; nicotinamide, 40; *d*-panthothenic acid, 12; cholin·Cl, 800; cyanocobalamin, 0.015; DL-tocopherol acetate, 15; menadione, 5; retinyl acetate, 3.4; cholecalciferol, 0.050; biotin, 0.100; folate, 1.0; $FeSO_4·7H_2O$, 300; MnO_3, 100; $CuSO_4·5H_2O$, 100; $ZnSO_4·7H_2O$, 150; $NaSeO_3$, 0.15; ethoxyquin, 100; avoparcin, 10. [c] The availability of P was calculated by a formula in which the inorganic P compounds were assumed to be 100% digestible and the organic P complex (phytate) presumed to be nondigestible; digestibility of the amino acids was based on the fecal digestibility values of the ingredients.

difffered in more than only tannin level. This may have interfered with their results.

In the present study six different pairs of near-isogenic lines of *V. faba* at an inclusion level of 500 g/kg of diet were used to investigate the effect of condensed tannins on body weight gain, feed intake, and feed conversion ratio in male and female broiler chicks. This study also describes the effects of breeding for the absence of condensed tannins on contents of the nutritional components protein and starch and on in vitro digestibility in addition to earlier described effects on the concentrations of antinutritional factors in faba beans (Helsper et al., 1993a).

MATERIALS AND METHODS

Near-Isogenic Faba Bean Lines. Near-isogenic pairs, from which the partners were distinguishable by the absence (TF = tannin-free) or presence (TC = tannin-containing) of condensed tannins, of six different faba bean (*Vicia faba* L.) genotypes were obtained as described by Helsper et al. (1993a). The near-isogenic pairs were derived from crosses between the following genotypes: Metissa × Herz Freya (M × H), Metissa × Pavane (M × P), Ewir × Herz Freya (E × H), Rowena × Minica.M5 × Hjan Mikko (RM × HM), Staygreen (S) open pollinated, and Mansholt's Wierboon (Ma) open pollinated. Seeds from the TF partner lines were virtually free of condensed tannins (detection limit of 0.5 g/kg of seed) as detected by the vanillin−sulfuric acid assay (Kuhla and Ebmeier, 1981). The TC partner lines contained 4.9−7.4 g of condensed tannins/kg of seed (Helsper et al., 1993a).

Chemical Analyses. For each partner of the six near-isogenic pairs triplicate samples of 140 seeds each were analyzed. Dry matter content (DM) was determined by drying the samples to a constant weight at 101 °C. Nitrogen was measured according to the Kjeldahl method. Crude protein (CP = nitrogen × 6.25) was calculated. Starch was measured in 1 g aliquots from powdered beans. Samples were ground to pass a 1 mm sieve. Monosaccharides were removed by extraction with ethanol (40% v/v). After autoclaving for 3 h at 130 °C, starch in the remaining samples was hydrolyzed by incubation for 1 h at 60 °C in 2.5 mL of 2 M acetate buffer (pH 5.0). After 5 min, 5 mL of an enzyme cocktail, containing amyloglucosidase, α-amylase, and pullulanase, was added. After filtration of the solution, starch-derived glucose in the filtrate was assayed using hexokinase/glucose-6-phosphate dehydrogenase according to the method of Bernt et al. (1974).

In vitro protein digestibility (IVPD) was determined in triplicate according to a modified procedure of Babinszky et al. (1990). In this procedure samples are incubated with pepsin/hydrochloric acid solution at 40 °C for 1.5 h. After neutralization with $NaHCO_3$, incubation is continued for 1 h at the same temperature with potassium phosphate buffer, containing hog pancreatin, α-amylase, lipase, and bile salts. Following incubation, Na_2CO_3 is added to stop the reaction. The undissolved material is then filtered on a sintered glass filter crucible, fitted with a layer of N-free ashless floc. The undigested residue and the ashless floc are transferred to a Kjeldahl flask for the determination of its N content.

