Production of grain legume crops alternative to soya bean and their use in organic dairy production

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Abstract

This work evaluates the possibility to substitute external soya bean, a high risk GMO alimentary source, with other legumes produced on farm, such as sweet lupin, protein pea and filed bean, as alternative protein source in the formulation of diet in organic dairy cattle nutrition. In 2005/2007 periods both the field and feeding trials were carried out in an organic dairy farm in Tuscany. The performances of grain legumes crops were evaluated in terms of grain yield and quality of grains. The alimentary experiment was carried out on two group of 18 dairy cattle fed with two diets: A with extruded soya bean and B with bitter lupin, both mixed with field bean and high protein pea. In the filed trial the Italian sweet lupin varieties (Multitalia) resulted the most interesting for CP production (1.607 kg/ha), pea the best for yield but intermediate for total CP, filed bean the last for both yield and protein content. The feeding trial provided that both the diets where very good. In particular the milk production and the protein content was higher for the soya bean diet while fat, somatic cells and urea content did not differ.

Introduction

Grain legumes crops represent a great resource in organic agriculture both for satisfy the nutritional content of organic livestock feeding and to maintain soil fertility. The commercial availability of organic grain legume are decreasing, the cost are high and the GMO contamination risk is particularly present for soya bean, used to achieve the high protein values required by the animals. So, the cultivation of grain legumes such as sweet lupin (*Lupinus albus*), filed bean (*Vicia faba var. minor*), high protein pea (*Pisum sativum*) on farm could solve the problem and improve the sustainability of the farm. In particular lupin appears more interesting and promising. It has a DM yield in grain of 1-4 t/ha with a crude protein (CP) and oil content of 30 - 35 % and 10% respectively (on DM). Whereas soya bean, a high risk GMO supplement, has a DM yield in grain of 2784 kg/ha and 40 - 41% of CP (on DM). Although sweet lupin is widely used in Northern Europe and other large areas of the world, in Italy it is not anymore widely cultivated and only one registered variety (Multitalia) is available. In this work we evaluate the substitution of soya bean with lupin to dairy cattle diet in terms of milk production.

Materials and methods

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The performances of grain legumes crops (sweet lupin, filed bean and high protein pea) were evaluated in an organic dairy farm of Tuscany in 2005-06 (Migliorini et al., 08) and 2006-07 in terms of grain yield, competitive ability against weeds and quality of grains.

The feeding trial was carried out on 36 dairy cattle of the Italian Holstein breed from the same dairy farm in Tuscany, divided in two groups, and fed with diet A, containing soya bean and diet B, containing lupin, from June 2006 to March 2007. To avoid the influence of age, season and ration, each group of 18 animals was composed with the same number of primiparous (9) and pluriparous (9), 6 in the 1st 100 days of lactation, 6 the 2nd (100-200 days) and 6 in the last part (>200 days). The two diets (table 1) were conform to the Reg CE 2092/91 for concentrate/forage ratio and they satisfied the energetic and protein needs of 600 kg milking cows with 32,5 kg/day milk production at 4% of fat (INRA, 1988). Feeds were analysed in order to determine dry matter (DM), Crude protein (CP), fat, crude fiber (CF), ash according with AOAC methodology (AOAC, 1990) and fibrous fraction (NDF, ADF, ADL) according with Van Soest (Van Soest et al 1991). Unfortunately, we were limited by commercial reasons to the use of bitter lupin and the one produced in the farm was not yet available. In a previous trial, in order to investigate alkaloids and anti-nutritional factors contained in the bitter lupin (Singh et al., 1994; El-Adawy et al., 2001), we compared two different diets (with and without bitter lupin) to evaluate the apparent digestibility (Lorenzini et al., 2007). Moreover, in order to eliminate the bitter flavour o the lupin bean that cattle seemed not to like, it was necessary to crush and mix the lupin with faba bean and protein pea, to make it more appealing to the animals.

Tab. 1: Characteristics of the two diets provided to two groups of milking cow.

Components	Dry matter kg		Crude protein kg		UFL	
	Diet A	Diet B	Diet A	Diet B	Diet A	Diet B
Alfalfa hay	1.7	1.7	0.2	0.2	1.1	1.1
May hay	0.9	0.9	0.1	0.1	0.5	0.5
Maize silage	7.2	7.2	0.6	0.6	6.1	6.1
Alfalfa silage	2.1	2.1	0.3	0.3	1.5	1.5
Corncob silage	3.4	3.4	0.3	0.3	3.1	3.1
Extruded soya bean	0.9	-	0.4	-	1.1	
Barley	2.7	2.7	0.3	0.3	3.1	3.1
Bitter lupin	-	0.8	-	0.3		0.9
Faba bean + protein pea	2.2	2.9	0.6	0.8	2.3	2.9
Total	21.1	21.7	2.8	2.9	18.8	19.2
Notes	For. 72%/ Conc. 28%	For. 71%/ Conc. 29%	13.3% DM	13.4% DM	0.9 UFL/kg DM	0.9 UFL/kg DM

Analysis of variance (ANOVA) was applied to milk production using SAS statistical procedures considering as fixed factor diet regime (diet A and diet B) and lactation phase.

