Iranian Journal of Applied Animal Science

Effect of Forage Feeding Level on Performance, Meat Quality and Economic Cost of Holstein Beef Calves Fed Organic Diet

Research Article

M. Sharifi[1*], R. Pahlavan[2], A.A. Khadem[3], B.J. Heins[4] and M. Sofizade[5]

[1] Department of Animal Science, University of Tabriz, Tabriz, Iran
[2] National Animal Breeding Center and Promotion of Animal Product, Karaj, Iran
[3] Department of Animal and Poultry Science, College of Abouraihan, University of Tehran, Tehran, Iran
[4] Department of Animal Science, University of Minnesota, St. Paul 55108, USA
[5] Department of Animal Science, University of Urmia, Urmia, Iran

Received on: 25 May 2014
Revised on: 11 Aug 2014
Accepted on: 15 Nov 2014
Online Published on: Jun 2015

*Correspondence E-mail: majidsharifi@tabrizu.ac.ir

Online version is available on: www.ijas.ir

ABSTRACT

The aim of this study was to compare conventional and organic diets in beef production. Thirty-two dairy beef calves were used in 4 treatments: organic diet with three levels of forage [70% of organic diet with high amount of forage (ORH), 55% of organic diet with medium amount of forage (ORM), 38% of organic diet with low amount of forage (ORL)] and conventional diet (CON). The dry matter intake (DMI), average daily gain (ADG) and feed conversion rate (FCR) of calves were measured. The calves were then slaughtered at the end of the study. DMI was significantly differed among groups after the 5th period. However, FCR and ADG were significantly differed among the treatments in several periods. Carcass physical size, lipid and cholesterol were lower in organic diets compared to the CON. Significant increases were observed in organic meat for C18:2, C18:3 fatty acids, heminic iron, α-tocopherol and ß-carotene. The results of the study showed that calves fedorganic diet with high amount of forage had significantly lower FCR compared to the other diets.

KEY WORDS beef calves, meat quality, organic diet.

INTRODUCTION

In the recent decades, global meat consumption increased drastically all over the world and this trend seems to be continued for the future while the economical and ecological of meat production is questioned by Shongwe *et al.* (2007). In a critical review, Sundrum (2001) demonstrated that the benefits of organic systems are more influenced by the specific farm management system than by the production method. Opponents of the organic animal production systems argue that this kind of farming leads to lower animal production due to lower stocking rates and lower output per unit land, meaning higher production costs (Van Ryssen, 2003). In contrast, the environmental advocates and the proponents of organic production say that conventional system has some production problems and risks. In addition to environmental protection, organic diets because meat quality production can be considered as a better alternative (Miotello *et al.* 2009; Cozzi *et al.* 2010). However, the quantity and quality of beef meat from these methods vary according to the animal age and degree of finishing. Walshe *et al.* (2006) and Cozzi *et al.* (2010) reported that grazing during the finishing period might be a way of improving the nutritional quality of organic beef by increasing the content of unsaturated fatty acids, including conjugated linoleic acid (CLA). Fernandez and Woodward (1999) found that production cost in organic systems was 39% higher than conventional systems. Nielsen and Thamsborg

(2005) reported that due to the low share of organic products in the market and because their prices are 25 to 50% higher than conventional products, an organic system can compete with conventional system. It can be noted the literature for organic beef cattle and the relationship between performance and production is relatively scarce and recent research has focused on the quality organic beef production systems as well.

MATERIALS AND METHODS

Animals, diets and experimental design

This study was conducted in Valfajr Agricultural Research Center farm, located in central Alborz range lands of Kojour region of Mazandaran Province, from March 2012 to the June 2013. All the activities were performed under the guidelines approved by the Standard Committee of the Ministry of Agriculture and Veterinary Organization of Iran. The average initial body weight (BW) of 32 Holstein beef calves used in this experiment was 90.9 ± 5.2 kg (Mean±SD). Calves were reared for 330 days, from the weaning through to the slaughter time. A completely randomized block design with 4 treatment groups was used. The treatment groups were: calves fed organic diet with high amount of forage (ORH), calves fed organic diet with medium amount of forage (ORM), calves fed organic diet with low amount of forage (ORL) and calves fed conventional diet (CON). The ingredients and the chemical composition of diets used in this experiment are shown in Table 1.

