Sunflower cake in the diet of Quarter Horses in activity

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ABSTRACT

The increased availability of sunflower cake, a by-product of oilseed extraction for biodiesel production, prompted us to test the scope of its utilization in the diet of Quarter Horses employed in equestrian shows. We substituted 600 and 1200 g of feed with 300 and 600 g of sunflower cake, respectively, so as to obtain isoproteic and isoenergetic diets. Digestibility evaluation by the AIA method evidenced generally improved nutrient utilization with the lower cake diet (300 g sunflower). The higher cake diet was associated with a reduction in organic matter, protein and ether extract digestibility coefficients. In particular, the trend of the protein coefficients (88.5 - 91.5 - 87.7 for control, 300 and 600 g sunflower cake, respectively) was confirmed by higher plasma urea levels.

Key words: Horse, Digestibility, Sunflower cake.

RIASSUNTO

PANELLO DI GIRASOLE NELLA DIETA DI CAVALLI QUARTER HORSE IN ATTIVITÀ

Il girasole introdotto in Europa nel XVI secolo come pianta ornamentale e utilizzato dal XVIII secolo come pianta oleifera, trova un rinnovato interesse. Attualmente viene coltivato per la produzione di olio utilizzato, a seconda delle tecniche di estrazione, a fini alimentari o per la produzione del biodiesel e i sottoproducti che ne residuano sono: panello e farina di estrazione. La possibilità di utilizzare un sottoprodotto con interessanti caratteristiche nutritive, soprattutto per l’apporto di energia, ha motivato questa ricerca per valutare la capacità di utilizzazione digestiva apparente in cavalli in attività agonistica.

Per la ricerca sono stati utilizzati 4 cavalli Quarter Horse impiegati in show equestri (età media 5 anni e peso vivo medio 445 kg), regolarmente allenati e mantenuti in box singoli su truciolo. Sono state formulate tre razioni (Controllo, Girasole A, Girasole B) utilizzando fieno silo (8 kg/d), mangime (4, 3,4 e 2,8 kg/d rispettivamente) e panello di girasole (0, 300 e 600 g/d rispettivamente). Le diete sono state formulate in modo da risultare isoproteiche ed isoenergetiche. I cavalli hanno ricevuto le tre diete in tre periodi consecutivi della durata di 20 d: 15 d di adattamento e 5 d di fase sperimentale durante la quale
Introduction

Sunflower (Helianthus annuus), a North-Western American plant introduced to Europe in the 16th century as a garden plant, has been used for oilseed extraction only since the 18th century.

The seed (achene) contains about 40-50% of its weight in oil. Seeds must be stored with a moisture level $\leq 10\%$.

The prevalent use of sunflower seed is oil extraction, which is performed on whole or dehulled seeds. The oil yield can exceed 1500 kg/ha but is on average 1000 kg/ha in good growing conditions.

Two different by-products are obtained according to the oil-extraction method applied:

- sunflower seed cake, the residue of mechanical pressing. It has a high fat content (8-15\%) and contains fat-soluble vitamins with a high energy value. It is difficult to preserve due to the frequent formation of peroxides;
- sunflower meal, the residue of chemical extraction with solvents. Its lower fat content (1-2\%) is due to the greater efficiency of this extraction method compared with mechanical one.

The nutritional content of the two by-products varies broadly according to whether seeds are whole or partially or completely dehulled before processing (Piccioni, 1989).

Both sunflower cake and meal are used as feeds; their characteristics are reported in Table 1.

Sunflower seed cake keeps well provided its moisture does not exceed 10-12%; sunflower meal provides 19.8\% as fed crude protein when obtained from whole seed, and 39\% as fed from dehulled seed, compared with 45\% as fed of soybean meal. The amino acid composition of sunflower seed (Table 2) is interesting for its lower lysine content but higher sulphurated amino acids compared with soybean and, according to the extraction method applied, it is possible to obtain oil for the food industry or for biodiesel use. The public is becoming increasingly aware of the issues related to the sustainability of agriculture. A strong interest in the search for alternative and “clean” fuels has also been awakened in the farming and animal husbandry sectors. In particular, sunflower as a source of fuel has captured the attention of farmers, given the opportunities it offers not only in terms of oil produc-
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but also of the characteristics of its by-product, seed cake. The possibility of using a by-product with such interesting nutritional characteristics, especially in terms of energy, prompted us to compare the digestibility of diets with different amounts of sunflower cake in Quarter Horses in activity.

