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Effect of Dietary Safflower Cake (*Carthamus tinctorius* L.) on Growth Performances, Carcass Composition and Meat Quality Traits in Garganica Breed Kids

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Abstract.- The objective of the present study was to assess the effects of a diet containing safflower cake in pelleted total mixed rations (TMR) on growth performance, carcass parameters and meat quality of kids. Sixteen male Garganica breed kids (12.0±0.4 kg), weaned at 40±3 days, were randomly divided into two equal groups blocked by BW. Kids were fed for 50 d, from weaning to slaughtering age, with one of the following dietary treatments: the control diet (Control) without safflower cake inclusion, and diet containing safflower cake (SFC, 200 g/kg). Findings of the performance trial of kids reported that feed conversion ratio was enhanced by dietary SFC (P<0.01). None of the traits evaluated at slaughter were modified by diets. Safflower cake supplementation positively affected colour indexes of meat from longissimus lumborum and semimembranosus muscles. The current study confirms that SFC can be used in lamb TMR diets as no significant reduction of productive performance and meat quality. It may be concluded that the use of a safflower cake in kid feeding may be considered as a sustainable and economically viable strategy because of the lower cost of the safflower byproduct.

Keywords: Safflower cake, feeding, performance, meat quality, kid.

INTRODUCTION

Animal products have an important role in the Mediterranean diet and small ruminant breeding has a great impact within livestock in South Italy regions. The consumption of lamb and kid meat is very appreciated and considered as a valid alternative to other intensively reared meat-type species (Rubino *et al*., 1999; Longobardi *et al*., 2012). The consumption of red meat, however, is held responsible for cardiovascular disease and other metabolic disorders due to the saturated fat and cholesterol present in intramuscular and other carcass fat depots (Resier and Shorland, 1990; Department of Health, 1994). Feeding strategies able to improve meat quality in ruminants, with particular concern to the quality of fat depots are, however, moderately effective due to the well known leveling effect of the rumen on dietary fatty acids (Ponnampalam *et al*., 2001, 2002). In Southern Italy, sheep and goat farming is traditionally performed using autochthonous breeds, well adapted to the environmental conditions and able to exploit the limited feed resources available (Vasta *et al*., 2011). The Garganica goat is possess an high adaptability to adverse environmental conditions and low-quality pasture of the southern areas (Albenzio *et al*., 2006). In Italy, there is a seasonal demand for meat from kids of 70-80 days of age including Garganica breed, mainly consumed during Christmas and Easter (Maiorano *et al*., 2001; Longobardi *et al*., 2012). Thus, the use of local breeds and low-input production systems is being ever more appreciated by consumers that are glad to rediscover traditional food products. Animal feeding must be economically viable in order to be competitive, leading to an increased exploitation of agriculture byproducts and to the cultivation of crops and herbages able to resist to the Mediterranean climate (Tufarelli *et al*., 2013). At this regard safflower (*Carthamus tinctorius* L.), despite being a native crop of the Middle East, has an excellent potential for being cultivated in Southern Italy (Istanbulluoglu, 2009), since it shows resistance to saline conditions and to drought (Landau *et al*., 2005). Safflower has been used in

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animal feeding as pasture and forage (Landau *et al*., 2005), silage (Cazzato et al., 2011), seeds (Bolte *et al*., 2002; Kott *et al*., 2003; Peng *et al*., 2010) and oil (Pinto *et al*., 2001). Safflower seeds used for oil production may be either cold pressed, expeller pressed or solvent extracted. Safflower cake is a byproduct of the safflower industry mostly used as a protein ingredient for animal feeding (Vonghia et al., 1992). The nutritive value of safflower cake is highly variable depending by the cultivar, the amount of hulls and by the extent of oil extraction (Peng *et al*., 2010). Oil content ranges from 1% for solvent-extracted meals to 15% for mechanically extracted ones, whereas protein content is about 20-25% in the hulled cake but can be over 40% in dehulled cake (Dajue and Mundel, 1996). In comparison with soybean meal, the protein quality of safflower cake is inadequate for monogastric species feeding due to its deficiency in lysine, methionine and isoleucine (Scholljegerdes *et al*., 2004).