Range forages used in diets contained of *Hordeum bolbosum* (35%), *Festuca pratensis* (30%), *Dorema ammoniacum* (25%) and others (10%). Calves were fed equal amounts of total mixed ration (TMR) diets at morning (08:00) and evening (20:00). Refusals were collected daily so that *ad libitum* TMR intake could be determined as the difference between the DM offered and refused. Calves had free access to the fresh water.

Range management

The range area was 20 hectares of grasslands in Kojour region of Mazandaran Province. In addition, a 10 hectare of agricultural land was also used. To harvest the range, the paddock area was divided into 4 sections and forage was harvested at 50 (in spring and summer) and 90 (in autumn and winter) days intervals. The range areas were not irrigated and the yearly average rainfall amounted to about 790 mm with 15.7 ˚C of average yearly temperature. The soil structures were classified as loam and / or sandy-loam, with a neutral pH (6.83-7.19) and a good organic matter (2.99%-4.75%) contents. During each harvesting time, botanical measurement was performed using Braun-Blanquet (1964) method and the percentage coverage of each species was recorded. Pasture samples were also collected at the same times and used for chemical analysis.

Table 1 Ingredients and chemical composition of the experimental diets

Item	ORH	ORM	ORL	CON
Ingredient, % of DM				
Barley straw	2.00	2.00	1.00	1.00
Rangeland forage	19.0	13.0	5.00	5.00
Alfalfa hay	20.0	13.0	9.00	9.00
Corn silage % 40 grain	27.0	25.0	21.0	21.0
Barley grain	12.0	20.0	28.0	28.0
Corn grain	5.00	6.00	6.00	6.00
Cotton seed meal	7.00	13.0	23.0	23.0
Wheat bran	2.00	2.00	2.00	2.00
Bicarbonate sodium	1.00	1.00	1.00	1.00
Carbonate calcium	0.10	0.10	0.10	0.10
Dicalcium phosphate	0.50	0.50	0.50	0.50
Limestone	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50
Urea	3.02	3.00	1.99	1.99
Mineral-vitamin mix[1]	0.38	0.40	0.41	0.41
Chemical composition, % of DM[2]				
Total digestible nutrients	63.0	65.0	66.0	69.0
Crude protein	22.8	23.7	24.7	25.7
Neutral detergent fiber	37.6	35.8	31.2	30.9
Non fiber carbohydrate	35.0	36.0	38.1	39.0
Calcium	1.00	0.99	1.00	1.01
Phosphorus	0.42	0.42	0.42	0.44
ME, Mcal/kg of DM	2.32	2.38	2.42	2.48
Fatty acid g/100g of total fat				
C18:0	9.20	10.1	11.61	11.67
C18:1	23.24	22.01	18.07	18.01
C18:2	19.12	23.65	28.93	29.01
C18:3	3.01	2.91	2.36	2.35

ORH: organic diet with high amount of forage; ORM: organic diet with medium amount of forage; ORM: organic diet with low amount of forage and CON: conventional diet.
[1] Mineral composition (g/kg): Ca: 180; P: 60; Mg: 50; Na: 50; Cu: 1.3; Zn: 6.0; Mn: 3.5; I: 0.06; Co: 0.032 and Se: 0.02.
Vitamin composition (IU/kg): vitamin A: 600000; vitamin D_3: 120000 and vitamin E: 1300.
[2] Data were measured using AOAC (1991) method, otherwise extracted from the nutrient requirements of beef cattle (NRC, 2000).