Diets. Each experimental diet (Table 1) contained 500 g of faba beans/kg of diet for both the TF and TC partner lines of the near-isogenic pairs. These pairs had the following concentrations of CP: 250 g/kg for the near-isogenic pair

Table 2. Dry Matter, Crude Protein, and Starch Levels (in Milligrams per Gram of Seed) and in Vitro Protein Digestibility (IVPD, in Percent) in Six Near-Isogenic Pairs of Faba Beans[a]

near-isogenic pair		dry matter	crude protein	starch	IVPD
M × H	TF	896.6 ± 0.5	247.8 ± 4.8	384.9 ± 5.3	72.9 ± 3.9
	TC	894.4 ± 0.8	248.7 ± 2.5	378.9 ± 16.6	65.7 ± 2.7
M × P	TF	899.1 ± 0.4	329.4 ± 3.2	336.7 ± 6.6	68.4 ± 3.6
	TC	897.7 ± 0.3	318.4 ± 4.5	326.2 ± 10.6	62.4 ± 1.0
E × H	TF	897.7 ± 0.3	319.1 ± 1.0	309.4 ± 11.5	73.7 ± 1.2
	TC	894.9 ± 0.2	292.7 ± 3.6	276.0 ± 9.5	65.5 ± 4.2
RM × HM	TF	899.6 ± 0.7	306.5 ± 2.8	316.1 ± 17.7	73.2 ± 0.5
	TC	895.6 ± 0.2	309.5 ± 3.9	307.1 ± 12.7	62.6 ± 0.8
Ma-open pollinated	TF	895.2 ± 0.2	316.7 ± 1.8	347.2 ± 14.7	70.6 ± 1.8
	TC	894.9 ± 1.0	329.9 ± 6.6	302.6 ± 13.4	66.2 ± 2.3
S-open pollinated	TF	894.5 ± 0.2	334.4 ± 4.7	343.0 ± 17.6	71.0 ± 0.6
	TC	892.1 ± 0.1	319.2 ± 2.6	315.7 ± 23.7	67.2 ± 1.7
probability of effects					
condensed tannins		<0.001	<0.001	<0.001	<0.001
genotype		<0.001	<0.001	<0.001	0.050
tannins × genotype		<0.001	<0.001	0.166	0.167

[a] Results are expressed as mean ± SE of three replications of 140 seeds. Within each near-isogenic pair the two partner lines were distinguishable by the presence or absence of condensed tannins. For further details and legend to abbreviations see Table 1.

derived from the cross M × H, 310 g/kg for the pairs from RM × HM and E × H, and 325 g/kg for the pairs from M × P, S-open pollinated and Ma-open pollinated. To adjust for differences in amino acid levels, due to differences in CP content between genotypes, synthetic amino acids and different quantities of maize meal were added to meet about 95% of the amino acid recommendations given by the NRC (1994). These levels are marginal to maximize the expected detrimental effects of high tannin levels in the TC lines. For sorghum diets with varying tannin levels, this effect was observed in broiler chicks (Rogler et al., 1985) and laying hens (Sell et al., 1983; Sell and Rogler, 1984). Metabolizable energy levels of the diets were adjusted to 12.8 MJ/kg of diet. Faba beans were ground in a Condux hammer mill (type LHM 20-16) and mixed for 20 min with the remainder of the diet. All diets were pelleted without steam addition in a Simon Heesen (type Labor-monrol) pellet press through a 2.5 × 25 mm die. Diets were pelleted without steam addition. Therefore, no effect of moisture on tannin activity can be expected as, for example, with wetting or reconstitution procedures (Van der Poel et al., 1992b). Pellet temperature in the press die will increase to about 45−55 °C as a consequence of friction due to pelleting without steam. It is not likely that the activity of tannins will change significantly at this temperature in the absence of water.

Animals and Husbandry. A total of 480 1-day-old Hybro broiler chicks (Euribrid, Boxmeer, The Netherlands) were allocated to 12 treatments (6 pairs of near-isogenic lines distinguishable within each pair by the presence of condensed tannins). Per treatment, four replicate cages with five female chicks and four cages with five male chicks were used. Temperature decreased gradually during the experiment from 36 to 20 °C. From day 0 to 6 all birds received a commercial broiler starter diet with adequate nutrient levels. From day 7 to 28 the experimental diets (Table 1) were provided *ad libitum*. Treatments were randomly distributed over 12 cages per row ($n = 8$). At days 14, 21, and 28 body weight gain (BWG) and feed intake (FI) were recorded. Feed conversion ratios (FCR = FI:BWG) were calculated.