Therefore, this study aimed to evaluate the growth parameters, carcass and meat quality of Garganica breed kids fed a diet containing safflower cake in comparison those obtained using conventional soybean-based diet in order to provide a possibility of alternative feeding management for kid producers.

MATERIALS AND METHODS

Diets and management

The trial was conducted at the facilities of University of Bari "Aldo Moro" (Modugno, Bari, Apulia region, Italy; 41° 5' 54'' 24 N, 16° 46' 43'' 68 E; 85 m above sea level). Sixteen male Garganica breed kids, weaned at 40±3 d of age, were randomly subdivided into two groups of eight kids each, homogeneous for age and initial live body weight. Kids were fed *ad libitum* from weaning to slaughtering age with one of the following dietary treatments: (1) the control diet (control) without safflower cake inclusion, and (2) the experimental diet containing safflower cake (SFC, 200 g/kg). The diets were balanced according to kid requirements as suggested by INRA (1988). The ingredient, chemical and nutrient composition of the two pelleted TMR are reported in Table I. Feeds were weekly sampled to determine the chemical composition according to the AOAC (2004). During the whole feeding period (50 d), kids had free access to feed, water and durum wheat straw. Kids were housed in individual pens in order to assess individual feed consumption. Animals were weekly weighed and the amounts of diets and feed residues were registered for calculate daily feed consumption, daily gains. Feed conversion ratio (FCR) was calculated as the ratio of body weight gain to dry matter intake.

Table I.- Ingredient, chemical composition and nutritive value of pelleted TMR fed to kids.

Item	Diet	
	Control	Safflower cake
Ingredients, % as fed		
Dehydrated alfalfa	29.00	5.00
Coarse corn	20.00	5.00
Wheat	13.50	28.00
Soybean meal, 45% CP	13.00	--
Oat	12.00	3.00
Mineral-vitamin premix	5.50	5.50
Barley	5.00	15.00
Soybean oil	2.00	--
Safflower cake	--	20.00
Faba bean	--	14.50
Whole soybean	--	4.00
Chemical composition, % DM		
DM	92.10	91.75
CP	18.09	18.20
Fat	6.32	7.70
Ash	10.40	7.40
Crude fiber	9.60	9.40
NDF	33.63	28.32
ADF	13.70	12.20
ADL	4.20	3.60
ME, MJ/kg DM	10.48	11.72
Milk forage units, *n*/kg DM	0.81	0.94

Slaughter procedure and carcass measurements

Kids were slaughtered at 90 days of age, after 12 h of feed deprivation, according to the veterinary rules and in respect of animal welfare. The slaughtering and dressing procedures were carried out according to AOAC (2004). Muscle pH was measured on the longissimus lumborum of the right side of the carcass with a pH-meter (Euthech Instruments, mod. 110) having penetrating glass electrode, immediately after slaughter (pH_1) and

after 24 h at 4°C (pH_2). After chilling, carcasses were weighed and split into two symmetric halves along the midline. The right half-carcass was then sectioned into commercial meat cuts (steaks, brisket shoulder), and the pelvic limb (leg) and the lumbar region (loin) were further sectioned in order to evaluate their tissue composition in lean, separable fat and bone, respectively (Zimerman *et al*., 2008).

Meat quality analyses

Meat quality characteristics were evaluated on samples taken from the longissimus lumborum (Ll) and semimembranosus (Sm) muscles. Meat color (L*, lightness; a*, redness; b*, yellowness) was assessed on both muscles with a spectrophotometer (Hunter Associates Lab Inc., Virginia, US).

