Substitution of soybean meal and cotton seed with whole crop soybean silage in dairy cow diets to increase feed self-sufficiency of dairy farms in Italy

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Introduction Finding new sources of home-grown protein is crucial for the future profitability and environmental sustainability of the dairy livestock sector in Italy (Borreani et al., 2013). Soybean meal is the source of protein used most frequently in dairy cow diets, but its overseas origin poses several threats for the economic and environmental impact of milk production. In Italy, in order to increase the protein and energy concentrations in cow diets, many farmers utilize cottonseed, which is generally imported from non-European countries and can be contaminated by aflatoxins. The European Union is concerned that such a massive dependency on protein imports makes the livestock sector extremely vulnerable to price volatility, which can cause an increase in production costs and a reduction in the profitability of the milk production sector. Soybean could be produced in Italy, and direct harvesting as a whole crop silage could offer greater flexibility and opportunities to increase the amount of protein and energy as fat produced on farm, to reduce or eliminate the use of soybean meal and cottonseed and to make the milk production chain more traceable. The aim of this research was to evaluate whether whole-crop soybean silage could replace soybean meal and cottonseed in the mid- to late-lactation rations of Holstein cows in Italy.

Materials and Methods The research was conducted on a commercial dairy farm in northern Italy. Soybean crop with low trypsin inhibitor activity (Ascasubi, SIS, San Lazzaro di Savena, Bologna, Italy) was sown in a 10-ha field at the end of May 2015 (after wheat harvested as a whole-crop silage). Soybean was harvested, at the R7-8 stage of growth (October 2015), by chopping it to a theoretical length of 10 mm with a self propelled forage harvester (Claas Jaguar 960, equipped with a direct disk whole-crop header) and ensiled in a bunker silo. The feeding case study was conducted from January to April 2016 (3 periods lasting 28 d, 14 d for adaptation and 14 d for sampling, no turnout). A total of 88 mid-lactation Holstein cows, housed in a naturally ventilated free-stall barn, were used in each period. The cows (272 ± 72 d in milk, parity 2.3 ± 1.0, mean ± SD) were blocked by parity, stratified by days in milk (DIM), and randomly assigned to 4 pens. Each pen contained 4 primiparous and 18 multiparous cows, and the mean DIM and milk yield were similar across pens. The treatments consisted of either a conventional diet based on corn silage, grass and legume silages, a high moisture ear corn silage, soybean meal and cottonseed diet (**CON**; n = 2 pens; n = 44 cows) or a similar diet reformulated using whole crop soybean silage to replace soybean meal and cottonseed (**SBS**; n = 2 pens; n = 44 cows). The compositions of the diets are presented in Table 1. The cows were fed once a day at 110% of the expected intake. The amounts of feed offered and orts were weighed from day 15 to 28 of each period, and the dry matter intake (DMI) was calculated at a pen-level. Milk weights were recorded (days 15-28) and milk samples were collected for component analysis during each milking for three consecutive days (days 18-20 and 25-27). Samples of TMR and dietary ingredients were also collected once a week for nutrient analysis. The dry matter (DM) content of the TMR and orts was determined each day. Energy corrected milk (ECM) and 3.5% fat corrected milk (3.5%FCM) were calculated. The milk production and quality parameters were analysed, with treatment as a fixed effect and pen and period as random effects, and significance was declared at $P < 0.05$.

Results and Discussion The whole crop soybean silage had a DM content of 53% and was well fermented (pH = 4.64; lactic acid = 44.1 g/kg DM; acetic acid = 14.8 g/kg DM; butyric acid = 0.3 g/kg DM; and NH_3-N = 75 g/kg TN). The chemical characteristics (% of DM) of the

soybean silage were 22.8% crude protein, 10.4% ether extract, 42.1% NDF and 6.2% lignin, and the estimated Net Energy of Lactation (NE_L) was 6.09 MJ/kg DM. The obtained values were consistent with data reported by Vargas-Bello-Perez et al. (2008) and Mustafa and Seguin (2003). Nutrient compositions of the two diets are reported in Table 2. Replacing soybean meal (2.7% of the DMI) and cottonseed (2.0% of the DMI) with soybean silage (8.7% of the DMI) decreased the milk yield, but not the ECM or 3.5%FCM yields (Table 3). The fat and protein contents were higher for cows fed the SBS diet, but the fat and protein yields did not differ between treatments. The DMI was higher in the cows fed SBS, but the conversion of feed to milk was higher for the cows fed the CON diet.

Conclusions Under the conditions considered in this study, whole crop soybean silage could be used to substitute soybean meal and cottonseed in diets fed to mid-lactation cows, as it was found to lead to similar ECM and 3.5% FCM yields, even though the feed conversion to milk was lower in the cows fed SBS. The inclusion of soybean silage in the total mixed ration for dairy cows can benefit the producer as it contributes to increasing farm self-sufficiency, in terms of crude protein and energy, and to improving the traceability of the milk production chain, without penalizing the milk production potential of mid-to late-lactation cows.

Table 1. Diet ingredients.

Item, % on the DM	CON	SBS
Corn silage	29.9	29.2
Alfalfa silage	17.3	16.9
Grass silage	17.9	15.7
High moisture corn	12.4	12.1
Soybean silage	-	8.7
Corn grain	5.7	5.5
Rapeseed meal	7.7	7.5
Soybean meal	2.7	-
Cotton seed	2.0	-
Molasses	2.8	2.7
Mineral and vitamin premix	1.6	1.5

Table 2. Nutrient composition of the diets.

Item	CON	SBS
DM (%)	43.1	42.5
Crude protein (% DM)	13.9	13.3
Ether extract	3.1	3.2
Neutral Detergent Fibre (% DM)	36.4	37.1
Acid Detergent Fibre (% DM)	22.9	24.3
Lignin (% DM)	4.3	4.1
Ash (% DM)	7.2	7.7
Starch (% DM)	20.9	21.7
Non-fibre carbohydrate (% DM)	39.3	38.8
Metabolizable Energy (MJ/kg DM)	9.7	9.6
Net Energy of Lactation (MJ/kg DM)	6.0	5.9

Table 3. Dry matter intake (DMI), milk production and composition when replacing soybean meal and cottonseed with whole crop soybean silage in mid-lactation dairy cow diets.

Item	CON	SBS	SE	*P-value*
Milk yield (kg/d)	29.5	28.5	0.116	**
Fat (%)	4.22	4.50	0.054	**
Fat yield (kg/d)	1.25	1.28	0.016	NS
Protein (%)	3.45	3.60	0.020	**
Protein yield (kg/d)	1.02	1.02	0.007	NS
Lactose (%)	4.82	4.83	0.005	NS
Milk urea nitrogen (mg/dl)	14.7	14.3	0.236	NS
Energy-corrected milk (ECM, kg/d)	33.8	33.7	0.271	NS
3.5% fat-corrected milk (3.5%FCM, kg/d)	33.2	33.0	0.286	NS
Dry matter intake (kg/d)	22.3	23.2	0.107	***
Milk:DMI	1.32	1.23	0.008	***
ECM:DMI	1.52	1.45	0.015	*
3.5%FCM:DMI	1.49	1.42	0.016	*

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