Material and methods

The research is part of a series of investigations on feed digestibility carried out at “Le 5 Querce” riding school in Campo Galliano, Italy and approved by the Veterinary Medicine Faculty Ethics Committee of Bologna University.

Four Quarter Horse subjects (mean age 5 years and mean live weight 445 kg) employed in equestrian shows were studied. They were trained according to the protocols of the school, housed in boxes with wood chips and fed twice daily. They received in succession three different rations (Table 4) that were composed of the following feedstuffs:

1. haylage (Secale cereale, Sweet veronal, Phleum pratense, Medicago sativa, Dactylis glomerata, Cynosurus cristatus and Festuca arundinacea), an industrial product sold in plastic vacuum-packaged bales obtained by drying the grass in the sun until moisture falls to 35-45%;
2. complete feed, containing dehydrated alfalfa meal, wheat bran, dried beet pulp, wheat straw, whole barley flakes, oats, whole maize flakes, toasted soybean meal, barley, maize, crushed carob, sugar cane molasses, calcium carbonate, dicalcium phosphate, sodium chloride, and sodium bicarbonate;
3. sunflower cake, from partially dehulled seed

Table 1. Chemical characteristics of the feeds derived from sunflower (from Piccioni, 1989).

| Item                                      | DM% | CP% | DP% | EE% | NFE% | CF% | Ash% |
|-------------------------------------------|-----|-----|-----|-----|------|-----|------|
| Sunflower cake from fat-rich dehulled seeds | 91.4| 36.4| 33.1| 11.0| 25.0 | 14.2| 4.8  |
| Sunflower cake from fat-poor dehulled seeds | 91.2| 36.7| 33.4| 6.9 | 26.9 | 14.6| 6.1  |
| Sunflower cake from partially dehulled seeds | 91.3| 30.6| 26.9| 8.0 | 26.7 | 20.1| 5.9  |
| Sunflower cake from whole seeds           | 90.8| 21.0| 17.4| 6.2 | 23.3 | 34.3| 6.0  |
| Sunflower meal from dehulled seeds        | 90.4| 39.0| 34.7| 2.0 | 25.7 | 16.5| 7.2  |
| Sunflower meal from partially dehulled seeds | 90.0| 29.6| 26.0| 1.2 | 31.2 | 21.5| 6.5  |
| Sunflower meal from whole seeds           | 89.4| 19.8| 16.2| 0.9 | 26.5 | 37.0| 5.2  |

DM: Dry matter; CP: Crude protein, DP: Digestible protein, EE: Ether extract, NFE: Non fibrous extractive, CF: Crude fibre
used for mechanical oil extraction for biodiesel production.

The chemical composition of the feedstuffs used in the daily ration is listed in Table 3.

Based on the nutritional characteristics of the feedstuffs used, three experimental diets were formulated with 0 (Control diet), 300 g/d (Sunflower A) and 600 g/d (Sunflower B) of sunflower cake. To obtain isoproteic and isoenergetic diets (Table 4) the sunflower cake was included in replacement of the complete feed. Only ether extract was higher in the Sunflower B diet. The daily energy and protein rations were slightly lower than those of the diets formulated by Kohnke (1992) to meet maintenance and work requirements.