In order to study meat quality features in raw and cooked meat, each meat sample was split into two equal sub-samples, one of which was used raw while the other was cooked in a ventilated oven at 180 °C until the internal temperature of 75 °C was obtained in sample core (Hanna Instruments, model HI 935005, Sarmeola di Rubano, PD, Italy). The cooking loss (%) was determined by weighing the meat samples before and after cooking. Raw and cooked meat samples were assessed for tenderness using a Warner-Bratzler Shear (WBS) testing machine (Instron, model No. 5544, Canton, MA, USA). Three cylindrical cores of 1.25 cm diameter were separated from raw meat, while cooked meat was cut in order to obtain three 1 cm^2 section parallelepipeds. All the meat cores were sheared perpendicularly to their long axis. Peak force was expressed as kg/cm^2. Raw and cooked meat samples of the Ll muscle were homogenised in a grinder in order to perform chemical analysis and fatty acid profile as described previously by Vicenti *et al.* (2009). Lipids were extracted according to Folch *et al.* (1957).

Statistical analysis

Data were analysed for variance using the General Linear Model procedure of SAS (2004). The data on growth performances, carcass measurements and meat parameters were analysed taking into consideration diet as the main effect. Data were reported as least square means and pooled SEM. Means were compared using Student's *t* test.

RESULTS

Results on the *in vivo* performances were given in Table II. No difference was observed neither for the live body weight at the end of trial nor for kids' body gains. Kids fed the control diet showed a higher (P<0.01) feed consumption. Moreover, when fed safflower cake kids showed a better feed efficiency utilization since their FCR was lower compared with other group (P < 0.01). Slaughtering traits and the proportion of meat cuts are reported in Table III. The dietary treatment did not influence any of parameters taken into consideration. Kids fed the SFC showed a similar cold carcass dressing percentage in comparison with the control group. The right-half carcass sectioning showed a significantly (P<0.05) greater proportion of steaks in SFC fed kids compared to the control diet, while kids fed unsupplemented diet presented a greater incidence of the loin (P<0.05). The two groups did not differ among each other with regards to the other primal wholesale meat cuts. The dissection of the leg (Table IV) evidenced a markedly greater incidence of the lean portion in the kids fed the soybean-diet. On the other hand, an higher percentage of bone was observed for SFC group following the dissection of the loin (P < 0.05).

Table II.- Productive performances of kids

Item	Diet		
	Control	Safflower cake	Root MSE
Initial live BW (kg)	11.95	12.07	2.11
Final live BW (kg)	20.97	20.32	1.99
ADG (kg/d)	0.15	0.16	0.02
ADFI (kg/d)	0.76^A	0.62^B	0.07
FCR (kg/d)	5.15^A	3.91^B	0.85

Root MSE, Root mean square error. A, B: P < 0.01.
ADG, average daily gain; ADFI, average daily feed intake; FCR, feed conversion ratio.

The two dietary treatments did not show any effect on the pH values measured at slaughter neither for the longissimus lumborum nor for the

Table III.- Slaughtering traits and meat cuts of kids.

Item	Diet		
	Control	Safflower cake	Root MSE
Slaughtering traits			
Slaughter weight (kg)	19.87	19.02	2.18
Empty BW (kg)	17.55	16.58	1.71
Right half carcass (kg)	4.17	4.03	0.48
Head (kg)	5.53	5.35	0.88
Skin (kg)	0.73	0.75	0.06
Offal parts (kg)	8.08	7.35	0.49
Cold carcass dressing (%)	51.10	51.51	0.87
Chilling loss (%)	3.85	3.55	0.36
Meat cuts[1], %			
Neck	8.80	8.87	1.25
Steaks	14.83[b]	16.63[a]	0.89
Brisket	12.21	11.98	0.55
Shoulder	19.80	19.30	0.56
Loin	7.52[a]	6.43[b]	0.64
Abdominal region	4.49	4.51	0.32
Leg	30.31	29.82	0.95

