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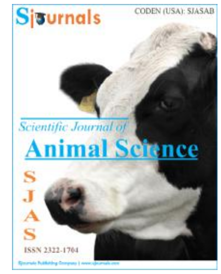


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**Original article**

# Feeding detoxified Ethiopian mustard (Brassica carinata) seed cake to sheep: Effect on intake, digestibility, live weight gain and carcass parameters

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A B S T R A C T

In Ethiopia, cultivation and usage of B. carinata is an old practice. The seeds are primarily cultivated for the extraction of oil, the meal that is remained after oil extraction is protein rich (30 – 45%) and may be used either as high protein feed supplement provided that glucosinolate level is reduced or as organic fertilizer. Oil extraction through the use of solvents has proven to be beneficial in improving the feed quality of the oil seed cake produced as by product. This is as a result of removing the anti-nutritional qualities like glucosinolates by the solvents. These technologies are under evaluation at pilot level in Ethiopia. Thus, a study was conducted to investigate the effect of including both untreated and detoxified Ethiopian mustard seed (Brassica carinata) cake as protein source in the concentrate supplement on feed intake, digestibility, and live weight gain using thirty yearling Afar male sheep with an average initial body weight of 17.1 + 0.6 kg. A completely randomized block design with six replicates per treatment was used. The treatments were: 0, 33, 67 and 100% replacement of noug cake by detoxified mustard cake and 67% replacement by undetoxified cake. All animals were fed and managed in individual pens. Feed intake, apparent digestibility, growth rate and carcass parameters did not differ among treatments. The results of the study showed that detoxified

Ethiopian mustard seed cake can completely replace noug seed cake when offered in a mixture with wheat bran for growing male sheep fed a basal diet of grass hay.



## 1. Introduction

The major feed resources in Ethiopia for ruminant livestock are crop residues and natural pasture; the contribution of agro-industrial by-products and formulated compound feeds generally is insignificant (Gebremedhin et al., 2009). Agro-industrial by-products produced in Ethiopia include by-products from milling industries, oil processing factories, abattoirs, breweries and sugar factories and are used as supplements. These products are mainly used for dairy and fattening animals (Alemayehu, 2004). The oil seed cakes are rich in crude protein (200-500 g/kg DM) and most are valuable supplements providing bypass protein for ruminant animals (Preston and Leng, 2009).

Ethiopian mustard seed (*Brassica carinata*) stands fifth after noug, sesame, linseed and groundnut in total production and area coverage in Ethiopia (CSA, 2009). High levels of proteins, suitable amount of essential amino acids, minerals and the bioavailability of these nutrients (Clandinin et al., 1981) has given mustard/rape seed cake, prime importance as a quality protein sources to be used as animal feed. However, low palatability of mustard cake is said to be the main problem for its utilization in ruminant diets. This problem is attributed to its glucosinolate content which yields hot and pungent metabolites upon hydrolysis due to the action of endogenous enzymes (Bell, 1984). As evidenced by Ethiopia spice extraction factory report, oil extraction through the use of solvents has proven to be beneficial in improving the feed quality of the oil seed cake produced as by product. This is as a result of removing the anti-nutritional like glucosinolates by the solvents acetone, methanol and ethanol. The technologies are under evaluation at pilot level in Ethiopia. This process was found successful and the result was confirmed by standard laboratories which showed that the level of glucosinolates in the detoxified cake was highly reduced in comparison to the press extracted mustard seed cakes (Table 1).

Therefore, the objective of this experiment was to study the effect of feeding detoxified and undetoxified Ethiopian mustard seed cake as a replacement to noug seed cake on feed intake, digestibility, live weight change and carcass parameters of Afar sheep fed natural pasture hay as basal diet.

## 2. Materials and methods

### 2.1. Experimental site

The experiment was conducted at Debre Zeit Agricultural Research Center at an altitude of 1900 m.a.s.l. and between 8.44$^{o}$N latitude and 39.02$^{o}$E longitude. The average annual rainfall is about 845 mm and the annual minimum and maximum temperatures are 10$^{o}$C and 22$^{o}$C, respectively. The experiment was implemented during the dry season from November to March.