Statistical Analyses. Differences in the chemical parameters DM, CP, starch, and IVPD and the animal performance traits BWG, FI, and FCR were analyzed using ANOVA with TC versus TF diets and faba bean genotype as the sources of variation. Cages with broiler chicks were arranged according to a randomized block design. To avoid unnecessary, sex-originated variance in the statistical evaluation, males and females were analyzed separately.

RESULTS

Chemical Characteristics of Faba Beans. The tannin-free (TF) lines showed higher CP ($P < 0.01$), DM ($P < 0.01$), and starch contents ($P < 0.01$), and IVPD ($P < 0.01$) as compared to their tannin-containing (TC) partners (Table 2) of the six near-isogenic pairs tested. The differences in CP and DM were rather small, but both starch and IVPD differed on average 6% and 10%, respectively.

Performance of Broiler Chicks. As expected, there was a clear sex effect; after 21 days on experimental diet, males consumed 8% more feed and grew about 10% more rapidly than female birds (Table 3). Mortality in animals fed TC diets (four females, three males) was slightly, but not significantly, higher than in those fed TF diets (two females, one male).

FI and BWG were not significantly different between TC and TF lines of the same near-isogenic pair ($P > 0.05$). However, data obtained after 7, 14 (not shown), and 21 days (Table 3) show a tendency toward a higher BWG and lower FI for animals fed a TF diet as compared to those fed the near-isogenic TC diet. Significant differences among the six cultivars were not observed.

FCRs, being the resultant of the two parameters BWG and FI, were on average 2.5% lower for the six TF lines as compared to the TC lines within the same age and sex group (Table 4). FCR values of the TF diets were significantly lower for male birds fed the experimental diets for 14 or 21 days ($P < 0.05$) and females fed during 7 and 14 days on these diets ($P < 0.01$). For the youngest male (14 days of age) and the oldest females (28 days of age) differences in FCR were not significant ($P > 0.5$), but showed the same tendency of higher values for the TC diets. FCR values differed significantly between faba bean genotypes for only female chicks during the first 14 days of feeding experimental diets ($P < 0.01$). The differences were smaller at higher ages. In females at younger ages an interaction was observed between the effects of condensed tannins and genotype, which suggests that the difference in effect between TF and TC partners varied among near-isogenic pairs, e.g. the near-isogenic pairs E × H and S-open pollinated showed relatively strong effects.

Table 3. Feed Intake (Grams) and Body Weight Gain (Grams) of 28-Day-Old Male and Female Broiler Chicks Given a Basal Diet for the First 6 Days and Subsequently Experimental Diets Containing Seeds from Near-Isogenic Pairs of Faba Beans for the Remaining Period

		feed intake		body weight gain	
near-isogenic pair		males	females	males	females
M × H	TF	1825 ± 63	1741 ± 49	1192 ± 37	1089 ± 44
	TC	1838 ± 61	1685 ± 109	1192 ± 56	1006 ± 69
M × P	TF	1911 ± 54	1686 ± 40	1262 ± 36	1061 ± 27
	TC	1828 ± 122	1719 ± 66	1167 ± 111	1165 ± 56
E × H	TF	1826 ± 39	1721 ± 55	1195 ± 45	1042 ± 62
	TC	1878 ± 98	1718 ± 96	1249 ± 76	1027 ± 71
RM × HM	TF	1757 ± 161	1662 ± 71	1182 ± 127	1058 ± 68
	TC	1829 ± 79	1721 ± 43	1137 ± 63	1091 ± 25
Ma-open pollinated	TF	1959 ± 67	1689 ± 84	1273 ± 33	1067 ± 62
	TC	1858 ± 50	1672 ± 73	1178 ± 63	1066 ± 27
S-open pollinated	TF	1826 ± 47	1676 ± 97	1175 ± 35	1090 ± 83
	TC	1802 ± 47	1803 ± 32	1140 ± 73	1076 ± 67
probability of effects (*P* values)					
condensed tannins		0.646	0.304	0.095	0.468
genotype		0.173	0.712	0.240	0.616
tannins × genotype		0.287	0.568	0.322	0.280

[a] For further details and legend to abbreviations see Tables 1and 2.