[1] % on right half carcass; a, b: $P < 0.05$

Table IV.- Dissection data (%) of the leg and loin of kids

Item	Diet		
	Control	Safflower cake	Root MSE
***Leg* (kg)**	1.26	1.20	0.15
Lean (%)	63.97[a]	61.34[b]	1.46
Dissectible fat	7.27	7.47	0.56
Bone	28.75	31.18	1.52
***Loin* (kg)**	0.31	0.26	0.06
Lean (%)	49.04	46.31	3.29
Dissectible fat	19.83	16.91	3.36
Bone	31.13[b]	36.77[a]	3.06

a, b: $P < 0.05$

semimembranosus muscles (Table V). In this study, the ultimate pH values of both muscles obtained from the SFC group were lower in comparison to the control group (5.64 vs. 5.71, for Sm and Ll muscles, respectively). As for meat colour characteristics, the longissimus lumborum muscle of the control diet reported a greater lightness, while the other two colour indexes were quite similar between the two groups. In semimembranosus meat, the only difference between groups was related to the a* index resulting markedly greater in kids fed the SFC diet ($P < 0.05$). Meat texture and cooking loss are shown in Table VI. Raw samples of the longissimus lumborum muscle showed a greater peak shear force in the SFC group ($P < 0.01$), while the difference was completely leveled following cooking, providing a desirable result in terms of tenderization. Raw meat from the semimembranosus muscle from SFC group showed a markedly higher shear force compared to the control diet. Moreover, cooking loss of the longissimus lumborum samples was markedly greater for SFC than the other group. Meat composition of longissimus lumborum muscle was reported in Table VII. The meat nutritive value did not differ between groups.

Table V.- pH measurements and colour indexes of meat from *Longissimus lumborum* and *Semimembranosus* muscles

Item	Diet		Root MSE
	Control	Safflower cake	
Longissimus lumborum			
pH_1	6.61	6.59	0.17
pH_2[1]	6.01[b]	5.71[a]	0.28
L*	43.36[a]	42.37[b]	1.21
a*	7.59	7.42	0.61
b*	8.44	8.29	0.98
Semimembranosus			
pH_1	6.34	6.40	0.12
pH_2[1]	5.88[b]	5.64[a]	0.34
L*	42.68	42.24	1.21
a*	7.37[b]	7.66[a]	0.60
b*	7.40	7.62	1.02

[1]pH at 24 h post-mortem
a, b: $P < 0.05$

Table VI.- The Warner-Bratzler Shear (WBS) in raw and cooked meat and cooking loss.

Item	Diet		Root MSE
	Control	Safflower cake	
Longissimus lumborum			
Raw, kg/cm^2	7.07[B]	9.83[A]	0.945
Cooked, kg/cm^2	3.62	4.09	0.94
Cooking loss, %	13.29[b]	17.20[a]	3.31
Semimembranosus			
Raw, kg/cm^2	3.61[b]	4.84[a]	1.39
Cooked, kg/cm^2	6.40	6.37	1.39
Cooking loss, %	28.83	26.67	3.02

A, B: $P < 0.01$; a, b: $P < 0.05$

Table VII.- Longissimus lumborum meat chemical composition (%)

Item	Diet		Root MSE
	Control	Safflower cake	
Moisture	75.81	74.80	0.93
Protein	19.72	18.98	0.64
Lipid	3.17	3.73	0.97
Ash	1.08	1.00	0.06

DISCUSSION

From our findings no dietary effects were observed neither for the live body weight nor for the kids' growth traits; however, kids fed the soybean diet reported a higher feed consumption, whereas when fed safflower cake kids showed a better feed efficiency. These results could be related to the higher energy concentration of safflower diet fed to kids. Our results supported the findings of Mir *et al.* (2000) who found enhanced feed conversion ratio and no changes in the average daily gain in lambs fed finishing rations containing safflower oil. In another study, Kott *et al.* (2003) did not report considerable differences in feedlot lambs performances fed diet containing safflower seeds. Vonghia *et al.* (1992) reported that dietary supplementation with a safflower cake in feedlot lambs improved both the daily gain and feed conversion ratio.

The dietary safflower treatment did not influence any of the slaughtering parameters investigated. Kids fed the SFC showed a similar same dressing percentage compared to those fed soybean meal, and the values recorded in the present trial are comparable to the findings of Kott *et al.* (2003) who found a mean dressing percentage ranging between 50.9-51.2% and to those reported by Marichal *et al*. (2003) for goats slaughtered at a live weight of 25 kg (51.3%). Adversely, Webb *et al.* (2005) reported higher dressing percentages for Boer goats (55.7%) and indigenous goats (55.7%). The right-half carcass sectioning showed a greater proportion of steaks in SFC fed kids compared to the control diet as well as a greater incidence of the loin, and it could be due to a better feeds utilization in kids fed safflower cake, as also found by Tufarelli *et al*. (2013).