Data collection

Forages were evaluated according to the methods of association of official analytical chemists (AOAC, 1991). Analyses of dry matter (DM), total digestible nutrients (TDN), crude protein (CP), crude fiber (CF), ether extracts (EE), fatty acid profile, ash and neutral detergent fiber (NDF) were made in present study. For this purpose, samples of sun cured hays were packaged and sent to the laboratory. During the experimental period, the average daily gain (ADG) of calves was taken at 30-day intervals prior to morning feed allotments. ADG is:

ADG= (ending weight-starting weight) / days on feed

Also, dry matter intake (DMI) and the relative orts of calves were recorded daily. However, the average of DMI in 30-day (11 periods) were reported. Moreover, feed conversion rate (FCR) was calculated by dividing amount of DMI on ADG of calves. Feed costs (FC) were based on the purchase prices of the diet ingredients, field preparation, harvesting, transport, chopping, electricity, worker, laboratory quality control and animal health. The feed cost from income meat (FCFIM) for calves in each group was calculated based on the costs of consumed feed dividing to cost of live weights obtained during the relative experimental period. At the end of experiment, finished calves were slaughtered and their carcasses weights were weighed individually. Following slaughter, the meat samples were vacuum packaged and transported to the laboratory. Fresh samples of M. Longissimus thoracis were used for colour determination (Minolta CM500 Spectrophotometer), while the freeze-dried samples were used for recognizing of meat chemical composition (AOAC, 1991). Cholesterol and heminic iron contents were detected according to Miotello *et al.* (2009). Fatty acids were analysed by gas chromatography (GC) analysis after lipid extraction (ASER instrument) and Trans-methylation (AOAC, 1991). The carcasses were then frozen in a freezing tunnel (-15 ˚C) to measure the cold carcass weights.

Statistical analyses

The independent variables of DMI, BW, FCR, FC and the FCFIM were considered as the fixed effects of dietary treatments, but the sex and the 30-d periods were nested within treatments. The MIXED model procedure of SAS (SAS, 2004) was used with calves nested within sex as a random variable with repeated measures.

The autoregressive covariance [AR (1)] structure was used because it resulted in the lowest Akaike's information criterion (Littell *et al.* 1998). Moreover, statistically significant differences among the 4 treatments for carcass were determined by general line model (GLM) procedure. Results are presented as least square means with the SEM and the relative P-values. Birth weight and weaning weight were included in the models as covariates. Statistical differences were considered significant at $P < 0.05$.

RESULTS AND DISCUSSION

DMI, FCR and ADG

Daily DMI was recorded from weaning to slaughter. There were no significant differences for the DMI of calves among treatments from the beginning of experiment until the 5th period (Table 2). However, significant differences were recorded after the 6th period ($P<0.01$). For the mean of periods, calves fed CON and ORL diets had higher DMI ($P<0.05$) than calves fed ORM and ORH diets (5.76 and 5.65 kg *vs.* 5.29 and 5.22 kg, respectively). Furthermore, calves fed CON and ORL diets had higher DMI ($P<0.05$) than calves fed ORM and ORH diets during the 6th, 7th, 8th, 9th, 10th and the 11th periods. Across the 330 days, CON and ORL cows had greater ($P<0.01$) ADG than ORM and ORH cows (Figure 1). Changes in DMI and ADG of calves were almost vice versa from the beginning to the end of experiment. But, calves fed the CON and ORL diets had the highest final body weights (425.7 and 420.8 kg, respectively); it is while the lowest finally body weights' were recorded for those fed the ORM and ORH diets (398.1 and 392.8 kg, respectively). For the mean of periods, calves fed ORM diets had higher FCR than calves of CON, ORH and ORL diets (5.90 *vs.* 5.86, 5.84, 5.80, respectively) ($P<0.05$). Furthermore, Table 4 shows that from the beginning of experiment until the 5th period, ORL and CON were better than other diets.