### 2.2. Description of the tested feeds

The detoxified mustard seed cake (DMSC) was processed by a solvent extraction procedure in which the glucosinolates are removed in the process. The undetoxified mustard seed cake (UMSC) had the oil extracted by a regular press extraction procedure.

**Table 1**
Glucosinolate content of detoxified and un-detoxified Ethiopian mustard seed cake and rapeseed cake.

| | Glucosinolate (µmol/g DM) |
|---|---|
| Ethiopian mustard undetoxified cake | 200 |
| Ethiopian mustard detoxified cake | 13-20 |
| Rapeseed (*Brassica napus*) Canola | <30 |

Source: Ethiopia spice extraction factory report (2009).

### 2.3. Animals and management

Thirty yearling male intact Afar sheep with mean initial live body weight of 17.1 $\pm$ 0.6 kg were used. Animals were blocked by initial body weight into six lots of five animals each. The five treatment diets were randomly assigned to experimental animals in each block. Thereafter the animal were individually penned and adapted to the experimental diets for 10 days before the actual 90 days of the growth experiment started. After the first phase, animals were adjusted to digestion crates for 3 days followed by a 7-day period for total collection of feces. Live weights of the animals were measured at weekly interval. Daily live weight gain was calculated by subtracting initial weight from final weight and dividing by the days of feeding. Representative samples of feed offered and refused were collected every three days for determination of dry matter and analysis of chemical composition.

### 2.4. Experimental diets

The test feed in this experiment was detoxified mustard seed cake as a replacement to the recommended protein concentrate supplement. Wheat bran and noug seed cake mixture of 300 g at the ratio of 2:1 was taken as a control (NG100) and the noug seed cake was replaced by detoxified mustard seed cake at 33% (33DMC), 67% (67DMC), and 100% (100DMC). A diet with 67% un-detoxified mustard seed cake (67UMC) replacing noug cake was used as a negative control. The natural pasture hay was dominated by Andropogon, Hyprehenia, sedge, and clovers offered *ad libitum* to all treatment groups of animals throughout the experimental period as basal diet. Feeds were offered twice a day at 8:00 h and 16:00h in two equal portions. Animals had free access to water and table salt was mixed 1% with the concentrate ration.

### 2.5. Digestibility trial

The animals were fitted with fecal collection bags three days before commencement of total collection of feces for seven consecutive days. The feces output from each animal was mixed thoroughly and 20% were sampled daily and stored at -20°C. Samples of ingredients of the test diets: offered, refused and feces were dried at 65° C in a forced draft oven for 72 h and ground to pass through 1 mm sieve size and used for determination of chemical composition. Ash, dry matter (DM), organic matter (OM), and crude protein (CP) content of samples were determined by AOAC (1990) procedures. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were analyzed according to (Van Soest et al., 1991).

### 2.6. Carcass parameters

At the end of the feeding and digestibility trials, three animals were randomly selected from each feeding treatment and fasted overnight, then weighed and slaughtered for carcass evaluation. The weights of the edible and inedible components of the carcass were measured and recorded for each sheep. The empty BW was calculated by subtracting the weight of the alimentary tract contents from the slaughter weight. The cross-section of the rib-eye muscle was traced on transparency paper between the 11th and 12th ribs (Galal et al., 1979) and measured using square paper.

### 2.7. Statistical analysis

Data from the experiment were analyzed by analysis of variance (ANOVA) using the General Linear Model (GLM) procedure in SAS (2002). Treatment averages were compared using Tukey's tests. The model for the data on feed intake, digestibility, and body weight change was $Y_{ij} = \mu + t_i + b_j + e_{ij}$ , where $\mu$ is the overall average, $t_i$ the ith treatment effect, $b_j$ the jth block effect and eij is the random error associated with Yij.

## 3. Results and discussion

### 3.1. Chemical composition of the experimental feeds

Oil extraction methods vary the CP and nutrient content of mustard seed meals (Table 2). This might be due to the variation of oil production processing method. Singhal (1986) reported that the composition of mustard seed cake varies with processing methods. Grala et al. (1994) also mentioned that the duration of toasting during processing affect composition, solubility and nutritional value of meal protein.