Dietary treatments did not influence the meat pH at slaughter and after carcass storage in both longissimus lumborum and semimembranosus meat muscles. The pH values found in this study are quite similar to those found for suckling kids slaughtered at 6 or 10 kg (Argüello *et al.*, 2005). Devine *et al*. (1993) found an ultimate pH value of meat should not exceed 5.8 since higher pH values are held responsible for dark meat that is considered as an undesirable feature. Webb *et al.* (2005) reported ultimate pH values for goat muscle ranging from 5.5 to 6.8.

Moreover, regarding the meat colour parameters, in longissimus lumborum muscle of soybean group the L* value resulted higher, while the other two colour indexes were quite similar between groups. In semimembranosus muscle, the only difference between groups was related to the a* index that resulted noticeably greater in kids fed safflower diet. The b* values of longissimus lumborum muscle in our trial resulted higher in comparison to the findings of Marichal *et al*. (2003) in goat slaughtered at 25 kg and to the findings of Caputi Jambrenghi *et al.* (2007) in Jonica kids at 45 days. Some Authors reported that higher live weights at slaughter may produce darker meat colour in lambs (Teixeira *et al*., 2005) and kids (Marichal *et al*., 2003; Argüello *et al*., 2005). We found higher L* values compared with those reported by Argüello *et al.* (2005) in kids slaughtered at 6 and 10 kg, respectively. Furthermore, the semimembranosus meat obtained from both dietary treatments showed reduced tenderness after cooking, and this may probably be related to the higher cooking loss found for this muscle compared to longissimus lumborum. Kannan *et al.* (2006) reported that that high shear forces for goat meat may be due to a combination of factors which involve low intramuscular fat, cold shortening, water holding capacity, high collagen content characterized by lower solubility in comparison with lamb meat. In a previous comparative study performed on 22 different lamb genotypes, Peña *et al.* (2009) found that optimal WBS values must be less than 5.5 kg/cm^2 in cooked meat, so that consumers may positively judge the eating quality of meat. The WBS values found in

this study are quite comparable to those reported by Caputi Jambrenghi *et al.* (2007), despite the higher slaughtering age of kids in the present trial. Goat meat quality has been extensively reviewed by Webb *et al*. (2005), who reported widely variable shear force values, depending on the muscle, slaughtering age and carcass handling conditions. The shear force results found in this study fall within the acceptable range for raw and cooked goat meat (<10 kg/cm^2; Webb *et al*. (2005). The cooking loss of the longissimus lumborum samples was markedly greater in the safflower group compared to soybean, but both values are comparatively lower respect to the findings reported by Caputi Jambrenghi *et al.* (2007). Moreover, no differences between dietary treatments were found for the cooking loss of semimembranosus meat samples. Meat from goat is very lean due to the lack of intramuscular fat which is desirable since it contains greater amounts of PUFA compared to other ruminant meats (Banskalieva *et al*., 2000). The lack of intramuscular fat, however, may negatively affect meat palatability, tenderness and the physical changes that occur during cooking, thus influencing the perception of chewiness and juiciness (Marinova *et al*., 2001). Miller *et al*. (2001) reported that meat tenderness and juiciness are closely related to the cooking loss. Moreover, the cooking method, depending on different combinations between heat treatment and time of cooking, may affect meat tenderization (Yarmand and Homayoumi, 2009). The proximate chemical composition of meat did not differ between groups and the results are satisfactory and quite similar to those reported by other Authors for kids slaughtered at approximately 45 days (Caputi Jambrenghi *et al*., 2007).

In conclusion, data from the present study suggested that supplementing safflower cake in diet of growing kids provides results similar to those obtained by using a commercial feed in terms of productive performances, carcass composition and meat quality.

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