Carcass characteristics

Carcass characteristics and meat quality results are summarised in Table 3. Cows fed CON diet had largest hot carcasses extracted than cows fed ORL, ORM and ORH diets (239.2, 230.1, 219.3 and 209.7 kg for calves, respectively), while the minimum cold carcass weight was recorded for calves fed ORH, ORM and ORL, respectively. Also, CON and ORL had significantly higher values than ORM and ORH for carcass physical size (CPS) (withers height, chest width, back length, carcass length and leg width). Also, the contents of C14:0 ($P<0.05$), C18:0 ($P<0.05$), C18:2 ($P<0.05$) and C18:3 ($P<0.001$) were greater in meat samples obtained from ORH and ORM groups than those obtained from ORL and CON groups. In contrast, C16:0 ($P<0.05$) and C18:1 ($P<0.01$) were lower in meat samples obtained from ORH and ORM groups than those obtained from other groups. Moreover, the chemical composition of meat samples shows that meat obtained from ORH and ORM had higher water, crude protein, ash, α-tocopherol, ß-carotene and himinic iron. But, ether extract and cholesterol were significantly lower in meat samples obtained from ORH and ORM calves compared to those obtained from the other groups.

FC, FCFIM and case study farm simulations

The results show that lower FC and FCFIM are calculated for calves fed ORH, ORM, ORL and CON diets, respectively (Tables 5).

Also, for the mean of periods, calves fed ORL and CON diets had higher FC than calves in ORM and ORH groups (4.73, 4.15, 3.54 and 3.08 dollars/day, respectively; $P<0.01$). On the other hand, Table 5 shows that the highest FCFIM (68.4%) was found for the ORL group. In addition, the average costs of production for each of the 4 treatments are listed in Table 6.

Table 2 Least squares means and standard errors for dry matter intake (DMI) (kg/day) of dairy beef calves from 90d to 420d of age

Measurement for 30-d period	ORH	ORM	ORL	CON	SEM	P-value
1	3.12	3.06	3.08	3.03	0.15	NS
2	3.83	3.80	3.93	3.94	0.15	NS
3	4.34	4.34	4.56	4.61	0.15	NS
4	4.77	4.80	5.09	5.20	0.15	NS
5	4.94	4.99	5.32	5.45	0.15	†
6	5.39^{b}	5.48^{b}	5.88^{a}	6.04^{a}	0.15	*
7	5.56^{b}	5.66^{b}	6.10^{a}	6.25^{a}	0.15	**
8	5.61^{b}	5.72^{b}	6.17^{a}	6.31^{a}	0.15	**
9	6.12^{b}	6.27^{b}	6.77^{a}	6.94^{a}	0.15	**
10	6.62^{b}	6.80^{b}	7.34^{a}	7.52^{a}	0.15	**
11	7.12^{b}	7.30^{b}	7.86^{a}	8.05^{a}	0.15	**

ORH: organic diet with high amount of forage; ORM: organic diet with medium amount of forage; ORM: organic diet with low amount of forage and CON: conventional diet.

† (P<0.1); * (P<0.05) and ** (P<0.001).

The means within the same row with at least one common letter, do not have significant difference (P>0.05).

NS: non significant and SEM: standard error of the means.

Production costs were greater in the ORL system than those in the organic system. Machinery and energy costs in organic production system were higher than conventional production system because of the greater use of transport, chopping silage and electricity costs.

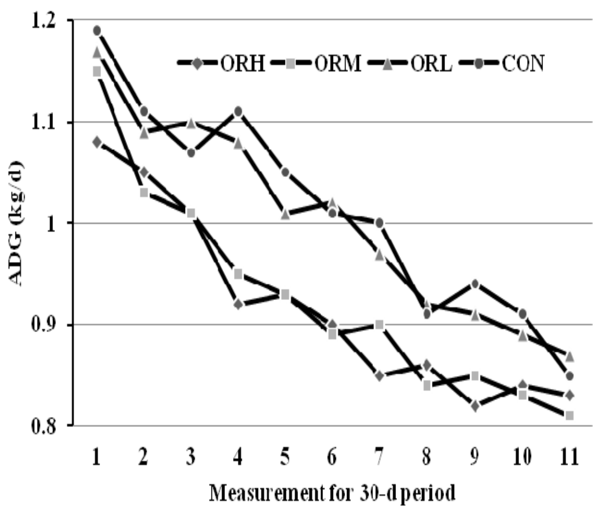

Figure 1 Time courses of body weight in an ORH: organic diet with high forage; ORM: organic diet with medium forage; ORM: organic diet with low forages and CON: conventional diet, during the observation periods. Means of body weight were staticticaly defferent among treatments for all periods (P<0.05). Overall SEM for the average daily gain (ADG, kg/d)= 0.11