### 3.2. Feed intake

The relatively lower intake of the supplement feed in 67UMSC might be the high availability of glucosinolates in undetoxified mustard seed cake. These results corroborate those of (Hill, 1991; Fenwick et al., 1982) higher level of glucosinolates have variable adverse effect on dry matter (DM) intake which are associated with bitter taste. Total DM intake as percent of body weight (3.38% - 3.62%) was relatively similar between treatments. Generally, the total DM intake as percent of BW in the present study was within the range of 2–6% as recommended by the ARC (1980) and 3.2% by (Ranjhan, 1997) .

**Table 2**
Chemical composition of feed ingredients used in the experiment.

| | Chemical composition (%DM) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Experimental feed ingredients** | **DM (%)** | **CP** | **OM** | **ASH** | **NDF** | **ADF** | **ADL** |
| Natural pasture hay | 93.4 | 6.5 | 89.0 | 11.0 | 72.3 | 40.7 | 6.0 |
| Detoxified mustard seed cake(*Brassica carinata*) | 90.2 | 39.7 | 90.9 | 9.1 | 44.3 | 24.7 | 10.2 |
| Undetoxified mustard seed cake(*Brassica carinata*) | 93.1 | 35.1 | 93.0 | 7.0 | 39.1 | 20.6 | 4.8 |
| Wheat bran | 90.3 | 15.4 | 95.3 | 4.7 | 52.4 | 13.0 | 2.5 |
| Noug seed cake | 92.1 | 28.2 | 87.9 | 12.1 | 39.3 | 29.2 | 11.5 |

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, ADL: acid detergent lignin.

**Table 3**
Daily dry matter feed and nutrient intake of Afar sheep fed with natural pasture hay basal diet and supplemented with different levels of *Brassica carinata.*

| | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameters** | **NG100** | **33DMSC** | **67DMSC** | **100DMSC** | **67UMSC** | **SEM** | **P** |
| **DMI (g/h/d )** | | | | | | | |
| Native hay | 539 | 533 | 5 530 | 537 | 543 | 2.67 | 0.91 |
| Concentrate supplement | $285^{a}$ | $285^{a}$ | $286^{a}$ | $283^{ab}$ | $281^{b}$ | 0.36 | <0.003 |
| DM intake ( % BW) | 3.5 | 3.6 | 3.4 | 3.5 | 3.6 | 0.03 | 0.15 |
| **Nutrient Intake (g/d)** | | | | | | | |
| OMI | 749 | 745 | 741 | 739 | 743 | 2.35 | 0.85 |
| CPI | $92^{d}$ | $95^{c}$ | $98^{b}$ | $102^{a}$ | $95^{c}$ | 0.25 | <0.0001 |
| NDFI | 526 | 523 | 519 | 528 | 527 | 2.32 | 0.93 |
| ADFI | 270 | 266 | 262 | 265 | 266 | 1.30 | 0.48 |

$^{abcd}$= Means in the same row without common letter are different at P<0.05; SEM = standard error of mean; *P* = probability; DMI= dry matter intake; OMI=organic matter intake; CPI = crude protein intake; ADFI = acid detergent fiber intake; NDFI= neutral detergent fiber intake; NG100 = hay + wheat bran and noug seed cake mixture of 300 g, at the ratio of 2:1; 33DMSC = hay + 200g WB + 67 g NSC + 33 g detoxified mustard seed cake (DMSC); 67DMSC = hay + 200g WB + 33 g NSC + 67 g DMSC; 100DMSC = hay + 200 g WB + 100 g DMSC and 67UMSC = hay + 200 g WB + 33 g NSC + 67 g undetoxified mustard seed cake (UMSC).

### 3.3. Apparent digestibility coefficient

Despite the variation in the treatments diet; the digestibilities of nutrients were similar. Moymbo et al. (1997) and Gerhard and Maike (1998) also did not find significant differences in utilization of nutrients on rapeseed meal. Tripathi et al. (2001) also reported non significant differences between treatments in digestibility of DM, OM, NDF, ADF, cellulose, lignin and GE on high glucosinolate mustard (Brassica juncea) meal.