During the experiments the feed was weighed daily and the residues checked. Faeces were collected twice a day at the same time of day in the last five days of each trial after a period of adaptation of 15 days to each diet, to obtain greater reliability of results. Feed samples were collected from the manger for each trial. Faeces from each subject, collected on the same day, were homogenized, frozen and lyophilized. Samples of feed and faeces were subjected to analyses of dry matter (DM), crude protein (CP), ether extract (EE), Fibrous fraction (NDF, ADF, ADL) and ash according to Martilotti et al., (1987), and acid-insoluble ash (AIA) according to Van Keulen and Young (1977). Gross Energy was determined with Adiabatic Calorimetric Bomb Parr 1261.

The results of these analyses enabled the coefficient of apparent digestibility (DUC) to be established for all nutrients, using AIA as a marker, with the formula reported by Borgioli (1995).

Digestible Energy values were calculated by the equations of Hoffman and Shiemann (1980) reported by Bittante et al. (1990). Energy digestibility was determined with the equation of Martin-Rosset (1996) and with AIA.

On the fifth day of each round of faeces collection, blood samples were obtained using heparinized vacutainer tubes. Red blood cells (RBC), haemoglobin (Hb) and packed cell volume (PCV) were determined with a Coulter Counter (Mod. S560); Glucose, Cholesterol, Total protein, Urea, and Albumin were determined in plasma with an automatic Olympus at 37°C.

Coefficient of digestive utilization and blood parameters were subjected to ANOVA using the JMP package (SAS) according to the model:

\[
Y_i = \mu + \alpha_i + \epsilon_i
\]

where

\[
Y_i = \text{parameter considered}
\]

\[
\mu = \text{general mean}
\]

\[
\alpha_i = \text{diet effect (1, 2, 3)}
\]

\[
\epsilon_i = \text{residual random effect}
\]
Results and discussion

The DUCa of some nutrients are reported in Table 5. Statistical analysis evidenced highly significant differences due to the diet effect. The organic matter DUCa of the diet containing 300g/d of sunflower cake was significantly higher (P<0.01) than those of the Control and Sunflower B diets (90.3 vs 88.6 and 86.9% respectively). In all three diets, the organic matter DUCa was greater than the values obtained in a previous digestibility study (Trombetta et al., 2006).

The apparent DUCa of protein and fat were significantly greater in the Sunflower A diet; they were also higher than those obtained in a
previous study (Trombetta et al., 2006) performed on horses receiving the same roughage (haylage) plus pellet or crushed seeds. In addition the DUCa of protein obtained in this experiment were higher than those reported by Palmgreen Karlsson et al. (2000) in subjects fed 40/60 hay/feedstuff ratio, and by Takagi et al. (2002) in horses fed diets with 30/70 and 70/30 fodder/concentrate ratio.

The DUCa of fibrous fractions (NDF, ADF, ADL), those of hemicellulose and of cellulose are reported in Table 6. Differences were significant for all fibre parameters except hemicellulose.

The DUCa of NDF was significantly greater than that of the Control diet for both Sunflower diets, and was also greater than the one we obtained in horses receiving rations containing haylage plus pellet or crushed seeds (Trombetta et al., 2006). The DUCa of ADF and ADL were significantly greater for the Sunflower A diet, followed by those of the Control diet. For these parameters, the Sunflower B diet (600g/d cake) evidenced lower DUCa that were nonetheless greater than those described in the literature (Crozier et al., 1997; Miraglia et al., 1999). The DUCa of cellulose was significantly greater in the Sunflower A diet, followed by the Control diet. The daily supplies of NDF were very similar; the lower DUCa of the Sunflower B diet could suggest that microbial activity was partially inhibited by the higher value of lipids.

The levels of digestible energy calculated according to the equations reported by Bittante et al. (1990) are listed in Table 7, along with the DUCs of Energy calculated according to the equation of Martin-Rosett (1996) (DUCMR) and the AIA method (DUCAIA). The values of digestible energy were slightly higher in the

Table 5. Apparent digestive utilisation coefficients (DUCa) (mean ± SD).

| Item     | Control  | Sunflower A | Sunflower B | P          |
|----------|----------|-------------|-------------|------------|
| Samples  | n.       | 20          | 20          | 20         | ----       |
| OM %     |          | 88.58±2.45  | 90.30±0.99  | 86.92±2.04 | 0.001      |
| CP "     |          | 88.55±3.07  | 91.47±1.46  | 87.71±2.79 | 0.001      |
| EE "     |          | 80.67±7.07  | 82.93±3.91  | 75.19±6.32 | 0.0004     |

A, B, C superscripts indicate significant differences for P<0.001.