Table 4. Feed Conversion Ratio of 14-, 21-, and 28-Day-Old Male and Female Broiler Chicks Given a Basal Diet for the First 6 Days and Subsequently Experimental Diets Containing Seeds from Near-Isogenic Pairs of Faba Beans for the Remaining Period

		days on experimental diet					
		males			females		
near-isogenic pair		7	14	21	7	14	21
M × H	TF	1.30 ± 0.03	1.39 ± 0.03	1.53 ± 0.05	1.33 ± 0.03	1.47 ± 0.05	1.60 ± 0.03
	TC	1.30 ± 0.03	1.41± 0.02	1.56 ± 0.05	1.40 ± 0.02	1.54 ± 0.01	1.68 ± 0.03
M × P	TF	1.28 ± 0.03	1.39 ± 0.05	1.52 ± 0.08	1.31 ± 0.03	1.44 ± 0.05	1.59 ± 0.06
	TC	1.27 ± 0.02	1.42 ± 0.04	1.57 ± 0.06	1.30 ± 0.02	1.43 ± 0.05	1.58 ± 0.06
E × H	TF	1.27 ± 0.02	1.39 ± 0.05	1.53 ± 0.05	1.31 ± 0.03	1.45 ± 0.01	1.61 ± 0.01
	TC	1.30 ± 0.05	1.41 ± 0.06	1.51 ± 0.08	1.36 ± 0.04	1.52 ± 0.04	1.68 ± 0.06
RM × HM	TF	1.25 ± 0.06	1.38 ± 0.05	1.49 ± 0.04	1.28 ± 0.05	1.42 ± 0.07	1.57 ± 0.06
	TC	1.31 ± 0.02	1.45 ± 0.02	1.61 ± 0.03	1.28 ± 0.02	1.42 ± 0.02	1.58 ± 0.05
Ma-open pollinated	TF	1.29 ± 0.08	1.41 ± 0.02	1.54 ± 0.02	1.28 ± 0.02	1.42 ± 0.02	1.58 ± 0.04
	TC	1.25 ± 0.04	1.40 ± 0.03	1.54 ± 0.01	1.31 ± 0.03	1.45 ± 0.05	1.57 ± 0.10
S-open pollinated	TF	1.22 ± 0.02	1.38 ± 0.02	1.55 ± 0.04	1.27 ± 0.02	1.39 ± 0.05	1.54 ± 0.08
	TC	1.29 ± 0.03	1.43 ± 0.06	1.58 ± 0.08	1.36 ± 0.04	1.49 ± 0.03	1.63 ± 0.04
probability of effects (*P* values)							
condensed tannins		0.135	0.022	0.048	< 0.001	0.002	0.064
genotype		0.373	0.991	0.638	< 0.001	0.002	0.107
tannins × genotype		0.072	0.624	0.280	0.018	0.079	0.341

[a] For further details and legend to abbreviations see Tables 1 and 2.

DISCUSSION

This study showed that feed conversion ratios in broiler chickens improved and that in vitro protein digestibility and starch and protein contents increased by selection for the absence of condensed tannins in faba beans. Positive effects of feeding diets containing TF lines as compared to those containing the near-isogenic TC partner lines were also observed for the animal performance parameters FI and BWG, although the differences were not significant.

In an earlier report Helsper et al. (1993a), using the same near-isogenic pairs as in this investigation, showed that pyrimidine glucosides, vicine and convicine, occur at higher concentrations in TF as compared to TC partners. It is unlikely that a higher level of these antinutritive components would result in a positive effect on growth performance as observed in the present study. Other antinutritional factors, such as lectins and proteinaceous trypsin inhibitors, were not affected by the absence of condensed tannins. Besides the proteinaceous trypsin inhibitors, also condensed tannins inhibit trypsin activity in vitro (Griffiths, 1979; Helsper et al., 1993a,b), probably by aselective interaction with the enzyme.