Although the costs of preparing the farm's ORH and ORM were lower, the cost of preparing in ORL is higher than the conventional system. Since the cost of manure, machinery and maintenance of organic production for grain production in the organic system is higher than other systems (Table 6). Consequently, results of this study indicate that the highest benefit index (BI=total revenue/total expenses) was related to the calves of ORH, ORM, ORL and CON diets (1.52, 1.42, 1.26 and 1.25, respectively) (Table 6). Therefore, the ORH and ORM system is more profitable than other systems.

DMI, FCR and ADG

Results for the DMI in this study are similar to those reported by Esterhuizen *et al.* (2008); Sami *et al.* (2003) and Walshe *et al.* (2006) who found that animals in conventional system consumed more feed than those on organic system. In addition, Nielsen and Thamsborg (2005) noted that DMI was significantly increased due to increase in use of concentrates in the diet of calves fed organic diets from 3 to 5 month of age. No significant differences were observed between the DMIs until the 5th period of experiment. This could perhaps be related to the quality for the spring forages (high in energy and protein) used in diets which could supply the needs for calves during their early life. The relatively lower ADGs in the ORH and ORM compared to the ORL and CON diets are in line with many reports in the literature. Esterhuizen *et al.* (2008) and Cozzi *et al.* (2010) found that the growth rate and the weight gain for steers raised on conventional beef systems were higher than those fed organic systems. In addition, results for ADG are consistent with the results of Sami *et al.* (2003) and Walshe *et al.* (2006) who reported that animals in organic system had lower ADG than conventional system. Therefore, results of our study are similar to those reported by others noting that by increasing the amount of concentrate in diets the BW of beef calves will be significantly improved. The results of our study are similar to those reported by Fernandez *et al.* (1999) showed that the FCR in conventional system was better than organic system. In contrast, Esterhuizen *et al.* (2008) showed that the FCR in calves fed organic diets was better than that in calves fed conventional diets contained high concentrates.

The main reason for increase in FCR during the latest periods of experiment is that calves have reasonably greater need for their maintenance requirements when BWs are increased. Also, huge mass of ORH or ORM ver. ORL and CON, development of low gastrointestinal tract and increasing demand for high growth rate led to rise in FCR in the first 5 periods for organic diets.

Table 3 Least squares means, standard errors and standard errors of means for carcass characteristic of dairy beef calves from 90d to 420d of age