Table 6. Digestibility of fibrous fractions (DUCa) (mean ± SD).

| Item          | Control  | Sunflower A | Sunflower B | P          |
|---------------|----------|-------------|-------------|------------|
| Samples n.    | 20       | 20          | 20          | ----       |
| NDF %         |          | 75.55±4.85  | 83.15±1.92  | 78.77±3.01 | 0.0001     |
| ADF "         |          | 78.91±3.99  | 81.41±2.72  | 76.36±3.31 | 0.0001     |
| ADL "         |          | 75.87±6.62  | 76.62±2.84  | 70.91±5.42 | 0.0018     |
| Hemicellulose "|          | 84.41±3.76  | 85.52±6.25  | 82.34±3.33 | 0.0977     |
| Cellulose "   |          | 79.22±3.61  | 82.46±3.05  | 77.16±2.96 | 0.0001     |

A, B, C superscripts indicate significant differences for P<0.001.
Sunflower A and Control diets than in the Sunflower B diet.

The energy DUC\(a\) were also significantly greater for the Sunflower A diet, followed by the Control diet, and were better than those obtained in our previous study (Trombetta et al., 2006). Again, the DUC\(a\) calculated with the equation of Martin-Rossett and the AIA method were very similar.

As regards the blood parameters (Table 8), statistical analysis evidenced no differences attributable to the diet effect; the means were similar to those reported by Falaschini and Trombetta (1994) for racehorses and to those indicated by Rose (quoted by Carlson, 1986) for endurance horses and by Crozier et al. (1997) for Arab mares as regards haematocrit and haemoglobin.

The statistical analysis for plasma parameters (Table 8) shows no significant differences due to the diet effect in any parameter except urea. In general, the values related to the metabolic profile exhibited rising trends from the Control, to the Sunflower A and the Sunflower B diets. Glucose levels were similar to those obtained by Falaschini and Trombetta (1994) in subjects receiving diets supplemented with oil and carnitine, whereas cholesterol values were
higher than those reported by these authors. Urea was significantly greater in the Sunflower B diet, reflecting a worse protein metabolism, in line with the reduction in the protein DUC. The urea values of both Sunflower diets were higher than those of Crozier et al. (1997).

Conclusions

The data obtained in this study of the scope for employing sunflower seed cake in the diet of the Quarter Horse prompted some considerations.

Its nutritional characteristics permit sunflower cake to replace soybean meal, at a time when soybean fodders are subject to limitations imposed by GMO legislation. The high protein content of sunflower coupled with a satisfactory energy content made it possible to formulate two experimental rations and reduce feed volume (sunflower/feed=1/2) without affecting the nutritional supply, with clear advantages in terms of the engagement of the gastrointestinal apparatus of the athlete horse.

As regards ration digestibility, all parameters exhibited fairly uniform trends. In the Sunflower A diet, where only 300 g/d seed cake was substituted to the common feed, the DUC of all nutrients rose significantly, whereas substitution with a double amount of seed cake (600 g/d) involved a generalized deterioration of all DUC.

As regards energy, there were no substantial differences attributable to the mode of calculation, and the favourable effect obtained with the lower seed cake dose was preserved.

Neither Sunflower diet affected the haematocrit values except for urea, whose plasma levels exhibited a significant increase confirming its value as a marker of protein metabolism.

A problem that arose in relation to the analysis of fibre and its fractions (Makkar et al., 1995) deserves further exploration, as it presents in all digestibility studies that include tannin-rich feedstuffs like sunflower. This could go some way towards explaining the reduction in DUC noted with the higher sunflower diet.

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