### 3.4. Body weight change

Similar performance among experimental sheep fed different treatment diets in live weight parameters reflected that the supplement feeds were comparable in their potential to supply nutrients for improving the weight gains of the sheep. This result also revealed that replacing noug seed cake with detoxified mustard seed cake in the feeding system of concentrate as in the present experiment could bring similar live weight change in local sheep. Mabon et al. (2000) suggested that glucosinolates intake varying from 242 to 692µmol/day before weaning and 1600-3900 µmol/day after weaning modified thyroid function, but growth and carcass characteristics of sheep was not influenced.

Average daily gain recorded in the present study (62.3-77.8) g/day were higher than other findings such as Mulu et al. (2008) ADG of 44.4-70.4g/day in growing sheep fed different levels of brewery dried grain. But in agreement with Fentie and Solomon (2008) ADG of 70.1 to 82.4g/day for Farta sheep supplemented with WB, NSC and their mixture. Hill (1991) reported that in early weaned lambs; the rate of weight gain from a concentrate feed containing high-glucosinolates rapeseed meal was less than that obtained using low-glucosinolates rapeseed meal or soybean meal but remained acceptable. Aherne and Kennelly (1982) reported also low glucosinolates rapeseed has been used successfully in diets for calves fed milk replacers, in calf starters and for growing dairy heifers, such meal may replace soya bean meal without affecting daily gains or efficiency of feed utilization.

### 3.5. Carcass parameters

The result of carcass parameter in the current study was in agreement with Deryckea et al. (1999) who reported that the incorporation of low-glucosinolates rapeseed meal in the diet had no significant negative effect on the parameter considered (carcass weight, dressing percentage, carcass classification, and fat level). Mabon et al. (2000) also suggested that varying glucosinolates intake modified thyroid function, but did not negatively affect growth and carcass characteristics. Empty body weight of 67UMSC was lower than 100DMSC, these might be as the result of high gut fill of 67UMSC (4963.3 g) than other treatment groups (4140.3 g – 4774.4 g). Devendera and Burns (1983) reported that dressing percentages are within the range of 35 to 60%, which is in line with the current study 37.3 – 40.9%.

**Table 4**
Apparent digestibility coefficient of nutrients in Afar sheep fed natural pasture hay basal diet and supplemented with different levels of *Brassica carinata.*

| | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|
| **Variables** | **NG100** | **33DMSC** | **67DMSC** | **100DMSC** | **67UMSC** | **SEM** | ***P*** |
| Dry matter digestibility | 0.66 | 0.67 | 0.66 | 0.63 | 0.69 | 0.01 | 0.93 |
| Organic matter digestibility | 0.68 | 0.69 | 0.68 | 0.65 | 0.70 | 0.01 | 0.91 |
| Crude protein digestibility | 0.73 | 0.73 | 0.75 | 0.72 | 0.75 | 0.01 | 0.65 |
| NDF digestibility | 0.61 | 0.63 | 0.62 | 0.59 | 0.65 | 0.01 | 0.96 |
| ADF digestibility | 0.57 | 0.59 | 0.57 | 0.55 | 0.61 | 0.01 | 0.89 |

ADF = acid detergent fiber; NDF = neutral detergent fiber, SEM = standard error of mean; *P* = probability; NG100 = hay + wheat bran and noug seed cake mixture of 300 g, at the ratio of 2:1; 33DMSC = hay + 200g WB + 67 g NSC + 33 g DMSC; 67DMSC = hay + 200g WB + 33 g NSC + 67 g DMSC; 100DMSC = hay + 200 g WB + 100 g DMSC and 67UMSC = hay + 200 g WB + 33 g NSC + 67 g UMSC.