The lower in vitro protein digestibility of the TC partner lines, observed for all six near-isogenic pairs of faba beans, confirms the results of Van der Poel et al. (1992a), in which only one near-isogenic pair of faba beans was used, and those of Bond (1976), who compared nonisogenic TF and TC genotypes. Our findings also substantiate the above-described inhibitory effect of condensed tannins on trypsin activity in vitro and studies on activities of trypsin and other digestive enzymes isolated from rats (Alzueta et al., 1992; Grif-

fiths and Moseley, 1980) and pigs (Jansman et al., 1994) which were given nonisogenic TC and TF faba bean diets.

Several investigations have been carried out to study the effect of condensed tannins on growth performance. For broiler chicks conflicting results have been obtained; Jansman et al. (1989, 1993) found no effect at an inclusion level of 300 g of faba beans/kg of diet. In contrast, Marquardt (1989) and Rubio et al. (1990) found a decrease in BWG using diets containing 500 g of TC faba beans/kg of diet. Ortiz et al. (1994) showed impaired BWG, FI, and FCR in rats and chicks due to the addition of tannin-containing extracts of faba beans. This lower performance was assigned to histological changes in the liver and intestinal tract. In accordance with the latter study our results indicate lower BWG and FCR values, but in contrast to Ortiz's observations we found higher FI values for TC as compared to near-isogenic, TF faba beans. Differences in effect on BWG and FI were not signficant in our study, which may be caused by the high level of variance between animals receiving the same diet. This high level of variance was considerably reduced when FCR, the resultant of these two parameters, was taken as a measure for animal performance. In our study FCR was significantly lower in TF as compared to TC near-isogenic partners, which is in agreement with the observations using tannin-containing extracts of Ortiz et al. (1994). The negative effect on growth performance in broiler chicks is also in agreement with observations of adverse effects of condensed tannins on apparent metabolizable energy, nitrogen-corrected apparent metabolizable energy (Lacasagne et al., 1988; Wareham et al., 1991, 1993), and carcass nitrogen retention (Wareham et al., 1993) and on in vitro protein digestibility as described in the present study.

Protein and/or methionine have been supplied at marginal levels in the present study to maximize the contrast in growth performance between tannin-free and tannin-containing diets. A similar approach was used for sorghum-based rations by Rogler et al. (1985) for broiler chicks and by Sell et al. (1983) and Sell and Rogler (1984) for laying hens. In our experiments, contrasts might have been larger if diets had been formulated far below the recommended requirements. At the present levels of nitrogenous compounds, the chicks were able to compensate "losses" toward the tannin−protein complexes by increased feed intakes.

Further studies are required to establish the antinutritive effects of condensed tannins in other animal species and the effects on plant resistance toward pests and diseases. Studies from our laboratory have shown that condensed tannins have no protective effect toward fungal diseases as chocolate spot or ascochyta blight (Helsper et al., 1994). Although tannins may be inhibitory for the development of foot rot (Pasqual Villalobos and Jellis, 1990), tannin-free faba bean cultivars which are also resistant to this latter fungal disease may be obtained by breeding and selection (Helsper et al., 1994). Similarly, despite a putative better emergence of tannin-containing faba bean cultivars (Van Norel, 1985), tannin-free seeds showing good germination performance have been found (Kantar et al., 1994).

The improvement in FCR for TF as compared to TC partners is on average 2.5% for the six near-isogenic pairs tested. This significant improvement should be taken into account as a basic argument when a choice is to be made between tannin-free or tannin-containing faba beans as an ingredient of livestock diets.

ABBREVIATIONS USED

ANF, antinutritional factor; BWG, body weight gain; CP, crude protein; DM, dry matter; FCR, feed conversion ratio; FI, feed intake; IVPD, in vitro protein digestibility; TC, tannin-containing; TF, tannin-free.

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