Item	ORH	ORM	ORL	CON	SEM	P-value
Hot carcass (kg)	209.7^{d}	219.3^{c}	230.1^{b}	239.2^{a}	1.89	**
Cold carcass (kg)	201.5^{c}	210.1^{b}	222.1^{a}	234.5^{a}	1.81	*
Hot carcass (%)	53.4^{c}	55.1^{ab}	54.7^{bc}	56.2^{a}	0.49	*
Cold carcass (%)	51.3^{c}	52.8^{b}	52.8^{b}	55.1^{a}	0.21	**
DBHCCW	8.24^{a}	9.15^{a}	7.99^{a}	4.68^{b}	0.11	*
Colour meat (redness)	9.51^{a}	7.94^{b}	4.95^{c}	4.83^{c}	0.52	***
Carcass physical size (cm)						
Withers height	94.3^{b}	97.1^{b}	104.8^{a}	107.8^{a}	3.01	*
Chest width	31.4^{b}	32.4^{ab}	34.9^{a}	35.9^{a}	0.60	**
Back length	91.8^{b}	94.5^{b}	102.3^{a}	104.9^{a}	1.49	**
Carcass length	99.4^{b}	102.4^{b}	110.5^{a}	113.6^{a}	1.51	**
Leg length	54.8^{b}	56.4^{b}	60.9^{a}	62.7^{a}	0.52	*
Leg width	32.6^{b}	33.5^{b}	36.2^{a}	37.2^{a}	1.02	**
Fatty acid composition of meat (g/100 g lipid extract)						
C14:0	5.59^{a}	5.23^{b}	4.30^{c}	4.28^{c}	0.12	**
C16:0	22.99^{b}	23.24^{b}	23.87^{a}	24.01^{a}	0.51	*
C18:0	20.01^{a}	18.67^{b}	14.54^{c}	14.61^{c}	0.46	**
C18:1	31.68^{b}	32.17^{b}	33.95^{a}	34.01^{a}	0.45	**
C18:2	16.93^{a}	16.78^{a}	15.12^{b}	15.22^{b}	0.36	**
C18:3	5.93^{a}	4.77^{b}	2.59^{c}	2.17^{c}	0.46	***
C18:2/C18:3	2.8^{c}	3.5^{c}	5.8^{b}	7.0^{a}	0.11	**
Chemical composition of meat						
Water (%)	76.2	75.1	74.8	74.9	0.31	†
Crude protein (% DM)	23.5^{a}	22.7^{b}	21.6^{c}	21.4^{c}	0.24	*
Ether extract (% DM)	1.69^{c}	1.81^{b}	2.31^{a}	2.34^{a}	0.19	**
Ash (% DM)	1.21^{a}	1.15^{a}	1.09^{b}	1.08^{b}	0.02	*
Cholestrol (mg/100 g)	50.1^{c}	53.6^{b}	58.7^{a}	59.1^{a}	1.29	**
Heminic iron (mg/kg)	52.22^{a}	47.01^{b}	27.61^{c}	27.32^{d}	1.78	***
α-tocopherol (mg/100g)	0.77^{a}	0.65^{b}	0.31^{c}	0.32^{c}	0.01	**
ß-carotene (mg/100g)	0.045^{a}	0.037^{b}	0.030^{c}	0.031^{c}	0.002	*

ORH: organic diet with high amount of forage; ORM: organic diet with medium amount of forage; ORM: organic diet with low amount of forage and CON: conventional diet.

[†] (P<0.1); [*] (P<0.05); [**] (P<0.01) and [***] (P<0.001).

The means within the same row with at least one common letter, do not have significant difference (P>0.05).

NS: non significant and SEM: standard error of the means.

DBHCCW: differences between hot and cold carcass weight.

Table 4 Least squares means and standard errors of means for feed conversion rate of dairy beef calves from 90d to 420d of age

Measurement for 30-d period	ORH	ORM	ORL	CON	SEM	P-value
1	2.89^{a}	2.66^{b}	2.63^{b}	2.55^{c}	0.07	*
2	3.65^{a}	3.69^{a}	3.61^{ab}	3.55^{b}	0.07	*
3	4.30	4.30	4.15	4.31	0.07	NS
4	5.18^{a}	5.05^{b}	4.71^{c}	4.68^{c}	0.07	**
5	5.31^{a}	5.37^{a}	5.27^{a}	5.19^{b}	0.07	*
6	5.99^{b}	6.16^{a}	5.76^{c}	5.98^{b}	0.07	*
7	6.54^{a}	6.29^{b}	6.29^{b}	6.25^{b}	0.07	**
8	6.52^{c}	6.81^{b}	6.71^{b}	6.93^{a}	0.07	*
9	7.46	7.38	7.44	7.38	0.07	†
10	7.88^{b}	8.19^{a}	8.25^{a}	8.26^{a}	0.07	**
11	8.58^{c}	9.01^{b}	9.03^{b}	9.47^{a}	0.07	**

ORH: organic diet with high amount of forage; ORM: organic diet with medium amount of forage; ORM: organic diet with low amount of forage and CON: conventional diet.

[†] (P<0.1); [*] (P<0.05) and [**] (P<0.001).

The means within the same row with at least one common letter, do not have significant difference (P>0.05).