**Table 5**
Live weight parameters, feed conversion ratio and efficiency of Afar sheep fed natural pasture hay basal diet and supplemented with different levels of Brassica carinata.

| | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameters** | **NG100** | **33DMSC** | **67DMSC** | **100DMSC** | **67UMSC** | **SEM** | ***P*** |
| Initial body weight (kg) | 17.0 | 17.0 | 17.2 | 17.1 | 17.0 | 0.12 | 0.93 |
| Final body weight (kg) | 23.9 | 22.6 | 24.2 | 23.6 | 23.0 | 0.23 | 0.31 |
| Average daily gain /sheep (g/d) | 76.4 | 62.3 | 77.8 | 71.3 | 67.1 | 2.69 | 0.73 |
| Feed conversion ratio (FCR) | 10.7 | 13.3 | 10.6 | 11.3 | 12.5 | 0.31 | 0.13 |
| Feed conversion efficiency (FCE) | 0.096 | 0.076 | 0.096 | 0.090 | 0.081 | 0.002 | 0.11 |

SEM = standard error of mean; P = probability; NG100 = hay + wheat bran and noug seed cake mixture of 300 g, at the ratio of 2:1; 33DMSC = hay + 200g WB + 67 g NSC + 33 g DMSC; 67DMSC = hay + 200g WB + 33 g NSC + 67 g DMSC; 100DMSC = hay + 200 g WB + 100 g DMSC and 67UMSC = hay + 200 g WB + 33 g NSC + 67 gUMSC; FCR = total dry matter intake/average daily gain; FCE= average daily gain/total dry matter intake.

**Table 6**
Carcass characteristics of Afar sheep fed natural pasture hay basal diet and supplemented with concentrate containing different levels of *Brassica carinata* cake.

| | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameter** | **NG100** | **33DMSC** | **67DMSC** | **100DMSC** | **67UMSC** | **SEM** | ***P*** |
| Slaughter BW (kg) | 23.5 | 22.7 | 22.9 | 22.8 | 22.8 | 0.28 | 0.83 |
| Empty BW (kg) | $18.6^{a}$ | $17.9^{ab}$ | $18.4^{ab}$ | $19.9^{a}$ | $17.4^{b}$ | 0.14 | <0.007 |
| Hot carcass weight (kg) | 9.6 | 9.0 | 9.3 | 9.1 | 8.5 | 0.11 | 0.17 |
| **Dressing percentage (%)** | | | | | | | |
| Slaughter BW base | 40.9 | 39.7 | 40.9 | 40.0 | 37.3 | 0.48 | 0.44 |
| Empty BW base | 51.6 | 50.3 | 50.5 | 45.7 | 48.9 | 0.01 | 0.17 |
| Rib-eye muscle area ($cm^2$) | 8.1 | 8.1 | 8.0 | 7.8 | 7.8 | 0.18 | 0.41 |
| TEOC (kg) | 3.4 | 3.6 | 3.5 | 3.4 | 3.7 | 0.08 | 0.86 |
| TNEOC (kg) | 10.4 | 10.2 | 10.0 | 10.1 | 10.6 | 0.18 | 0.41 |

$^{ab}$= Means in the same row without common letter are different at P<0.05; SEM=standard error of mean; *P*= probability; NG100 = hay + wheat bran and noug seed cake mixture of 300 g, at the ratio of 2:1; 33DMSC = hay + 200g WB + 67 g NSC + 33 g DMSC; 67DMSC = hay + 200g WB + 33 g NSC + 67 g DMSC; 100DMSC = hay + 200 g WB + 100 g DMSC and 67UMSC = hay + 200 g WB + 33 g NSC + 67 g UMSC; TEOC = total edible offal component; TNEOC = total non-edible offal component.

## 4. Conclusion

The overall conclusion of this study was that detoxified Ethiopian mustard seed cake can completely replace noug seed cake when offered in mixture with wheat bran at the rate of 200g wheat bran mixed with 100 g detoxified mustard seed cake per head per day for growing male sheep. At this rate of supplement, feed intake, digestibility, weight gain and carcass characteristics were not significantly different compared to the commonly recommended wheat bran noug seed cake mixture supplements. In this study, it was also observed that the undetoxified Ethiopian mustard seed cake could also replace the noug seed cake at up to 67% without affecting the above measured parameters significantly. This could generally encourages the use of Ethiopian mustard seed cake, which is relatively available at higher quantity and lower price compared to other protein sources in Ethiopia.

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