Results and Discussion

The quantity and quality parameters of grain legumes cultivated on farm in 2005-06 are shown in table 2. Considering only the crude protein content, sweet lupin var. Multitalia is the best varieties producing 1.607 kg/ha of protein, almost double the field bean var. Vesuvio (CP 819 kg/ha), the less productive one. The protein pea crop varieties, although the CP content is not very high, are very interesting for the production of total CP, due to the good yields. The field bean produced the lower CP total quantity, due to not high yield, compared to others grain legumes crop.

Tab. 2: Characteristics of the grain legumes produced in a Tuscan organic farm in 2006. (F: field bean; P: protein pea; L: sweet lupin; a: autumnal; s: spring; CP: crude protein; CF: crude fibre; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin). (Values are the mean of two replicates)

Species Variety	GY DM (t/ha)	DM%	CP % DM	FAT % DM	CF % DM	Ash % DM	NDF % DM	ADF % DM	ADL % DM	CP (kg/ha)
F. Vesuv.	3.16	93.65	25.93	0.88	13.77	3.82	30.37	19.86	5.01	819
F. Chiaro	3.49	93.93	27.66	0.76	9.37	3.83	34.58	14.12	2.87	965
P. Class.	5.36	93.75	21.14	1.25	5.16	3.09	30.39	9.73	0.50	1133
P. Hardy a	6.03	93.68	20.32	1.29	1.45	3.10	31.03	11.32	0.10	1225
P. Ideal	5.15	94.53	23.60	1.19	8.01	3.17	30.48	11.82	1.11	1215
P. Hardy s	0.00	93.33	22.41	1.08	10.34	3.62	32.73	18.51	2.03	0
L. Multi.	4.50	95.05	35.72	3.96	15.61	8.68	33.77	26.34	4.42	1607
L. Luxe	0.00	95.05	36.36	5.60	16.66	4.58	27.16	23.23	4.92	0

The results of milk production of the two group fed with different diet are shown in table 3. Although the quantity and quality of milk of the B cow group, fed with bitter lupin, is good, is not the same of the A cow group, fed with soya bean. In particular the alimentary treatment and the lactation period (0-100 days, 100-200 days, >200 days) had a positive influenced to the diet A for milk production (+4,7 kg/day) and protein content (+0,2%), while never had influenced on fat, somatic cells and urea content. Although the interaction of the two parameters did not highlighted differences statistically significant, we reported the mean value in the table 3 to get an idea of the lactation curve of the two experimental groups. The bitter lupin has never influenced the urea contents in the milk, that was always at physiological levels in both the experimental groups. It means that it didn't negatively influence the protein metabolism.

Tab. 3: Result of milk productions (diet A, with soya bean and B, with lupin)

DFR = 306		Treatment		Lactation period	Treatment x Lactation period			
		Mean	Sign	Sign	0-100 days	100-200 days	>200 days	Sign
Milk kg	Diet A	32.5	***	***	36.7	33.2	30.0	ns
	Diet B	27.8			30.0	28.5	24.6	
Fat %	Diet A	4.1	ns	ns	4.1	4.1	4.0	ns
	Diet B	4.1			4.3	3.9	4.2	
Protein %	Diet A	3.3	**	***	3.0	3.2	3.4	ns
	Diet B	3.1			2.9	3.1	3.4	

SCCx1000/ml	Diet A	361	ns	ns	503.0	437.6	251.9	ns
	Diet B	267.1			266.5	196.7	362.6	
Urea g/100 ml	Diet A	0.026	ns	ns	0.027	0.025	0.026	ns
	Diet B	0.026			0.027	0.026	0.028	

* significant for P<0.05 **significant for P<0.01 *** significant for P<0.01

Conclusions

Alternative of buying soya bean is feasible for dairy organic farms in Central Italy. In fact the production on farm level of file bean, protein pea and sweet lupin provide a good amount of nutrient for cattle. In particular, sweet lupin var. Multitaila produced the highest total protein content, while the other non-Italian varieties failed. Protein pea is very interesting for its higher grain yield and field bean suffering from climatic condition resulted the less motivating. Anyway more research work is needed on local varieties.

The introduction of lupin as alternative to soya bean in the formulation of diet in organic dairy cattle nutrition is interesting also in case of bitter lupin. In fact, when mixed with filed bean and protein pea, to make it more palatable, the quantity and quality productive levels are slightly lower in comparison with soya bean diet. Moreover, there was no difference in urea contents in both diets, showing a good nutritional efficiency and adequate diet, in order to obtain milk of good quality with high protein contents and healthy animals at the same time.

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