NS: non significant and SEM: standard error of the means.

Carcass characteristics

In this study, values for carcass characteristics were significantly different among treatments.

The results of the current study are in agreement with findings of Miotello *et al*. (2009), Esterhuizen *et al*. (2008) and De-la-Vega *et al*. (2013) who reported that dietary or ganic versus conventional diets had an impact on carcass characteristics. For example, Esterhuizen *et al.* (2008) found that the hot and cold carcass weights and the percentages of extracted carcass were higher for animals in conventional system compared to the organic system. Also, Cozzi *et al.* (2010) reported that the cows in conventional systems had higher hot carcass weights than those in organic systems. Moreover, in agreement with Cozzi *et al.* (2010) and Miotello *et al.* (2009) color redness was significantly difference when ORH and ORM were used.

Higher redness of meat derived from ORH and ORM, due to the high content of heminic iron (P<0.001), was probably due to higher forage consumption of organic animals. Miotello *et al.* (2009) and Cozzi *et al.* (2010) indicated that CP, ash, α-tocopherol, ß-carotene and heminic iron content of meat in calves fed organic diets were higher than those fed conventional diets. Conversely, Walshe *et al.* (2006) reported that CP, ash, β-carotene and α-tocopherol were not significantly different for cows fed organic or conventional diets.

Table 5 Least squares means and standard errors of means for feed cost and feed cost from income meat of dairy beef calves from 90d to 420d of age

Item	ORH	ORM	ORL	CON	SEM	P-value
Feed cost (Dollars/day)						
Spring	2.15^{d}	2.48^{c}	3.28^{a}	2.85^{b}	0.13	**
Summer	2.59^{d}	2.98^{c}	4.05^{a}	3.50^{b}	0.13	***
Autumn	3.35^{d}	3.85^{c}	5.17^{a}	4.55^{b}	0.13	***
Winter	4.24^{d}	4.85^{c}	6.43^{a}	5.70^{b}	0.13	**
Feed cost from income meat (%)						
Spring	28.6^{c}	32.8^{b}	40.9^{a}	39.4^{a}	0.77	**
Summer	39.3^{d}	44.9^{c}	54.3^{a}	51.2^{b}	0.77	***
Autumn	55.2^{d}	62.0^{c}	77.1^{a}	73.8^{b}	0.77	***
Winter	70.5^{c}	82.2^{b}	101.6^{a}	100.1^{a}	0.77	**

ORH: organic diet with high amount of forage; ORM: organic diet with medium amount of forage; ORM: organic diet with low amount of forage and CON: conventional diet.

** (P<0.01) and *** (P<0.001).

The means within the same row with at least one common letter, do not have significant difference (P>0.05).

NS: non significant and SEM: standard error of the means.

Table 6 A comparison of simulated annual feed production, use and economics for 4 group study organic and conventional diets

Item	ORH	ORM	ORL	CON
Income				
Total BW (kg)	3142.4	3184.8	3366.4	3405.6
Total revenue ($)	22625.2	22930.5	24238.0	22136.4
Gross revenue ($/Farm)[1]	7774.5	6874.4	5150.1	4540.8
Benefit index[2] (P<0.05)	1.52^{a}	1.42^{a}	1.26^{b}	1.25^{b}
Feed cost				
Total feed consumption (kg DM)	13780.8	13972.8	14904.0	15201.6
Grain consumption (kg DM)	4134.2	6287.7	9240.4	9424.9
Forage consumption (kg DM)	9646.5	7685.0	5663.5	5776.6
Feed intake cost ($)	7867.2	9036.0	12096.0	10593.6
Grain intake cost ($)	3530.6	5369.7	7891.3	7200.6
Forage intake cost ($)	4336.5	3666.2	4204.6	3392.9
Fixed cost ($)[3]	6983.5	7020.1	6991.9	7002.0
Production cost				
Field preparation ($)	2910.8	3994.8	6410.8	5113.5
Seed and fertilizer ($)	582.1	1038.6	2172.0	2147.6
Manure and machinery ($)	1455.4	1917.5	2956.6	2045.4
Storage feed ($)	873.2	1038.6	1282.1	920.4
Harvesting ($)	1408.2	1372.5	1692.2	1484.1
Transport ($)	864.6	801.4	792.2	688.5
Electricity and fuel ($)	638.0	653.3	630.2	777.5
Chopping ($)	156.5	167.1	158.4	140.8
Worker ($)	1337.4	1282.2	1243.4	1259.5
Laboratory ($)	157.3	201.5	302.4	280.7
Animal health ($)	394.1	562.9	866.0	848.5

ORH: organic diet with high amount of forage; ORM: organic diet with medium amount of forage; ORM: organic diet with low amount of forage and CON: conventional diet.

[1] Aggregation of income from the sales of farm outputs ($GR=\sum^{N} R_{xi} Y_i$).

[2] Benefit index: the ratio of total revenue to total expenses (BI ratio=total revenue/total expenses).

[3] Fixed costs included: purchase costs of calve and maintenance costs of farm.

In addition, results for ether extract and cholesterol in ORH and ORM are consistent with the results of Cozzi *et al*. (2010), Miotello *et al*. (2009) and Walshe *et al*. (2006) who reported that animals in organic diets had lower extract and cholesterol. Despite of the increasing saturation in the rumen (by increasing the C18:0), ORH and ORM increased polyunsaturated FA (C18:2 and C18:3) concentration in the meat. This result is consistent with those reported by several authors using organic diets based on high forage (Cozzi *et al*. 2010; Miotello *et al*. 2009; Walshe *et al*. 2006). Positive biological functions have been attributed to these C18:2 and C18:3, therefore, this method is considered more suitable for fattening. It should be mentioned that increasing unsaturated fatty acids can reduce the storage of meat due to fat oxidation. However, due to the increased α-tocopherol in meat, fat oxidation can be controlled.

FC, FCFIM and case study farm simulations

Both, FC and FCFIM were different among diets (P<0.01). This finding is in accordance with many studies. Results obtained for FC values in this experiment are consistent with those reported by Esterhuizen *et al*. (2008) confirming that the feed costs of animals fed organic system managements were cheaper than those on conventional system. On the other hand, Rosmann *et al*. (2004) showed that the cost for organic system is lower due to higher efficiency and lower cost. In contrast, Fernandez *et al*. (1999) stated that to reach the weight of calves to a certain goal, the cost of organic diet was significantly higher than conventional diet. As with other reports, our results show that higher costs for organic production are expected due to increased labor and management requirements. The high cost of organic cereals or purchased concentrates as ORL can result in relatively high feed costs per head, particularly in finishing beefs. Even if cereals are grown on the farm, the opportunity cost of selling these home-grown cereals at high premiums must be taken into account. On the other hand, forage costs in organic systems are generally lower than in conventional system, because of reduced fertiliser costs. However, seed and establishment costs may be marginally higher.

CONCLUSION

By focusing on different levels of evaluation, we conclude that beef calves fed on organic systems differ from conventional system. Gradual replacement of concentrate to forage in the experiments presented clearly shows the difference in productivity and efficiency. DMI and ADG were higher in calves fed the CON and ORL diets compared to those in calves fed other diets. But, profitability is likely to be higher for calves fed ORH diets. Because, calves fed the ORL and CON diets had significantly higher FC and FCFIM than other diets. While, the weight of carcasses and CPS of calves fed the CON diet a higher than other groups. Moreover, calves of ORH and ORM diets had higher C18:2 and C18:3, α-tocopherol, ß-carotene and heminic iron contents than calves of ORL and CON diets during experiment. In addition, the carcass weight loss due to freezing is less in calves fed conventional diet. However, despite the lower ADG in organic systems, this system compared with conventional due to greater benefit index (BI) and lower cost is deemed appropriate.

ACKNOWLEDGEMENT

This join-work was supported by the University of Tehran which is gratefully acknowledged. The assist of operators at Kojour range lands and that in the Abbas-abad abattoir is also appreciated.

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